

New species of *Eurycletodes* Sars, 1909 and *Odiliacletodes* Soyer, 1964 from the deep Gulf of California (Copepoda, Harpacticoida, Argestidae)

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Abstract

To date, three species of the family Ancorabolidae, three species of the family Argestidae, and one species of the family Rhizothrichidae are known from the deep sea of the Gulf of California. The descriptions of two new species, *Eurycletodes paraephippiger* **sp. n.** and *Odiliacletodes secundus* **sp. n.** collected from the Southern Trough of Guaymas Basin at 1440 m and 1642 m depths, respectively, are presented herein. The closest relatives of these two species, *E. ephippiger* Por, 1964 and *O. gracilis* Soyer, 1964 are known from the Mediterranean, but some relatives have been reported also from the southern Atlantic. *Eurycletodes paraephippiger* **sp. n.** is undoubtedly related to *E. ephippiger* Por, 1964 known from Israel and Banyuls-sur-Mer (France). These two species can be separated by the armature complement of the basis of the maxillule, by the armature complement of the syncoxa of the maxilliped, and by the relative position of the anal operculum. *Odiliacletodes secundus* **sp. n.** showed to be closely related to *O. gracilis* Soyer, 1964 known from Banyuls-sur-Mer only. The latter two species can be separated by the armature complement of the syncoxa of the maxilliped, by the structure of the antenna, and by the inner armature complement of the third exopodal segment of the fourth swimming leg.

Keywords

Deep Sea, distribution, diversity, taxonomy

Introduction

The family Argestidae is considered a typical deep-sea taxon (Hicks and Coull 1983, Huys and Conroy-Dalton 1997, George 2004). However, some species of several genera of this family have been reported at 200 m depths or less (Boeck 1872, Sars 1920, Lang 1936, Por 1959, 1967, 1979, Soyer 1966, Menzel et al. 2011). For a more complete list of the bathymetric distribution of the family in general, and of *Mesocletodes* Sars, 1909 in particular, see George (2004) and Menzel and George (2012). Argestidae are common inhabitants of muddy substrates, are one of the dominant groups of meiobenthic deep-sea harpacticoids (Menzel and George 2009), and some of its genera, e.g., *Mesocletodes* and *Eurycletodes* Sars, 1909, are the most abundant in deep-sea samples, accounting for more than 25% of total abundance of Argestidae (Menzel 2011a). Due to their high abundance and high species richness, this family might play an important ecological role in the benthic realm and is a good subject for phylogenetic, biogeographical, and chorological investigations on deep-sea harpacticoids and meiofauna due to its worldwide distribution (Menzel and George 2009, George 2011). For example, George (2004) hypothesized on how deep-sea argestids may have colonized shallow habitats, and Gómez (2018) reported on some new species of *Mesocletodes* from the Gulf of California, whose closest relatives have been found in the Angola Basin (Central Atlantic), and are probably present also in the Clarion-Clipperton Fracture Zone (Pacific Ocean) (pers. obs.). Additionally, from Menzel et al. (2011), Menzel and George (2012), and Gómez (2018) it is evident that the same species or closely related species are present in distant localities across vast areas of the world ocean, seemingly “ignoring” geographical barriers. Nevertheless, despite its importance, only few studies are available on the diversity of Argestidae and few of them have tackled the monophyly of the entire family and its constituent genera (e.g., Huys and Conroy-Dalton 1997, George 2004, 2008, 2011, Menzel and George 2009, Corgosinho and Martínez Arbizu 2010, Menzel 2011a, Menzel et al. 2011).

About 225 harpacticoid copepods belonging to an undetermined number of species of 46 genera and 16 families were gathered during examination of deep-sea sediment samples taken during Talud X cruise (February 2007) in the Southern Trough of Guaymas Basin, revealing a high species-richness of benthic harpacticoids (pers. obs.). So far, three species of the family Ancorabolidae, *Ancorabolus hendrickxi* Gómez & Conroy-Dalton, 2002, *Ceratonotus elongatus* Gómez & Díaz, 2017, and *Dendropsyllus californiensis* Gómez & Díaz, 2017, three species of the family Argestidae, *Mesocletodes simplex* Gómez, 2018, *M. brevisetosus* Gómez, 2018 and *M. unisetosus* Gómez, 2018, and one species of the family Rhizothrichidae, *Rhizothrix longiseta* Gómez, 2018, are known from the deep sea of the Gulf of California. Here I report on two new species, *Eurycletodes paraehippiger* sp. n. and *Odiliacletodes secundus* sp. n. collected from the Southern Trough of Guaymas Basin at 1440 m and 1642 m depth, respectively.

Materials and methods

Sediment samples for meiofaunal analyses were taken during Talud X cruise (February 2007) in the Southern Trough of Guaymas Basin. Sediment samples were collected at depths ranging from about 379 m to 1902 m using a box corer from which triplicate subsamples were taken with 69 cm² cores of 20 cm in length. The upper 3 cm layer of sediment was preserved in 70% ethanol, sieved through 500 and 38 µm sieves to separate macro- and meiofauna, and stained with Rose Bengal. Meiofauna was sorted at a magnification of 40× using an Olympus SZX12 stereomicroscope, and harpacticoid copepods were stored separately in 1 ml vials with 70% ethanol. Illustrations were made from whole individuals and their dissected parts using a Leica DMLB microscope. The dissected parts were mounted on separate slides using lactophenol as mounting medium. Huys and Boxshall (1991) and Menzel (2011a) were followed for general terminology. Abbreviations used in the text:

- acro** acrothek;
ae aesthetasc;
EXP exopod;
ENP endopod;
EXP(ENP)1(2, 3) first (second, third) exopodal (endopodal) segment;
P1–P6 first to sixth legs;

The type material was deposited in the Copepoda collection of the Instituto de Ciencias del Mar y Limnología, Unidad Académica Mazatlán (**ICML-EMUCOP**).

Taxonomy

Family Argestidae Por, 1986

Genus *Eurycletodes* Sars, 1909

Type species. *Cletodes laticauda* Boeck, 1872 now regarded as a synonym of *Eurycletodes* (*Eurycletodes*) *laticauda* (Boeck, 1872), by original designation.

Other species. *Eurycletodes ephippiger* Por, 1964, *E. paraephippiger* sp. n., *E. (Eurycletodes) gorbunovi* Smirnov, 1946, *E. (E.) rectangulatus* Lang, 1936, *E. (E.) serratus* Sars, 1920, *E. (Oligocletodes) abyssi* Lang, 1936, *E. (O.) aculeatus* Sars, 1920, *E. (O.) arcticus* Lang, 1936, *E. (O.) denticulatus* Por, 1967, *E. (O.) diva* Menzel, 2011a, *E. (O.) echinatus* Lang, 1936, *E. (O.) hoplurus* Smirnov, 1946, *E. (O.) irelandica* Roe, 1959, *E. (O.) latus* (T. Scott, 1892), *E. (O.) major* Sars, 1909, *E. (O.) minutus* Sars, 1920, *E. (O.) monardi* Smirnov, 1946, *E. (O.) oblongus* Sars, 1920, *E. (O.) parasimilis* Por, 1959, *E. (O.) peruanus* Becker, 1979, *E. (O.) petiti* Soyer, 1964, *E. (O.) profundus* Becker, 1979, *E. (O.) quadrispinosa* Schriever, 1986, *E. (O.) similis* (T. Scott, 1895), *E. (O.) uniarticulatus* Smirnov, 1946, *E. (O.) verisimilis* Willey, 1935.

***Eurycletores paraephippiger* sp. n.**

<http://zoobank.org/F4992154-5397-4E77-9727-CE28797923D8>

Material examined. One female holotype (ICML-EMUCOP-020207-01) dissected on eight slides; collected on February 2, 2007.

Type locality. Southern Trough of Guaymas Basin, Gulf of California, Mexico, 27°09'08"N, 111°39'57"W, depth 1440 m.

Description of female. *Habitus* (Figs 1A, 2A) cylindrical, without clear distinction between prosome and urosome. Total body length, 831 µm, measured from tip of rostrum to posterior margin of caudal rami.

Rostrum well-developed (Fig. 1A, B), fused to cephalothorax, triangular, with pointed tip flanked by apical sensilla on each side.

Cephalothorax and free thoracic somites with reticulated pattern along posterolateral margin, posterior margin coarsely denticulated dorsally and laterally, denticles increasing in size posteriorly (Figs 1A, 2A); with sensilla and tube pores issuing from conspicuous tubercles.

Urosomites with coarsely denticulated posterior margin dorsally and laterally, denticles increasing in size posteriorly (Figs 1A, 2A), much more developed than those of prosomites. Second and third urosomites distinct dorsally and laterally, posterior margin of anterior half of genital-double somite with denticulated posterior margin dorsally (Figs 1A, 2A), fused ventrally forming genital-double somite (Fig. 3A), with reticulated pattern along posterior margin dorsally and laterally, ventral reticulated pattern interrupted medially; posterior margin of second half of genital-double somite and fourth urosomite poorly developed ventrally, of fourth urosomite comparatively coarser and with reticulated pattern as in preceding somite (Fig. 3A); posterior margin of fifth urosomite with well-developed denticles dorsally and ventrally, coarser than in preceding somites, with continuous reticulated pattern along entire posterior margin (Fig. 3A), with dorsal (Fig. 1A) and lateral (Fig. 2A) sensilla and ventral tube-pores (Fig. 3A).

Anal somite nearly as long as three preceding somites combined, almost square from dorsal and lateral view, seemingly without spinular ornamentation dorsally and laterally (Figs 1A, 2A), ventrally cleft medially and with four proximal transverse rows of spinules (Fig. 3A); laterally (Fig. 2A, B) and ventrally (Fig. 3A) with posterior and inner margin, respectively, coarsely denticulated, and with minute spinules close to joint with caudal rami; anal operculum (Fig. 1A, C) coarsely denticulated, associated surface ornamentation seemingly two pores somewhat displaced anteriorly (seemingly without sensilla, probably broken off during dissection).

Caudal rami semi-cylindrical, about 1.6 times as long as broad from dorsal view (Fig. 1C), and about 2 times as long as broad from ventral view (Fig. 3A, B); ventrally with some minute spinules and one tube pore subdistally (the latter arrowed in Figs 1C, 2B, 3B); with seven setae as follows: seta I small, ventral and anterior to seta II, the latter about 3 times as long as the former; seta III arising from small protrusion, situated ventrally close to inner margin; setae IV and V longest; seta VI arising at inner distal corner, as long as seta I; dorsal seta VII tri-articulated, issuing from median dorsal process.

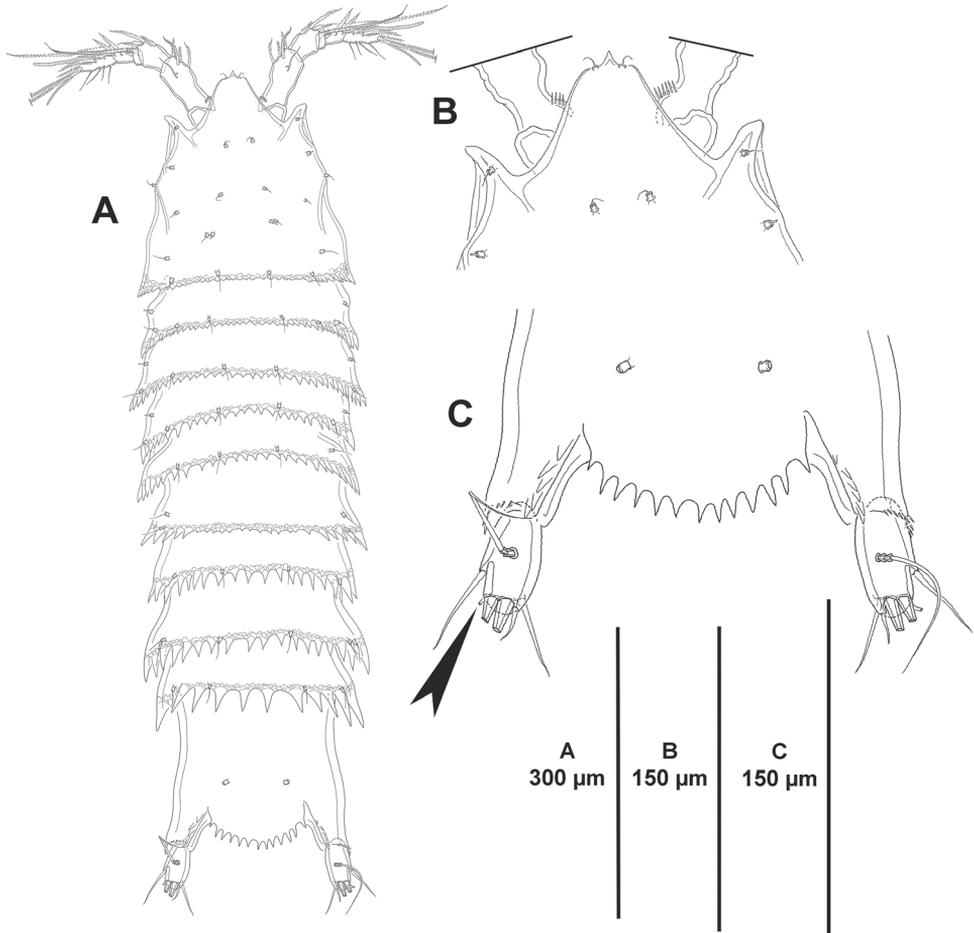


Figure 1. *Eurycletodes paraehippiger* sp. n., female holotype. **A** habitus, dorsal **B** anterior part of the cephalothorax and rostrum, dorsal **C** posterior part of anal somite and caudal rami, dorsal.

Antennule (Fig. 4A). Hexa-segmented; first segment small; second segment longest; surface of segments smooth except for spinular row on first segment; fifth segment with two well-developed bipinnate setae and a modified small element (see insert in Fig. 4A); last segment with five bi-articulated setae, one subapical well-developed seta, and acrothek, the latter consisting of one aesthetasc and two setae fused basally. Armature formula as follows: 1(0); 2(7); 3(4+[1+ae]); 4(1); 5(3); 6(8+[acro]).

Antenna (Fig. 4B). Allobasis ornamented with inner spinules as shown; without abexopodal seta. Exopod represented by single seta. Free endopodal segment with longitudinal spinular row along inner proximal margin, and with some subdistal spinules; with two lateral, bare, inner spines (proximal one clearly longer), and five distal elements (two spines, and two geniculate elements, of which outermost fused to one small seta basally).

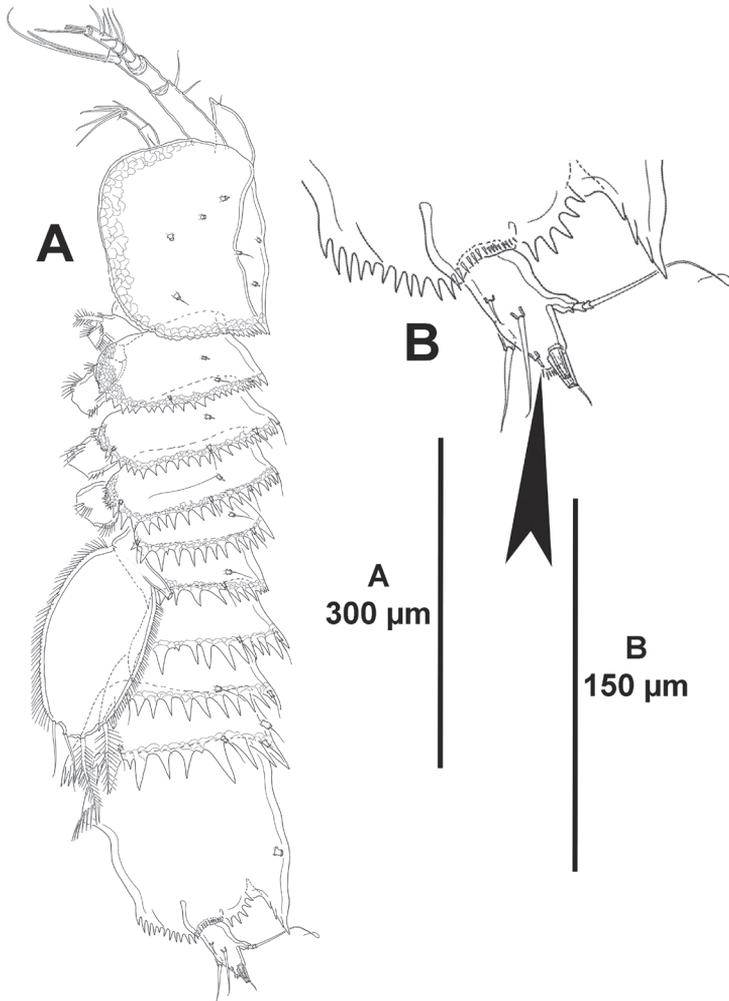


Figure 2. *Eurycletodes paraehippiger* sp. n., female holotype. **A** habitus, lateral **B** posterior part of anal somite and left caudal ramus, lateral.

Mandible (Fig. 5A). Coxa with some proximal spinules. Gnathobase formed by four tooth-like projections, and with a lateral small seta. Palp bi-segmented; first (basal) segment with spinules as shown, without basal seta, with one outer (exopodal) seta; second (endopodal) segment without surface ornamentation, with four bare setae, two of which fused basally.

Maxillule (Fig. 5B). Praecoxa with some proximal spinules; arthrite with six distal spines, one lateral and two surface setae. Coxal endite with three setae, one of which very strong and pinnate. Basis with some spinules, armed with one bare and one pinnate seta. Without endopod. Exopod represented by one pinnate seta.

Maxilla (Fig. 5C). Syncoxa with outer spinules, with two endites; proximal endite small, with one slender seta; distal endite with two slender setae and one strong spi-

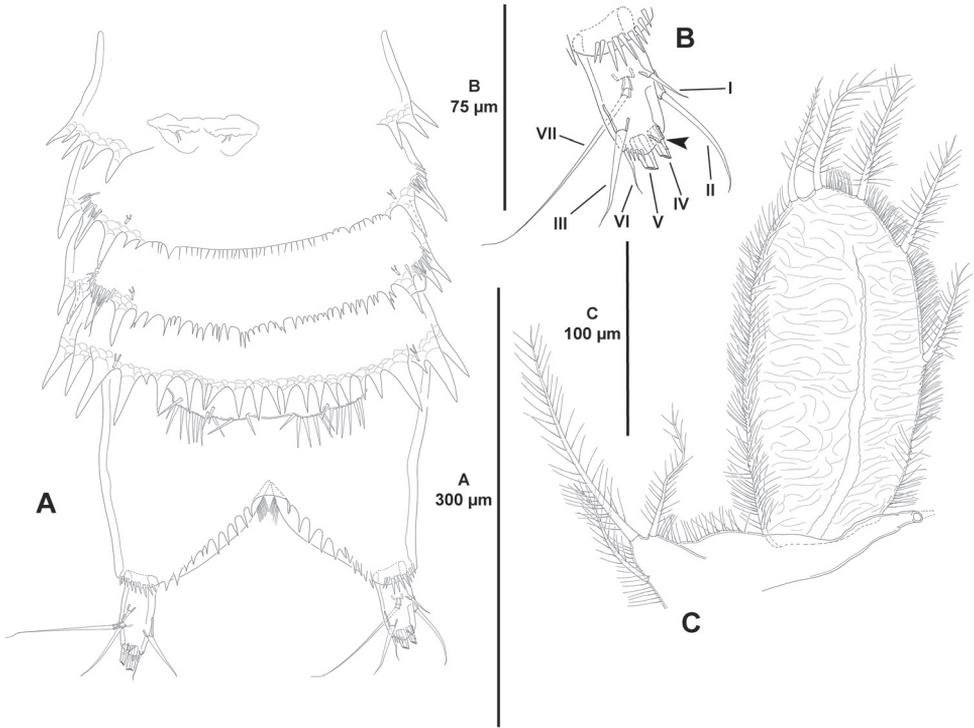


Figure 3. *Eurycletodes paraehippiger* sp. n., female holotype. **A** urosome, ventral (P5-bearing somite omitted) **B** caudal ramus, ventral (tube pore arrowed) **C** P5, anterior.

nulose element. Allobasis with some slender spinules, drawn out into strong pinnate claw, with two slender bare setae, one of which small and issuing from claw proximally, and a strong spinulose spine. Endopod uni-segmented, small, with two pinnate seta.

Maxilliped (Fig. 5D). Subchelate. Syncoxa with inner and outer tuft of slender spinules, with two setae. Basis with longitudinal outer spinules, unarmed. Endopod uni-segmented, fused to long, slender, pinnate claw.

P1 (Fig. 6A). Coxa with spinules as shown. Basis with outer and inner seta, the former stronger, with spinules at base of outer seta and at base of endopod. Exopod and endopod subequal in length. Exopod tri-segmented; segments with outer and apical spinules as shown; first and third segment subequal in length, second segment half as long as first segment; first segment without, second segment with one inner seta, third segment with two apical and three outer setae/spines. Endopod bi-segmented; first segment about 1.5 times as long as wide, with longitudinal row of outer, fine spinules, with one inner seta; second segment elongate, with one inner, two apical and one outer element, of which outer a spine.

P2-P4 (Figs 6B, 7A, B). Praecoxa presumably as in P2, with row of distal spinules. Coxa presumably as in P2 and P3, with one median, proximal row of minute spinules on anterior face, and long spinules close to outer margin on anterior and posterior face. Basis more or less triangular in shape with slender, long spinules along inner margin, with small

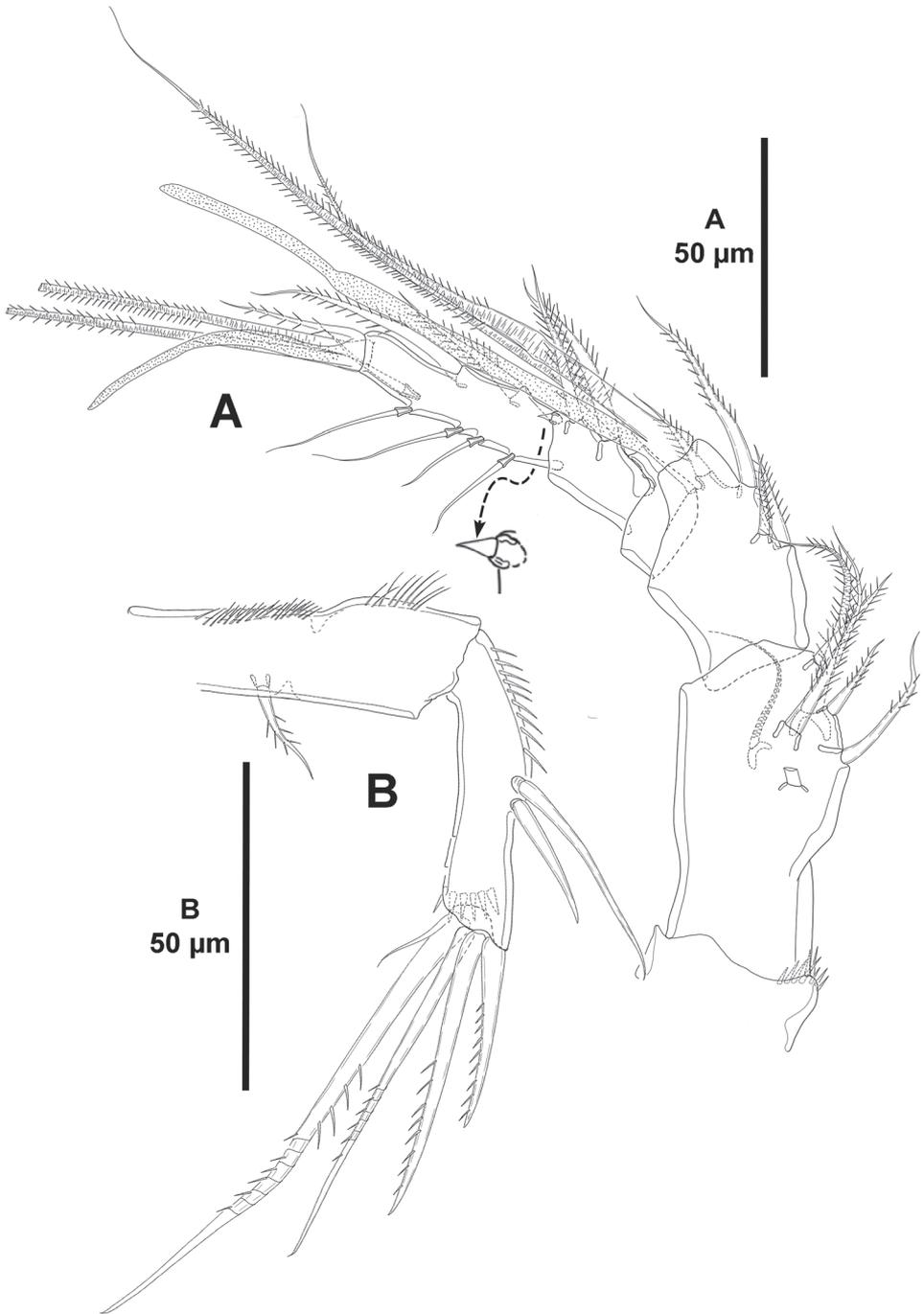


Figure 4. *Eurycletodes paraephippiger* sp. n., female holotype. **A** antennule **B** antenna.

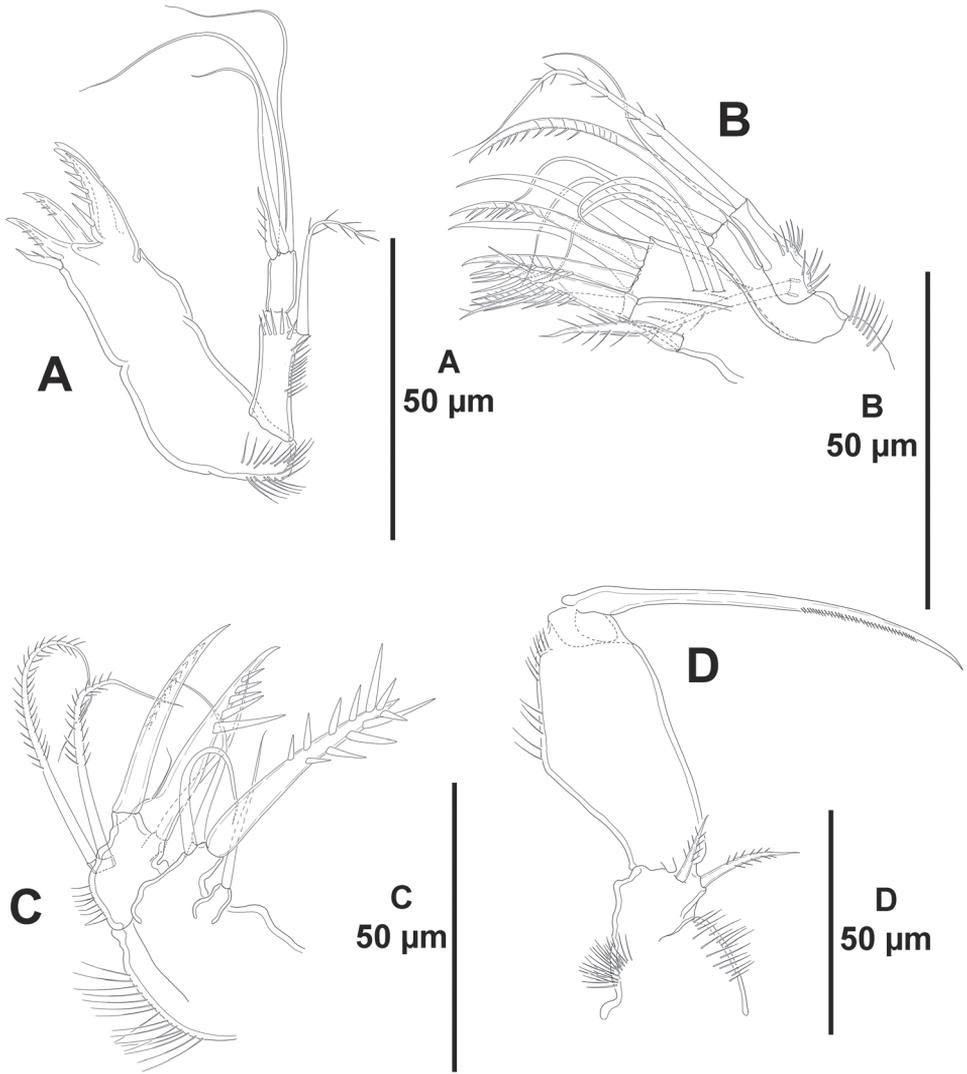


Figure 5. *Eurycletodes paraephippiger* sp. n., female holotype. **A** mandible **B** maxillule **C** maxilla **D** maxilliped.

spinules at base of endopod, of P2 without, of P3 and P4 with spinules at base of outer element; outer element spine-like in P2, a long, well-developed seta in P3 and P4. Exopod tri-segmented; first and third segment elongate, third segment slightly longer; second segment small, as long as broad; segments with inner slender, and outer strong spinules as shown; first segment with irregular outer margin; first and second segments with one inner seta; third segment of P2 and P3 with two inner well-developed setae, two apical setae and three outer spines, of P4 with two inner elements, of which proximal reduced and spine-like, two apical setae and three outer spines. Endopod bi-segmented; of P2 and P3 reaching insertion of proximal inner seta of EXP3, of P4 barely beyond apical margin of

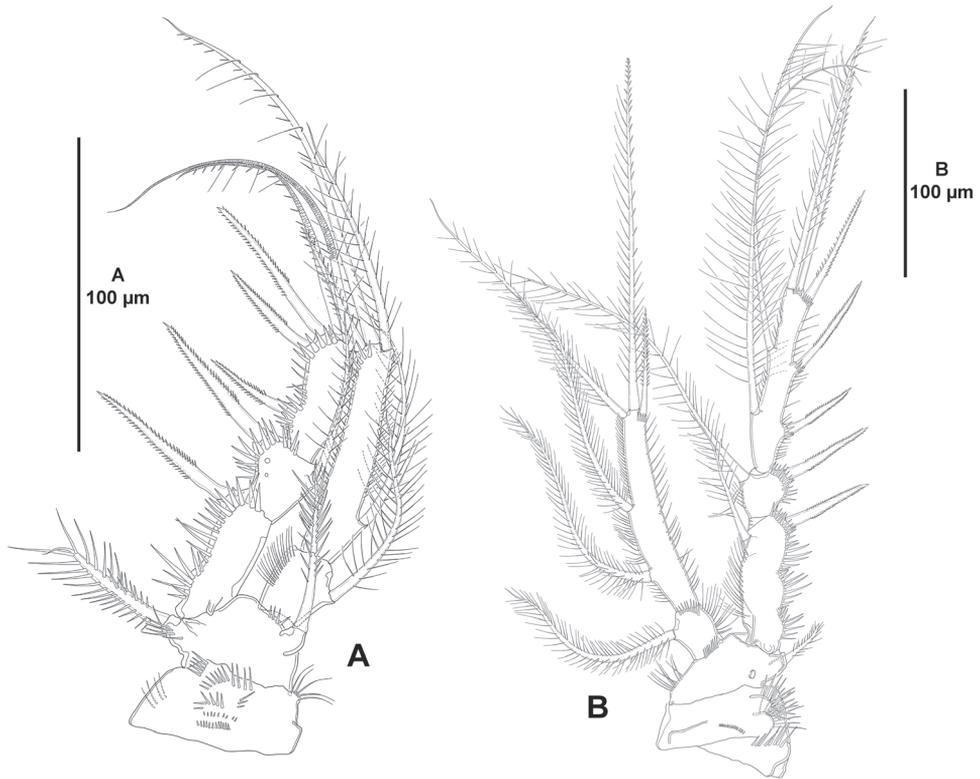


Figure 6. *Eurycletodes paraephipiger* sp. n., female holotype. **A** P1, anterior **B** P2, anterior.

EXP2; first segment small, 1.5 times as long as wide, with one inner seta; second segment elongate, of P2 and P3 with five (two inner and two apical setae, and one outer spine), of P4 with four setae/spines (one inner and two apical setae, and one outer spine).

Armature formula of P1-P4 as follows:

	P1	P2	P3	P4
EXP	I-0;I-1;III,2,0	I-1;I-1;III,2,2	I-1;I-1;III,2,2	I-1;I-1;III,2,1I
ENP	0-1;I,2,1	0-1;I,2,2	0-1;I,2,2	0-1;I,2,1

P5 (Fig. 3C). Baseoendopod and exopod distinct. Baseoendopod with outer basal seta on short setophore, endopodal lobe with three setae, of which median longest. Exopod large, foliose, ovate, with reticulated surface, about 2 times as long as wide, with five setae, with slender spinules along inner and outer margin, and between setae, except between inner most and adjacent element.

P6 (Fig. 3A). Very reduced, each leg represented by two small setae; genital field located medially, with one aperture.

Male unknown.

Etymology. The specific epithet and the Latin suffix *pār*, similar, refers to the resemblance between the new species and *E. ephippiger* Por, 1964. Gender masculine.

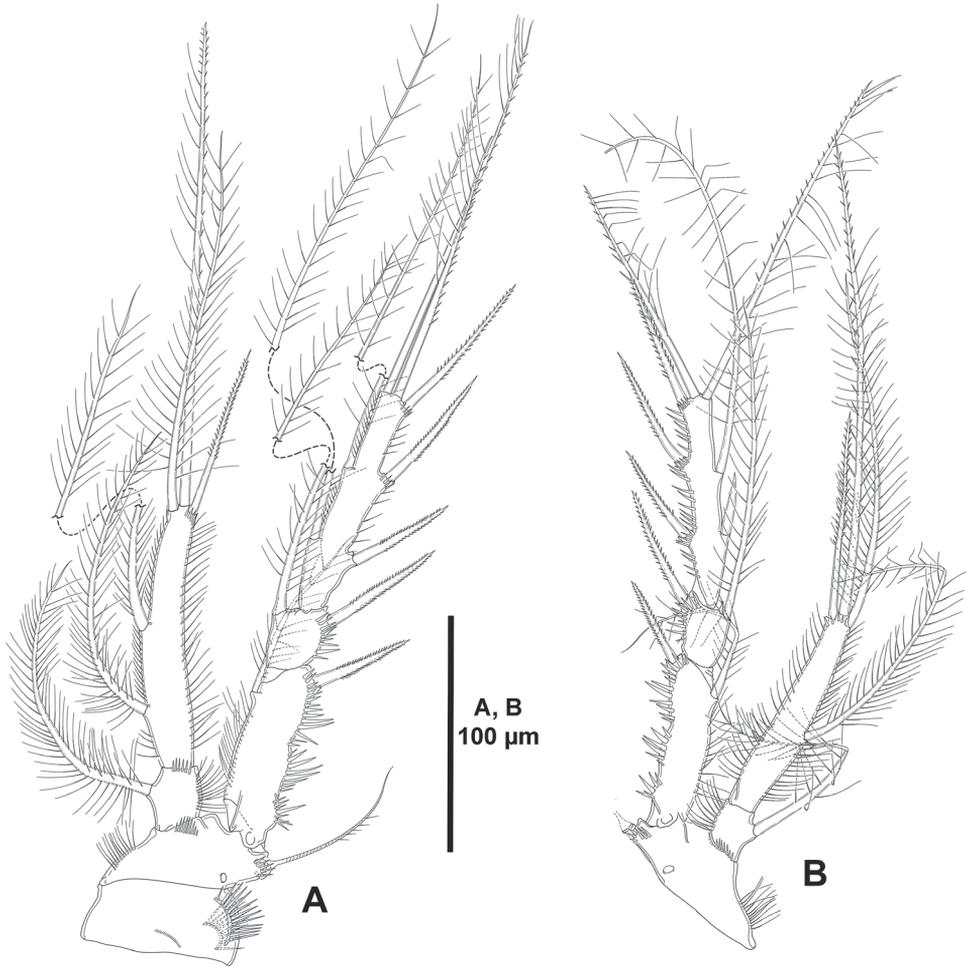


Figure 7. *Eurycletodes paraephippiger* sp. n., female holotype. **A** P3, anterior **B** P4 anterior.

Genus *Odiliaeletodes* Soyler, 1964

Type species. *Odiliaeletodes gracilis* Soyler, 1964, by monotypy.

Other species. *Odiliaeletodes secundus* sp. n.

***Odiliaeletodes secundus* sp. n.**

<http://zoobank.org/888683DE-2B29-41AC-AB0A-080E129471CD>

Material examined. One female holotype (ICML-EMUCOP-130207-02) dissected on seven slides; collected on February 13, 2007.

Type locality. Southern Trough of Guaymas Basin, Gulf of California, Mexico, 27°07'N, 110°53.4'W, depth 1642 m.

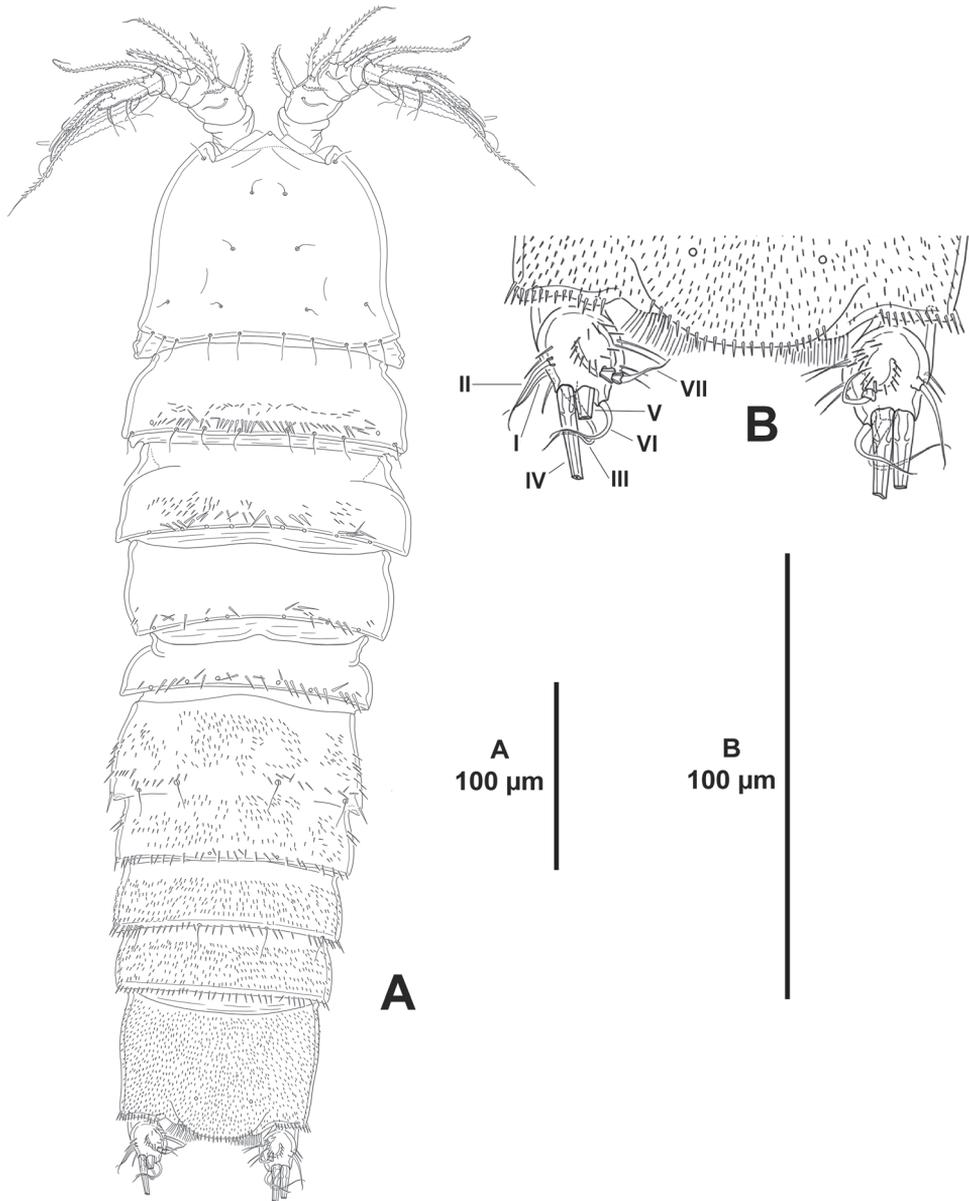


Figure 8. *Odiliaetodes secundus* sp. n., female holotype. **A** habitus, dorsal **B** posterior part of anal somite and caudal rami.

Description of female. *Habitus* (Figs 8A, 9A) cylindrical, without clear distinction between prosome and urosome. Total body length, 545 μm , measured from tip of rostrum to posterior margin of caudal rami.

Rostrum poorly-developed (Fig. 8A), fused to cephalothorax. I was unable to observe the two sensilla typically associated to the rostrum; the latter was probably fold-

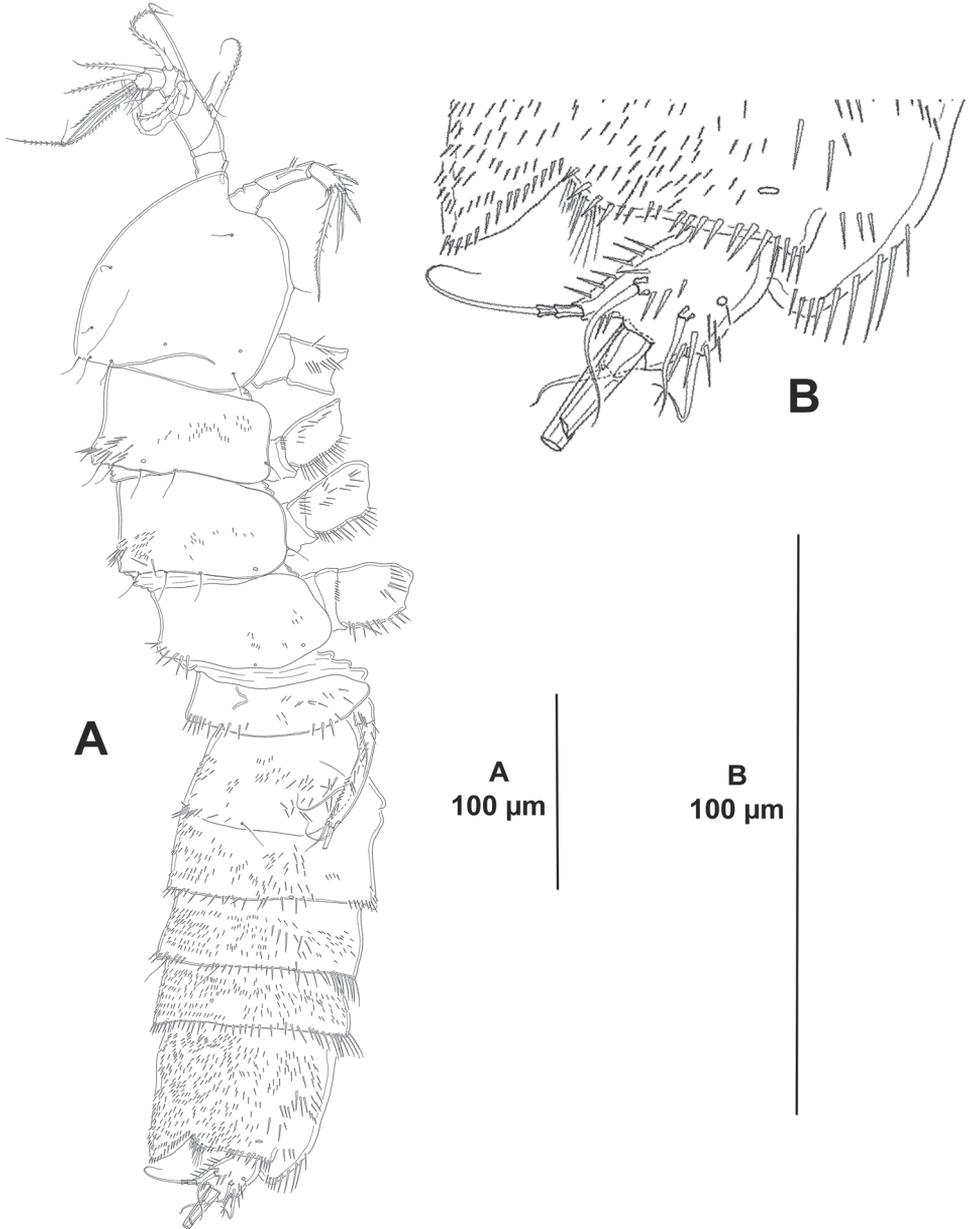


Figure 9. *Odiliacletodes secundus* sp. n., female holotype. **A** habitus, lateral **B** posterior part of anal somite and right caudal ramus.

ed downwards making the sensilla hard to see. The cephalothorax and free thoracic somites with smooth posterior margin (Figs 8A, 9A); with sensilla as shown, dorsal sensilla of P3–P4-bearing somites broken off in Fig. 8A; cephalothoracic integument with posterior rudimentary pleurotergite of fused P1-bearing somite.

Urosomites with smooth posterior margin (Figs 8A, 9A). P5-bearing somite with spinules along posterior margin dorsally, with some spinules laterally. Second and third urosomites fused dorsally and ventrally forming genital-double somite (Figs 8A, 10A), former division between both halves of genital-double somite indicated by dorsal transverse row of spinules close to posterior margin of anterior half (Fig. 8A) and by lateral chitinous rib (Fig. 9A); anterior half without spinules ventrally, posterior half with spinules along posterior margin dorsally and laterally (Figs 8A, 9A), ventrally with median spinular row flanked by two pores (Fig. 10A). Fourth and fifth urosomites (Figs 8A, 9A, 10A) covered with minute spinules dorsally, laterally and ventrally, with row of spinules close to posterior margin, of which, ventral spinules longer and stronger (Fig. 10A).

Anal somite as long as two preceding somites combined, square from dorsal and lateral view (Figs 8A, 9A), dorsal and lateral surface covered with minute spinules, ventral spinules less abundant and comparatively stronger (Fig. 10A), ventrally cleft medially, with spinules close to joint with caudal rami; anal operculum rounded, with

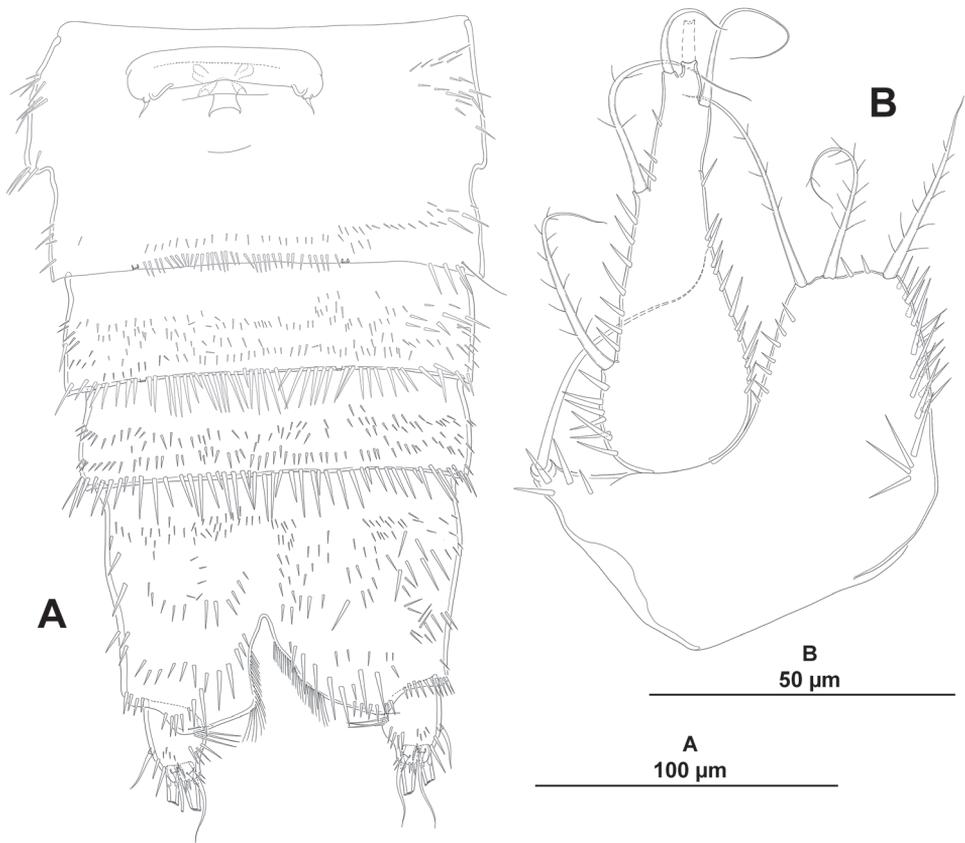


Figure 10. *Odiliaclerodes secundus* sp. n., female holotype. **A** urosome, ventral (P5-bearing somite omitted) **B** P5, anterior.

small spinules along posterior margin (Fig. 8A, B), associated surface ornamentation, two pores (seemingly without sensilla).

Caudal rami oval from dorsal (Fig. 8A, B) and ventral view (Fig. 10A), about 1.3 times as long as wide, rectangular from lateral view (Fig. 9B); with spinular ornamentation as shown; with seven setae as follows (Figs 8B, 9B): seta I ventral to seta II, aligned, subequal in length; seta III situated ventrally close to outer margin; setae IV and V longest; seta VI arising at inner distal corner; dorsal seta VII tri-articulated at base, issuing from median dorsal process.

Antennule (Fig. 11A). Hepta-segmented; surface of segments smooth except for two rows of spinules on first segment; second and last segments longest; sixth segment with two bipinnate elements and one slender, seemingly bare, short seta; last segment with eleven elements, five of which bi-articulated, three pinnate elements and acrothek, the latter consisting of one aesthetasc and two setae fused basally. Armature formula as follows: 1(0); 2(8); 3(3); 4(2+[1+ae]); 5(1); 6(3); 7(8+[acro]).

Antenna (Fig. 11B). Allobasis with two sets of inner spinules as shown; without abexopodal seta. Exopod represented by single seta. Inner margin of free endopodal segment with longitudinal spinular rows; with two lateral inner spines subequal in length, and five distal elements (two spines, and two geniculate elements, of which outermost fused to one seta basally).

Mandible (Fig. 12A). Coxa without spinular ornamentation. Gnathobase with three serrated teeth and a single spine, and with a lateral seta. Palp bi-segmented; first

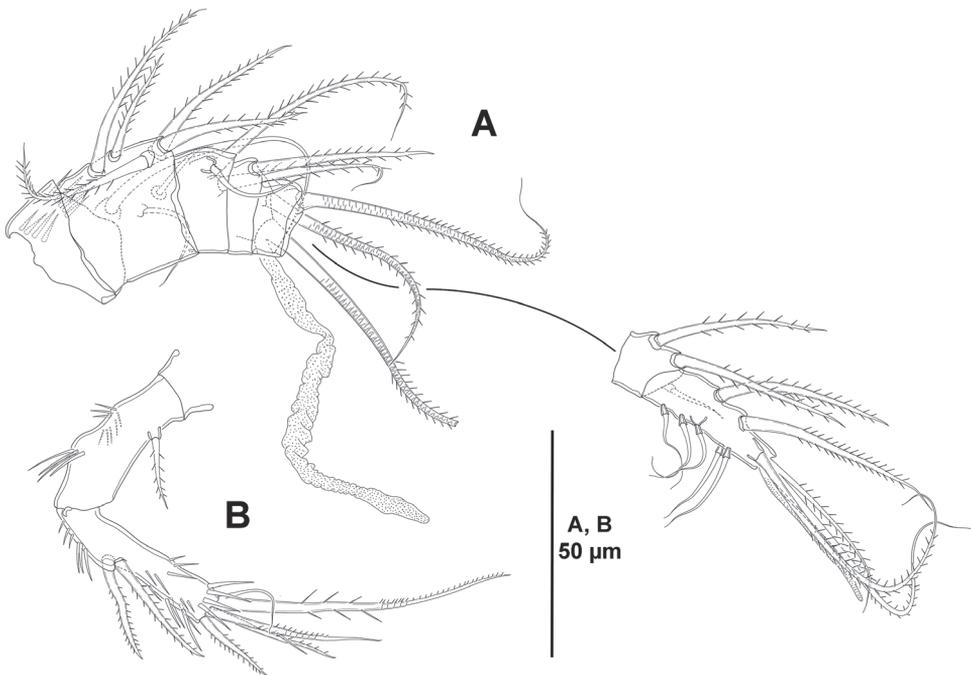


Figure 11. *Odiliacletodes secundus* sp. n., female holotype. **A** antennule **B** antenna.

(basal) segment with few subdistal spinules, with two basal setae, with one outer (exopodal) seta; second (endopodal) segment without surface ornamentation, with one lateral seta, and two pairs of distal setae fused basally.

Maxillule (Fig. 12B). Arthrite of praecoxa armed with six apical spines, one lateral element, and two surface setae. Other parts lost during dissection.

Maxilla (Fig. 12C). Syncoxa with outer spinules, and with two endites; proximal endite small, with one slender seta; distal endite with two slender setae and one strong spinulose element. Allobasis without spinular ornamentation, drawn out into strong pinnate claw, with one slender bare seta and a strong spinulose spine. Endopod represented by two setae.

Maxilliped (Fig. 12D). Subchelate. Syncoxa with several rows of spinules as shown, with two setae. Basis with longitudinal outer spinules, unarmed. Endopod uni-segmented, fused to claw, the latter with subapical spinules.

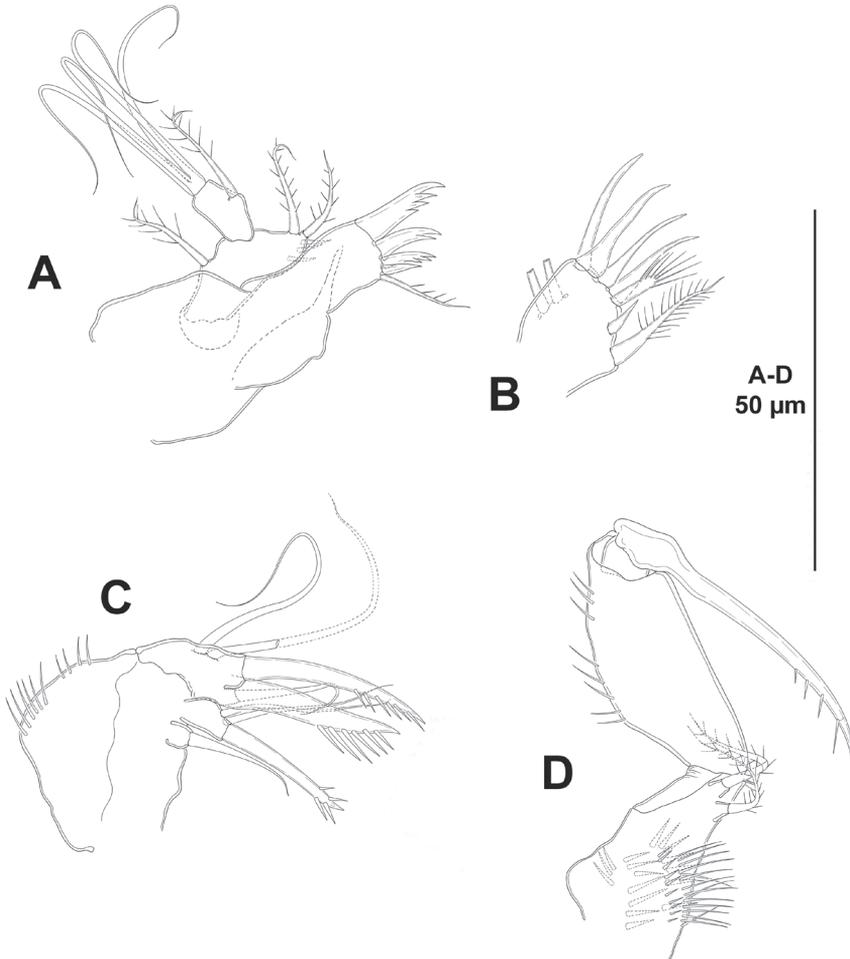


Figure 12. *Odiliactodes secundus* sp. n., female holotype. **A** mandible **B** arthrite of praecoxa of the maxillule **C** maxilla **D** maxilliped.

P1 (Fig. 13A). Coxa ornamented with spinules as shown. Basis with outer and inner seta, with spinules at base of outer and inner seta and between rami. Exopod and endopod subequal in length. Exopod tri-segmented; segments with outer and apical spinules as shown; first segment longest, second and third segments subequal in length; first segment without, second segment with one inner seta, third segment with two outer spines and two apical setae. Endopod bi-segmented; first segment about 1.3 times as long as wide, with outer and distal spinules on anterior face, and with some spinules on posterior face, with one inner seta; second segment elongate, 4 times as long as wide, and 1.7 times as long as first segment, with one inner element, two distal setae, and one outer spine.

P2-P4 (Figs 13B, 14A, B). Praecoxa with row of distal spinules. Coxa of *P2* and *P3* with one median row of spinules on anterior face, some spinules close to inner distal corner, and longitudinal row of spinules on anterior and posterior face, of *P4* presumably as in *P2* and *P3*. Basis with slender, long spinules along inner margin, with spinules between rami and at base of outer seta, the latter spine-like in *P2*, lost during dissection in *P3* and *P4*. Exopod tri-segmented; first and third segment elongate, third segment slightly longer than first; second segment small; first segment with inner slender, and

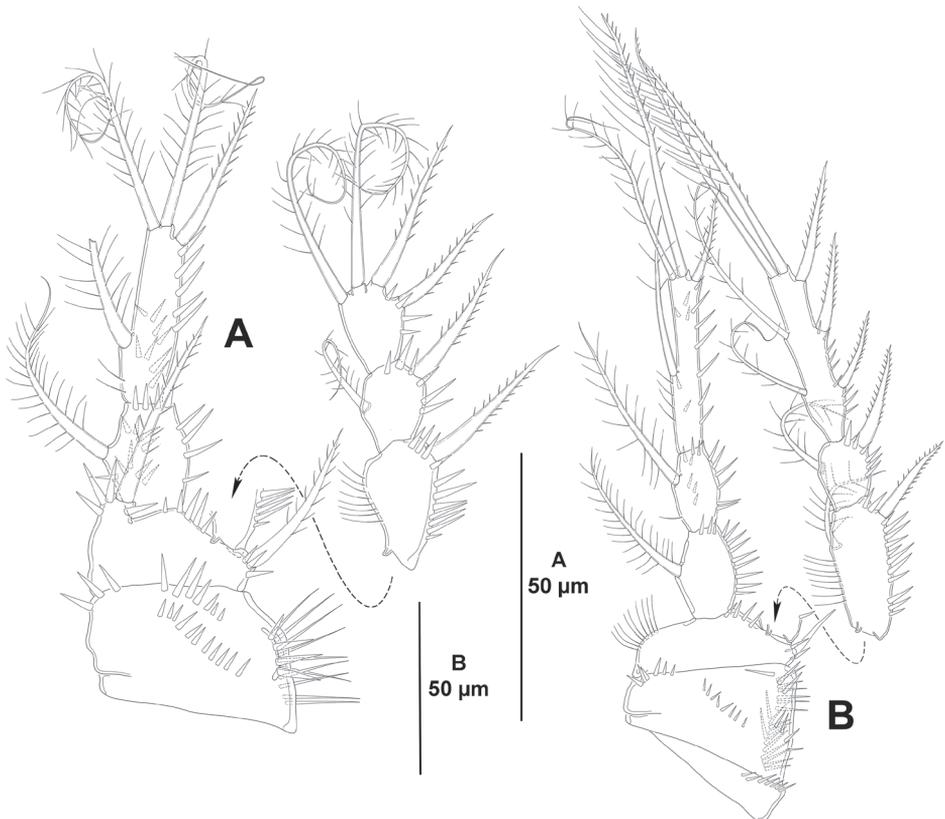


Figure 13. *Odiliacletodes secundus* sp. n., female holotype. **A** *P1*, anterior **B** *P2*, anterior.

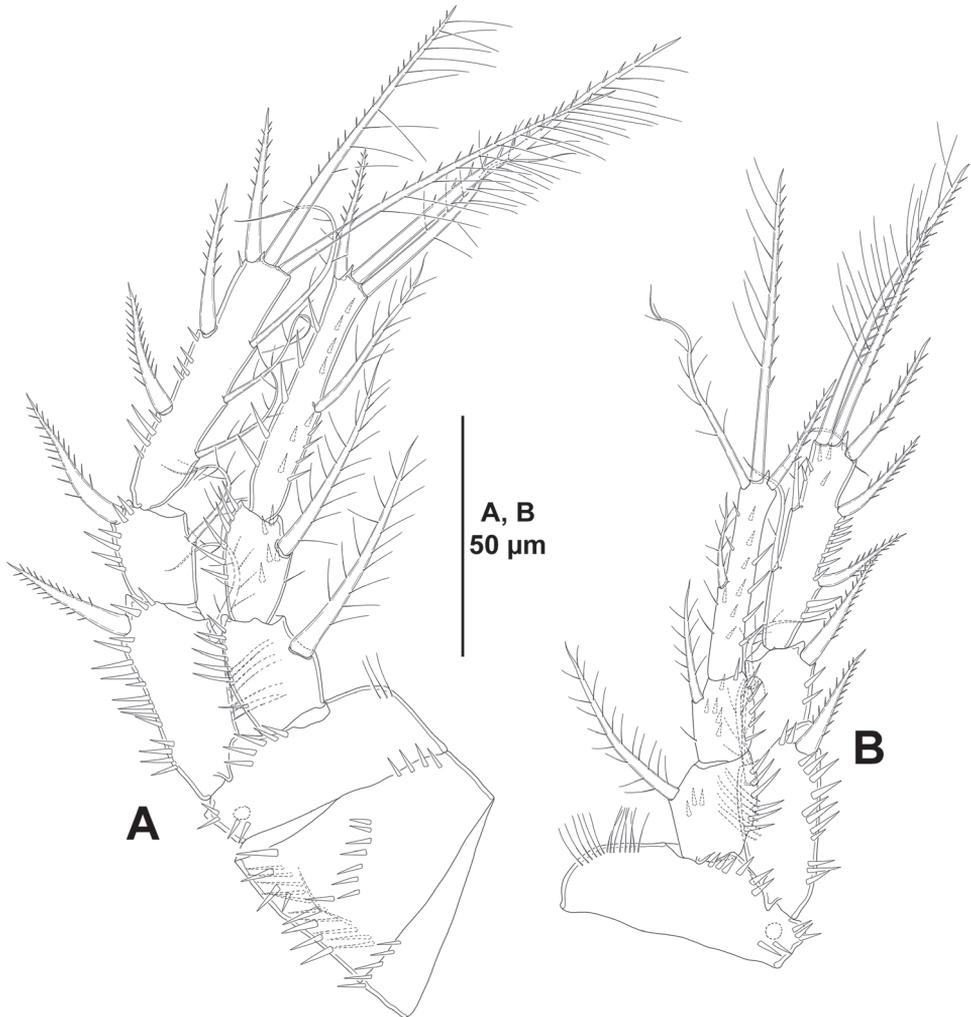


Figure 14. *Odiliaetodes secundus* sp. n., female holotype. **A** P3, anterior **B** P4, anterior.

outer strong spinules; second and third segments with outer spinules only; first and second segments with one inner seta; third segment of P2 and P4 with two inner setae, two apical elements, and three outer spines, of P3 with three inner elements, two apical elements, and three outer spines, outermost apical element on third exopodal segment of P2-P4 spine-like. Endopod tri-segmented; of P2 and P3 as long as exopod, of P4 reaching insertion of subdistal inner seta; first and second segments subequal in length; second segment elongate, longest, with one inner and two apical setae, and one outer spine.

Armature formula of P1-P4 as follows:

	P1	P2	P3	P4
EXP	I-0;I-1;II,2,0	I-1;I-1;III,1,2	I-1;I-1;III,1,3	I-1;I-1;III,1,2
ENP	0-1;I,2,1	0-1;0-1;I,2,1	0-1;0-1;I,2,1	0-1;0-1;I,2,1

P5 (Fig. 10B). Baseoendopod and exopod distinct. Baseoendopod with spinules at base of outer basal seta on short setophore, along inner and outer margin of endopodal lobe, and between innermost and adjacent endopodal seta; endopodal lobe reaching almost to middle of exopod, with three setae, of which outermost slightly longer, innermost and median seta subequal in length. Exopod elongated, triangular, 3 times as long as wide, with two outer, two apical and one inner seta, with inner and outer spinules as depicted, seemingly without tube-pores.

P6 (Fig. 10A) very reduced, each leg represented by one small seta; genital field situated proximally on first half of genital-double somite, with one aperture.

Male unknown.

Etymology. The specific epithet from the Latin *secundus*, second, refers to the second species of *Odilicletodes* reported to date. The name is an adjective in the nominative singular, gender masculine.

Discussion

The family Argestidae, composed of 18 genera, is a typical deep-sea taxon (Hicks and Coull 1983, Huys and Conroy-Dalton 1997, George 2004) commonly found in muddy substrates, where it is one of the dominant harpacticoid taxa (Hicks and Coull 1983, George 2004, 2008, Menzel and George 2009, Menzel 2011a). Yet, some species of *Argestes* Sars, 1910, *Argestigens* Willey, 1935, *Corallicletodes* Soyer, 1966, *Dizahavia* Por, 1979, *Eurycletodes*, *Fultonia* Scott, 1902, *Mesocletodes*, and *Parargestes* Lang, 1944 have been reported from depths ranging from a few meters (e.g., 4.5 m for *Dizahavia halophila* Por, 1979, 35 m for *Corallicletodes boutieri* Soyer, 1966, 20 m for *Eurycletodes* (*Oligocletodes*) *parasimilis*, to less than 200 m (e.g., 91.44 m for *Eurycletodes* (*O.*) *aculeatus* (50 fathoms, not 50 m as in George (2004)), 150 m for *Argestigens glacialis* Lang, 1936, 180 m for *Eurycletodes* (*O.*) *denticulatus*, 60 m–120 m for *Eurycletodes* (*Eurycletodes*) *lati-cauda*) (for a complete list of depth range of the species of Argestidae and references see George (2004: 257–259, Table 2); for the genus *Mesocletodes* see Menzel et al. (2011)).

Despite George (2011: 157, fig. 18) gave a preliminary list of tentative apomorphies for Argestidae, at present, no true apomorphies have been detected to prove the monophyletic status of this family (George 2004, 2008, 2011). More recently, Corgosinho and Martínez Arbizu (2010) suggested that the shape and armature of the maxilla could shed some light on the monophyly of the family. Some advances towards the monophyly of the family have been presented earlier. Huys and Conroy-Dalton (1997) suggested that the genus *Argestoides* Huys & Conroy-Dalton, 1997, currently relegated to *incertae sedis* within Argestidae, could eventually be accorded family rank occupying an intermediate position between the Ameiridae and Argestidae. George (2004) proved the monophyly of the genus *Bodinia* George, 2004, and relegated that genus as *incertae sedis* within Argestidae, and George (2008) proved the monophyly of the genus *Argestes*. Menzel and George (2009) showed the monophyly of *Mesocletodes* and of the *Mesocletodes abyssicola*-group, suggested that the loss of mouth parts in some

species of *Mesocletodes* might support a monophylum of derived Argestidae, and that the presence of bifid dorsal processes on some other species might support another monophyletic clade within the *M. abyssicola*-group. George (2011) proved the monophyly of the genus *Fultonia*, created the subfamily Argestinae Por, 1986 for *Fultonia* and *Argestes*, and transferred the genus *Parargestes* into the latter genus (the latter action was previously suggested by George (2008)). Menzel (2011a) demonstrated the monophyly of the genus *Eurycletodes*, and of its two subgenera, *E. (Eurycletodes)* and *E. (Oligocletodes)*, and allocated the enigmatic *E. profundus* Becker, 1979 into the subgenus *E. (Oligocletodes)*.

The genus *Eurycletodes*, with 27 species, including the new species presented herein, is one of the most species-rich genera of Argestidae, outnumbered only by the genus *Mesocletodes*, and can account for up to 25% of total abundance of the entire family in sediment samples (Menzel 2011a). The position of *Eurycletodes* inside Argestidae is far from resolved, but Menzel (2011a) hypothesised that this genus could occupy a derived position within Argestidae given the loss of setae and fusion or loss of segments. For a complete account on the taxonomic history of the genus see Menzel (2011a). Briefly, Lang (1944) subdivided the genus *Eurycletodes* into two subgenera, *E. (Eurycletodes)*, with *Cletodes laticauda* as its type species, and *E. (Oligocletodes)* Lang, 1944, with its type species *C. lata* T. Scott, 1892. The former was defined by the lack of inner armature on the P1 EXP2, and presence of three setae on the female P5 endopodal lobe. The latter was characterized by the presence of one inner seta on the P1 EXP2, but with two setae only on the female P5 endopodal lobe. In his monograph, Lang (1948) listed three species in the subgenus *E. (Eurycletodes)* (he was probably unaware of the description of *E. (E.) gorbunovi*), and ten species were recognized as members of *E. (Oligocletodes)*. Subsequent description of 13 new taxa of *Eurycletodes* raised the number to 27 species within the genus. No new species attributable to the subgenus *E. (Eurycletodes)* have been described since Lang's (1948) monograph, 11 of 13 new species have been attributed to the subgenus *E. (Oligocletodes)*, and two species, *E. profundus* and *E. ephippiger*, could not be attributed to any of these two subgenera (for example see Wells 2007).

Becker (1979) described *E. profundus* based on one female collected at 3820 m depth in Eastern Tagus Basin, off Portugal. Given the armature complement of the P1 EXP2 (with one inner seta) and P5 endopodal lobe (with only one seta) Becker (1979) suspected that his newly found species could well belong to a new subgenus of *Eurycletodes*. Later, to prove the monophyletic status of *Eurycletodes*, and to analyse the phylogenetic relationships within the genus, Menzel (2011a) gave three apomorphies [plesiomorphies] for *Eurycletodes*, viz. antennular segments III and IV fused [antennular segments III and IV separated], basal seta of the mandibular palp absent [basal seta of the mandibular palp present], and exopod of the mandibular palp reduced to one seta [exopod expressed]. Additionally, she considered the lack of inner armature of the P1 EXP2 as apomorphic for the subgenus *E. (Eurycletodes)* and did not accept Soyer's (1964) view regarding the apomorphic nature of the lack of inner armature of P4 EXP1 in *E. (Oligocletodes)* but considered this character potentially useful to characterize a monophylum within the genus. Also, she considered the presence of three

setae on the endopodal lobe of the female P5 (outer, medial and inner seta) as plesiomorphic for *Eurycletodes* but considered the presence of two setae only (innermost seta lost) as apomorphic for *E. (Oligocletodes)*. Under this scheme, she hypothesised further loss of the second terminal seta of the P5 endopodal lobe of *E. profundus* and attributed this species to *E. (Oligocletodes)*.

Por (1964) described *E. ephippiger* based on three females from Rosh Hanikra (Israel, Mediterranean Sea) collected at 475.5 m depth. That same year, Soyer (1964) described *E. knoeppfleri* Soyer, 1964 based on one female and one male from off Banyuls-Sur-Mer (Gulf of Lion, France, western Mediterranean) collected at 360 m and 390 m depth, respectively. Later, Bodin (1988), probably based on the strong similarities in the description of both species and on their presence in the Mediterranean, relegated *E. knoeppfleri* as synonym of *E. ephippiger*. As noted by Menzel (2011a), neither *E. ephippiger* can be attributed to *E. (Eurycletodes)* nor *E. (Oligocletodes)* because of the presence of an inner seta on P1 EXP2 and three setae on the female P5 baseoendopod, both considered as plesiomorphic for *Eurycletodes* in Menzel (2011a), nor could it be placed at a basal position within the genus because no synapomorphies have been detected for the subgenera *E. (Eurycletodes)* and *E. (Oligocletodes)*, to exclude *E. ephippiger*. The new species of *Eurycletodes* presented herein is undoubtedly related to the Mediterranean *E. ephippiger*. Based on Por's (1964) and Soyer's (1964) descriptions, both species can be separated by 1) the armature complement of the basis of the maxillule (basis with two setae, and exopod and endopod represented by one seta each in *E. ephippiger*, but with two basal and one exopodal seta in *E. paraephippiger* sp. n., 2) by the armature complement of the syncoxa of the maxilliped (with one seta only in the Mediterranean species, but with two setae in the new species), and 3) by the relative position of the anal operculum (situated in the middle of the anal somite in *E. ephippiger*, but posterior margin of anal operculum aligned with the anterior margin of caudal rami in the Mexican species). A more detailed re-description of *E. ephippiger* could shed some light on the position and relationships of the latter and the new species, within the genus *Eurycletodes*.

The genus *Odiliacletodes* is very rare and is known from a single female of its only species, *O. gracilis*, which was originally described from Banyuls-Sur-Mer (Gulf of Lion, France) at 610 m depth (Soyer 1964). More recently, Menzel and George (2012) reported on five adults and one copepodid attributable to *O. gracilis* and one adult of an undescribed species from the Eastern and Western Guinea Basin, and Northern Angola Basin (southeastern Atlantic), respectively, at 5000+ m depth. Soyer (1964) noted that *O. gracilis* could be related to the genus *Fultonina* given the bi-segmented endopod of P1 and the presence of up to four elements on the third endopodal segment of P2-P4. However, *Odiliacletodes* does not fit the diagnosis of the subfamily Argestinae by George (2011), to which the genus *Fultonina* belongs. As shown for *O. secundus* sp. n., the body surface of prosomites and first urosomite are not densely covered with small cuticular spinules (such surface ornamentation is present, to some extent on the genital-double somite and two succeeding somites, and only the anal somite is densely covered with small spinules), the sixth segment of the antennule possesses two bipinnate elements and one slender, seemingly naked, short seta, the latter homologous

to the long, strong seta found on the same segment of the antennule of *Fultonia* and *Argestes*, and the dorsal thoracic sensilla are of “normal” (small) length.

Itô (1983) observed a “membranous structure...inserted beneath posterior hyaline membrane of cephalothorax and seemingly covering over articulation membrane between cephalothorax and first free thoracic somite” (Itô 1983: 238) in several deep-sea cerviniid and ameirid species. He, Itô (1983), interpreted this structure as a possible rudimentary pleurotergite of the fused first thoracic somite. George (2008) considered the presence of such pleurotergite in *Argestes* as another diagnostic character for that genus, and George (2011) as another synapomorphy uniting *Argestes* and *Fultonia* into the subfamily Argestinae. George (2011: 152) hypothesised that such pleurotergite could be regarded as a secondarily evolved joint to enhance the copepod’s movement on or in the sediment, and that it could constitute another derived trait, but refrained to use that character in his phylogenetic analysis, since the nature of this structure is, at most, speculative. The presence of such pleurotergite in *O. secundus* sp. n. (its presence in *O. gracilis* still needs to be confirmed) indicates that it may have been evolved independently in several genera as an adaptation to life in or on the sediment.

Amongst the basal genera of Argestidae, *Argestes*, *Dizahavia* and *Fultonia* (see George 2008), only *Fultonia* (Argestinae; composed of four species) and *Odiliacletodes* (composed of two species), are known to bear a bi-segmented endopod of P1 and tri-segmented endopods of P2–P4. *Argestes sarsi* Smirnov, 1946 was described with a bi-segmented endopod of P1 and tri-segmented endopods of P2–P4. However, after a complex taxonomic history (see George 2011), *A. sarsi* has been relegated to species *incertae sedis* within Argestidae (Wells 2007, George 2011); this view has been adopted here. The position of *Odiliacletodes* within Argestidae remains unclear. However, Soyer’s (1964) view regarding the relationship between *Fultonia* (and consequently, with Argestinae) and *Odiliacletodes* seems possible given the evidence above. However, at this point, this is, at most, speculative, and despite *O. secundus* sp. n. fitting the generic diagnosis by Soyer (1964), no clear synapomorphies have been detected for the genus. The redescription of *O. gracilis* could shed some light on these issues. Finally, as noted above, *O. gracilis* and *O. secundus* sp. n. are similar in almost every respect, but can be separated by 1) the armature complement of the syncoxa of the maxilliped (with one seta only in *O. gracilis*, but two in *O. secundus* sp. n.), 2) by the structure of the antenna (with basis and one segmented exopod in *O. gracilis*, but with allobasis and exopod represented by one seta only in *O. secundus* sp. n.), and 3) by the presence of one inner seta on P4 EXP3 in *O. gracilis*, but with two inner elements in *O. secundus* sp. n. Intraspecific variability in deep-sea harpacticoids is greatly underestimated (George 2008, Menzel 2011b), but has been detected in the armature complement of P1 ENP and P2 ENP of *Neoargestes variabilis* Drzycimski, 1967 (Drzycimski 1967), and in P4 EXP3 of *A. angolaensis* (George 2008), and in the armature complement of P2–P4 ENP2 and surface ornamentation, among others, of *M. elmari* Menzel, 2011b (Menzel 2011b). Unfortunately, *O. gracilis* and *O. secundus* sp. n. are known from a single female each, and intraspecific variability of these two species could not be assessed.

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A synopsis of the scorpion fauna of French Guiana, with description of four new species

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Abstract

A synopsis is provided for all scorpion species collected in French Guiana, including thorough diagnoses and additional distributional records for each documented species. Four new species are also described in this paper (one *Ananteris* from northeastern Guiana, two *Auyantepuia* from central and northeastern Guiana and one *Hadrurochactas* from western Guiana), raising the total number of species described from French Guiana to 30. Most of the species are illustrated, geographical distribution maps are presented, and a key to the species is proposed.

Keywords

Ananteris, *Auyantepuia*, French Guiana, geographical distribution, *Hadrurochactas*, key, new scorpion species, synopsis

Introduction

Since the comprehensive work of Lourenço on the scorpion fauna of French Guiana published in 1983, several genera, species, and subspecies were described, few species were synonymized or transferred to other genera and additional collection material increased our knowledge of the geographical distribution of several species. Lourenço (1983) documented a total of 18 species belonging to eight genera and three families, while the present paper records a total of 30 species belonging to 12 genera and three

families. All new species described since 1983 were by Lourenço (eight species; 1997b, 2001b, 2003b, 2008, 2012c, 2012d, 2016a, 2016b), Lourenço and Monod (one species; 1999), Lourenço and Ythier (one species; 2011) and Ythier (five species; 2015 and present paper).

As discussed in several publications (Lourenço 1986, 1991, 2001a, 2016a, 2016b) the scorpion fauna of the Guianan region (Guayana floristic province as described in Mori 1991) presents a great complexity of endemism. The Guianan rainforests are one of the largest continuous tracts of relatively pristine lowland tropical rainforest in the World. This ecoregion is characterized by high species richness and local and regional endemism, as well as relatively intact ecological processes. Species assemblages are shared with the Amazon and Orinoco basins, and with the Guianan highlands and Tepuy formations, and the ecoregion is thus a convergence zone for species diversity. The degree of endemism for the scorpion species present in the region is high, with 21 of the 30 species presented in this paper possibly endemic to French Guiana. Despite its reasonably small size of 83,000 km², French Guiana is a biodiversity hotspot presenting remarkable scorpion diversity and the present paper probably represents only a small part of the scorpion fauna actually present, since most of the region has not been studied yet and several specific areas with potentially high degrees of endemism (e.g., inselbergs) have only been recently started to be studied. For several sections of the lowland rainforest such as the canopy, knowledge of the scorpion fauna is also still almost nonexistent.

French Guiana has a wide range of habitats (Fig. 33). Most of its land area (90%) is covered by lowland tropical rainforest (Fig. 34) interspersed with forests of higher altitude (Fig. 35), 95% of these rainforests consisting of primary forest. Along the coast there are also patches of dry forest including white sand forests (Fig. 36) and savannas (Fig. 37), as well as many types of wetlands including mangroves and swamps. While several species are commonly found in many different habitats across French Guiana (e.g., *T. obscurus*, *T. silvestris*, *B. gervaisii*, *B. granulatus*) including zones impacted by human activities, some others remain endemic elements from specific ecosystems like e.g., coastal dry forests or savannas (e.g., *A. elisabethae*, *A. kalina* sp. n., *J. pintoi kouroensis*, *O. heurtaultae*, *T. mana*) or French Guiana massifs represented by inselbergs (e.g., *A. polleti*, *A. sabineae*, *S. mitaraka*).

Materials and methods

Material presented herein is deposited in the following collections:

MNHN	Muséum national d'Histoire naturelle, Paris, France,
MHNG	Muséum d'histoire naturelle, Geneva, Switzerland,
EYPC	Eric Ythier Private Collection, Romanèche-Thorins, France,
RNA	Reserve Naturelle de l'Amana, Awala-Yalimapo, French Guiana, France.

With the exception of the specimens deposited in the MHNG, most of the presented material was examined by the author. For each species documented in this work, geographical distribution is presented based on the studied material (see material section for each species and corresponding distribution maps in Figs 31, 32). Distribution data for specimens not deposited in one of the above-mentioned collections was not taken into account.

Thorough diagnoses are presented for the species described previously to this note, extracted from original descriptions and in some cases translated from French, German, Spanish, and Portuguese. For detailed descriptions or additional information, readers can refer to the publications indicated in the references. Photographs of alive or fixed specimens are presented, when available. Measurements and illustrations were made using a Motic DM143 digital stereo-microscope together with a Nikon D810 camera and a Wacom Intuos drawing tablet. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations are those developed by Vachon (1974) and the morphological terminology mostly follows Hjelle (1990).

List of scorpion species from French Guiana

Family Buthidae C. L. Koch, 1837

Genus *Ananteris* Thorell, 1891

- Ananteris coineaui* Lourenço, 1982 (*)
- Ananteris elisabethae* Lourenço, 2003 (*)
- Ananteris guyanensis* Lourenço & Monod, 1999 (*)
- Ananteris intermedia* Lourenço, 2012 (*)
- Ananteris kalina* sp. n. (*)
- Ananteris polleti* Lourenço, 2016 (*)
- Ananteris sabineae* Lourenço, 2001 (*)

Genus *Isometrus* Hemprich & Ehrenberg, 1828

- Isometrus maculatus* (DeGeer, 1778)

Genus *Jaguajir* Esposito, Yamaguti, Souza, Pinto da Rocha & Prendini, 2017

- Jaguajir pintoii kourouensis* (Lourenço, 2008)

Genus *Microananteris* Lourenço, 2003

- Microananteris minor* Lourenço, 2003 (*)

Genus *Tityus* C. L. Koch, 1836

- Tityus (Tityus) gasci* Lourenço, 1981
- Tityus (Archaeotityus) mana* Lourenço, 2012 (*)
- Tityus (Atreus) obscurus* (Gervais, 1843)
- Tityus (Archaeotityus) silvestris* Pocock, 1897

Family Chactidae Pocock, 1893

Genus *Auyantepuia* Gonzalez-Sponga, 1978

- Auyantepuia aluku* sp. n. (*)

- Auyantepuia aurum* sp. n. (*)
Auyantepuia fravalae Lourenço, 1983 (*)
Auyantepuia gaillardi Lourenço, 1983 (*)
Auyantepuia kelleri Lourenço, 1997 (*)
Auyantepuia laurae Ythier, 2015 (*)
Auyantepuia sissomi Lourenço, 1983 (*)
 Genus *Broteochactas* Pocock, 1893
Broteochactas delicatus (Karsch, 1879)
 Genus *Brotheas* C. L. Koch, 1837
Brotheas gervaisii Pocock, 1893
Brotheas granulatus Simon, 1877
 Genus *Guyanochactas* Lourenço, 1998
Guyanochactas flavus Lourenço & Ythier, 2011 (*)
Guyanochactas gonzalezspingai (Lourenço, 1983) (*)
 Genus *Hadrurochactas* Pocock, 1893
Hadrurochactas cristinae sp. n. (*)
Hadrurochactas schaumii (Karsch, 1880)
 Genus *Spinochactas* Lourenço, 2016
Spinochactas mitaraka Lourenço, 2016 (*)
 Family Hormuridae Laurie, 1896
 Genus *Opisthacanthus* Peters, 1861
Opisthacanthus heurtaultae Lourenço, 1980 (*)

Total 30 species. 21 (*) are possibly endemic elements to French Guiana. Other species also occur in Brazil (*J. pintoii*, *T. gasci*, *T. obscurus*, *T. silvestris*, *B. delicatus*, *B. gervaisii*, *B. granulatus*), Peru (*T. gasci*, *T. silvestris*), Ecuador (*T. gasci*), Suriname (*T. obscurus*, *T. silvestris*, *H. schaumii*), Guyana (*R. pintoii*, *H. schaumii*), Venezuela (*H. schaumii*) or have cosmopolitan distribution (*I. maculatus*).

Taxonomic treatment

Family BUTHIDAE C. L. Koch, 1837

Genus *Ananteris* Thorell, 1891

Ananteris coineaui Lourenço, 1982

Fig. 1

References. Lourenço 1982, Lourenço and Cuellar 1999, Fet et al. 2000, Lourenço 2003a.

Material. Downstream from Saut Pararé on Arataye river, Approuague tributary, one female (holotype), MNHN-RS-8504, J.P. Gasc coll., IV-V/1979. Right bank of



Figure 1. *Ananteris coineai*, female holotype from Saut Pararé (photo MNHN / E.-A. Leguin).

Arataye river, downstream from Saut Pararé, in a palm tree (*Astrocaryum paramacca*) in forest, two females (paratypes), J.P. Gasc coll., I/1981. Saül, in a palm tree, one female, deposited in the MNHN, W. Lourenço leg.

Diagnosis. Species of medium to large size compared to the average size of the other species within the genus (32.7 mm in total length for female holotype). General coloration dark yellow with brown to dark brown variegated pigmented zones. Carapace dark yellow with dark brown spots mainly on the anterior edge; lateral and posterior edges with less spots; eyes surrounded by black pigment. Mesosoma dark yellow with confluent brownish spots on all tergites; the VII with a triangular brownish spot; the lateral edges with square spots with the center lighter. Venter yellow ochre to brownish, with dark brown spots on edges of sternites V to VII, especially on the VII. Metasomal segments I to III reddish yellow, IV and V reddish; one triangular brownish spot on I to IV, dorsally. Vesicle reddish yellow, lighter than metasomal segment V; base of aculeus yellowish, tip reddish. Chelicerae yellow with a dark brown spot anteriorly, at the base of fingers; fingers reddish black. Pedipalps dark yellow; femur, patella, and chela strongly marked with dark brown spots; chela almost entirely dark brown; fingers reddish yellow. Legs reddish yellow, with numerous dark brown spots. Carapace with moderately marked granulation; anterior margin almost straight; all furrows moderate to weak. Tergites with moderately marked granulation, similar to that of carapace, better marked posteriorly; median carina well-marked on all tergites. Pectinal tooth count 16–16 to 17–17 in female. Sternites with spiracles linear. Metasomal segments with 10-10-8-8-5 crenulate carinae; intercarinal spaces strongly granular on all segments; segment V rounded. Vesicle with some granulation laterally; subaculear tooth strongly marked. Pedipalp femur pentacarinata; patella and chela with weak to vestigial carinae; movable fingers with seven linear rows of granules.

***Ananteris elisabethae* Lourenço, 2003**

References. Lourenço 1983, Lourenço 1993, Lourenço 2003a, Lourenço 2016b.

Material. Kourou, in the forest, one male (holotype), MNHN-RS-8086, mission M. Boulard & P. Pompanon coll., 3-7/VIII/1975.

Diagnosis. Species of small size when compared with the average size of the other species of the genus (17.7 mm in total length for male holotype). Generally pale yellow without any spots or pigmented zones on the body and its appendages. Carapace yellowish; only the eyes surrounded by black pigment. Mesosoma yellowish with some pale reddish zones on the posterior edges of tergites. Venter pale yellow. All segments of metasoma yellowish; segment V slightly darker. Vesicle yellowish and aculeus yellowish. Chelicerae and teeth globally yellowish. Pedipalps yellowish overall, including the rows of granules on the dentate margins of the fingers. Legs yellowish. Carapace moderately to weakly granular; anterior margin weakly emarginated; all furrows moderate to weak. Tergites moderate to weakly granular; median carina moderate to weak in all tergites; tergite VII pentacarinata. Pectinal tooth count 16–16 in male. Sternites weakly granular with moderately elongate stigmata; VII with vestigial carinae. Metasomal segments with 10-8-8-8-5 crenulate carinae; intercarinal spaces weakly granular; segment V rounded. Telson elongated and weakly granular with three ventral carinae; the latero-ventral vestigial; aculeus short and moderately curved; subaculear tooth strong and spinoid. Pedipalp femur pentacarinata; patella and chela with a few vestigial carinae; internal aspect of patella with 7–8 spinoid granules; all aspects weakly granular, almost smooth; fixed and movable fingers with six almost linear rows of granules; two small accessory granules present at the base of each row. Leg tarsus with very numerous fine median setae ventrally; tibial spurs strongly developed on legs III and IV.

***Ananteris guyanensis* Lourenço & Monod, 1999**

Fig. 2

References. Lourenço and Monod 1999, Fet et al. 2000, Lourenço 2003a, Lourenço 2016b.

Material. Saint Eugène, rainforest, in rotten log, one female (holotype), deposited in the MHNG, R. Boistel leg., 15/IV/1998. Mana, near Saut Sabbat, Gîte Angoulême, one male, deposited in the EYPC, EY0106, J. Chevalier & B. Tan coll., 04/XI/2017. Mana, near Saut Sabbat, Gîte Angoulême, one female, deposited in the RNA, J. Chevalier & B. Tan coll., 07/I/2018.

Diagnosis. Species of medium size when compared with the average size of the other species of the genus, ranging from 25 to 30 mm in total length. General coloration yellowish brown, symmetrically marbled with dark reddish brown, producing an overall spotted appearance. Carapace yellowish brown and heavily spotted;



Figure 2. *Ananteris guyanensis*, female from Saut Sabbat (photo J. Chevalier).

eyes surrounded with black pigment. Mesosoma yellowish brown with confluent brown stripes and two longitudinal yellowish stripes. Venter yellowish with spots only on sternite VII. Metasomal segments I to V yellowish brown, with numerous brown spots; segments IV and V reddish, darker than the others. Vesicle reddish yellow without spots, but with some darker areas over the carinae. Chelicerae yellowish without variegated spots over their entire surface, and with only a dark thin zone at the base of the fingers; fingers reddish. Pedipalps dark brown with spots on the femur and patella; chelae yellowish; fingers brownish. Legs brownish with fuscous spots. Carapace feebly to moderately granular; anterior margin with a slight median concavity; all furrows moderate to feeble. Tergites moderately granular; median carina moderate to strong in all tergites. Pectinal tooth count 17–16 in female. Sternites almost smooth with moderate elongate stigmata; VII with four vestigial carinae. Metasomal segments with 10-10-10-8-5 crenulate carinae; intercarinal spaces moderately granular; segment V rounded. Telson moderately granular with one ventral carina and with a fairly short and moderately curved aculeus; subaculear tooth strong and spinoid. Pedipalp femur pentacarinata; patella and chelae with a few carinae but moderately crenulate; internal side of patella with only vestigial spinoid granules; all sides moderately to feebly granular; movable fingers with seven oblique rows of granules; only one accessory granule present at the base of each row. Leg tarsus with very numerous fine median setae ventrally; tibial spurs strongly developed on legs III and IV.

***Ananteris intermedia* Lourenço, 2012**

Fig. 3

References. Lourenço 2012c.

Material. St. Jean du Maroni, road to Saint Laurent, primary forest, winkler, one male (holotype), deposited in the MNHN, W. Lourenço coll., 12/VI/1987.

Diagnosis. Very small species when compared with the average size of the other species of the genus (9.3 mm in total length for male holotype). General coloration yellow to pale yellow with carapace and tergites intensely marbled with dark brown spots, producing an overall spotted appearance. Carapace yellow, almost totally covered with brown spots; eyes surrounded by black pigment. Mesosoma yellowish brown with three longitudinal stripes. Venter pale yellow with infuscations only on sternite VII. Metasomal segments I to V yellow to pale yellow, with several brown annular spots distally; segment V with better marked spots. Vesicle yellow without spots; aculeus yellow at the base and reddish at the tip. Chelicerae pale yellow with diffused variegated spots over their entire surface; better marked anteriorly; fingers pale yellow with reddish teeth. Pedipalps pale yellow, only slightly infuscate on the femur and patella; chela paler than patella; fingers pale yellow with the rows of granules slightly reddish. Legs yellow, densely marked with brownish spots. Carapace weakly granular to smooth; anterior margin almost straight; all furrows weak. Tergites weakly granular to smooth; median carina weak in all tergites. Pectines rather long; pectinal tooth count 17–18 in male. Sternites smooth with short semi-oval to round spiracles; VII with a few granulations and vestigial carinae. Metasomal segments with 10-10-8-8-5 weakly crenulate carinae; intercarinal spaces weakly granular to smooth. Telson with a fusiform shape, smooth with one vestigial ventral carina; aculeus moderately long and weakly curved; subaculear tubercle extremely reduced to vestigial. Pedipalps rather short; femur pentacarinat, with carinae weakly marked; patella with a few vestigial carinae; chela smooth; internal side of patella with some vestigial granules; all sides weakly granular, almost smooth; movable fingers with six almost linear rows of granules; two accessory granules present at the base of each row; extremity of movable fingers with three accessory granules. Leg tarsus with very numerous fine median setae ventrally; tibial spurs weakly developed on legs III and IV.

***Ananteris kalina* sp. n.**

<http://zoobank.org/B08E25E5-D903-4C47-94F8-508E5BE467EF>

Figs 4–5

Type material. French Guiana, Mana, path of the Forêt des Sables Blancs, one male (holotype), deposited in the MNHN, J. Chevalier coll., 13/I/2018. French Guiana, Mana, path of the Forêt des Sables Blancs, one male (paratype), deposited in the EYPC, EY0107, J. Chevalier & B. Tan coll., 08/VII/2017.



Figure 3. *Ananteris intermedia*, male holotype from St. Jean du Maroni (photo MNHN / E.-A. Leguin; 2012 Elsevier Masson SAS)

Etymology. The specific name refers to the ethnic group Kali'na, living in the area where the new species was found.

Diagnosis. Total length 18.9 mm for male holotype (see morphometric values after the description). General coloration dark yellow, intensely marked with brownish variegated spots. Chelicerae pale yellow with variegated dark brown spots over the entire surface. Fingers with six rows of granules. Pectines of males holotype and paratype rather long with 16–17 and 17–17 teeth, respectively; female unknown. Telson with a fusiform shape and strong and spinoid subaculear tubercle. Carinae and granulation moderately to strongly marked. Metasomal segments with 10-8-8-8-5 weakly crenulate carina. Trichobothriotaxy, type A- β .

Description based on male holotype. Coloration. Generally dark yellow with brown to dark brown variegated pigmented zones on the carapace, the tergites, and the appendages. Carapace dark yellow with dark brown spots on anterior, lateral and posterior edges; eyes surrounded by black pigment. Mesosoma dark yellow with confluent brown to dark brown zones forming three longitudinal stripes, one brownish surrounded by two reddish yellow ones. Venter yellow to pale yellow; coxapophysis and sternites with light brown zones on lateral edges. Metasomal segments I to V dark yellow with brown to dark brown variegated pigmented zones. Vesicle reddish yellow marbled with light brown zones; base of aculeus yellow, tip reddish. Chelicerae pale yellow with variegated dark brown spots over the entire surface; fingers yellowish with dark brown spots; teeth reddish yellow. Pedipalps yellowish, all segments almost entirely covered with brownish spots, dark brown on dorsal side and light brown on ventral side; tip of fingers pale yellow. Legs yellowish, intensely marked with brown to dark brown spots.

Morphology. Carapace with moderately to strongly marked granulation; anterior margin almost straight, with a small median concavity; anterior median superciliary



Figure 4. *Ananteris kalina* sp. n., male holotype from Mana. Habitus, dorsal and ventral aspect.

and posterior median carinae weak or absent; all furrows moderate to weak; median ocular tubercle distinctly anterior to the center of carapace; median eyes separated by approximately half of one ocular diameter; three pairs of reduced lateral eyes. Tergites with moderately to strongly marked granulation, similar to that of carapace; median carina moderately to weakly marked on all tergites, better marked posteriorly; tergite VII pentacarinata. Sternum subpentagonal. Pectines rather long; pectinal tooth count 16–17 in male holotype (17–17 in male paratype); basal middle lamellae of pectines not dilated; fulcra absent. Sternites almost smooth, only VI and VII slightly granular; spiracles rather short, semi-oval; setation moderate; sternite VII with vestigial carinae; genital operculum divided longitudinally, each plate more or less suboval in shape. Metasomal segments with 10-8-8-8-5 weakly crenulate carinae; intercarinal spaces moderately to

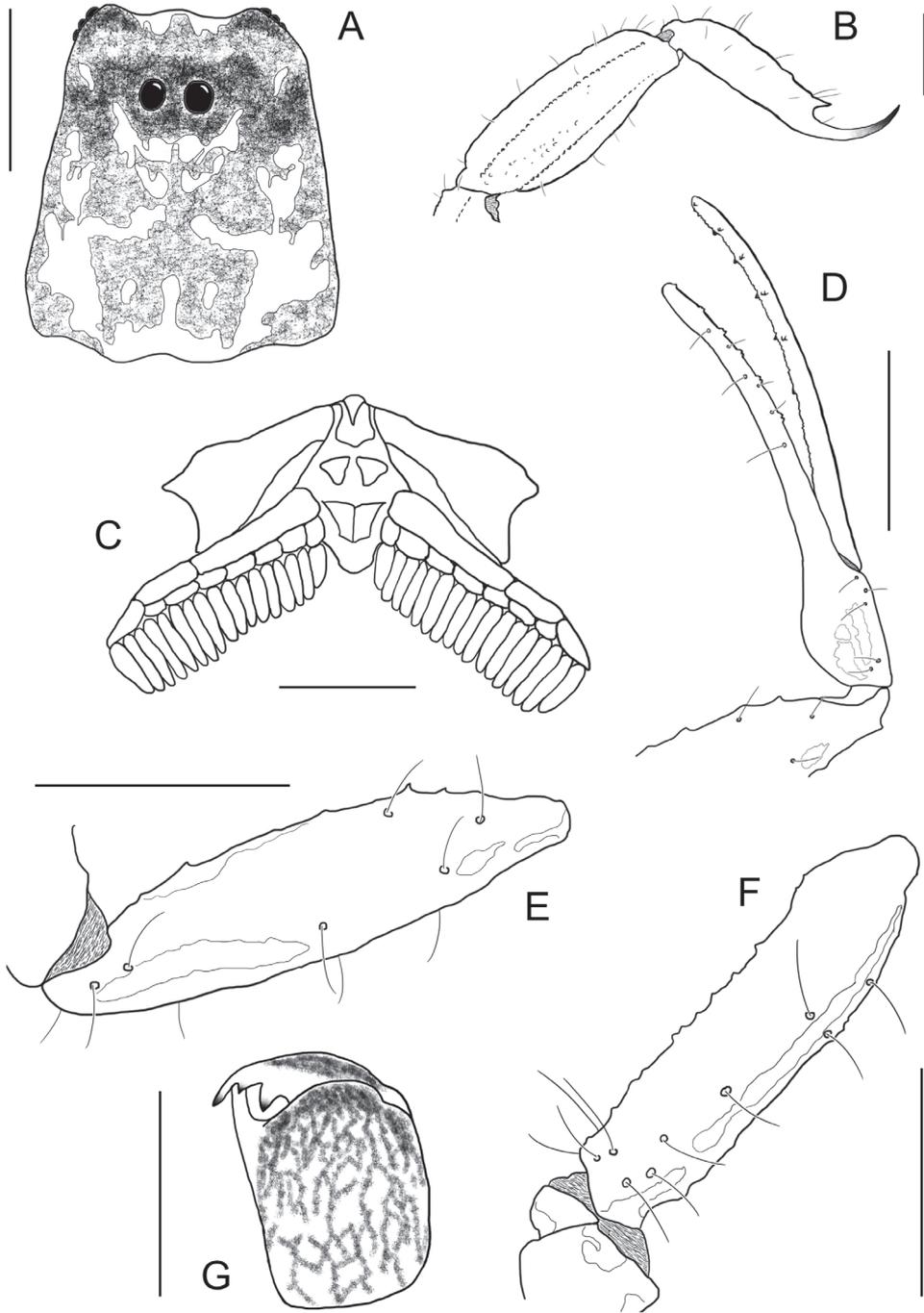


Figure 5. *Ananteris kalina* sp. n. male holotype. **A** Carapace **B** Metasomal segment V and telson, lateral aspect **C** Sternum, genital operculum, and pectines **D** Chela, dorso-external aspect **E** Patella, dorsal aspect **F** Femur, dorsal aspect **G** Chelicera. Scale bars: 1 mm except chelicera (**G**) 0.5 mm.

weakly granular; segment V slightly rounded and smooth. Telson with a fusiform shape, smooth; aculeus moderately long and weakly curved; subaculear tooth strong and spinoid. Pedipalp femur pentacarinata; patella and chela with weak to vestigial carinae, internal face of patella with some vestigial spinoid granules, all faces weakly granular, almost smooth; fixed and movable fingers with six rows of granules, two small external and one internal accessory granule present at the base of each row, three granules at the extremity of the fingers. Leg tarsus with very numerous, fine, median setae ventrally; tibial spurs strongly developed on legs III and IV. Cheliceral dentition characteristic of family Buthidae (Vachon, 1963); fixed finger with two strong basal teeth; movable finger with two vestigial basal teeth; ventral surface of both finger and manus with long, dense setae. Trichobothriotaxy of type A- β (Vachon, 1974). Morphometric values (in mm) of the male holotype. Total length including telson, 18.9. Carapace: length, 2.2; anterior width, 1.1; posterior width, 2.1. Mesosoma length, 5.1. Metasomal segments. I: length, 1.0; width, 1.2; II: length, 1.3; width, 1.1; III: length, 1.2; width, 1.1; IV: length, 1.8; width, 1.1; V: length, 3.1; width, 1.3; depth, 1.1. Telson: length, 3.2; width, 0.5; depth, 0.5. Pedipalp: femur length, 2.1, width, 0.4; patella length, 2.2, width, 0.5; chela length, 2.9, width, 0.3, depth, 0.3; movable finger length, 1.9.

Relationships. *Ananteris kalina* sp. n. can be readily distinguished from other species of the genus *Ananteris* and, in particular, from the three species occurring in the northern part of French Guiana, by the following main features:

- *A. guyanensis* Lourenço & Monod, 1999 (described from Saint-Eugène (Petit-Saut) and also found in Saut Sabbat (Mana)): (i) different pigmentation pattern on pedipalps and legs, (ii) chelicerae with variegated dark brown spots over the entire surface (uniformly yellow in *A. guyanensis*), (iii) metasomal segments with 10-8-8-8-5 carinae (10-10-10-8-5 in *A. guyanensis*).
- *A. intermedia* Lourenço, 2012 (described from Saint Jean du Maroni): (i) larger size (9.3 mm in total length for *A. intermedia*), (ii) subaculear tooth strong and spinoid (extremely reduced to vestigial in *A. intermedia*), (iii) metasomal segments with 10-8-8-8-5 carinae (10-10-8-8-5 in *A. intermedia*).
- *A. elisabethae* Lourenço, 2012 (described from Kourou): (i) darker general coloration (no spots or pigmented zones in *A. elisabethae*), (ii) chelicerae with variegated dark brown spots over the entire surface (uniformly yellow in *A. elisabethae*).
- The biotope where the new species occurs (coastal white-sand dry forest) is also different from biotope where other species of the genus are found in French Guiana (moist rainforest). The new species may be a possible endemic element of the white-sand coastal dry forest of Mana, French Guiana.

Ananteris polleti Lourenço, 2016

Fig. 6

References. Lourenço 2016b.



Figure 6. *Ananteris polleti*, male holotype from Mitaraka (photo MNHN / E.-A. Leguin; 2016 Elsevier Masson SAS).

Material. Mitaraka massif, 433 m, tropical moist forest, in plateau, one male (holotype), deposited in the MNHN, MNHN/PNI Guyane 2015 (APA 973-1), M. Pollet coll., 2–8/III/2015. Mitaraka massif, 352 m, tropical moist forest, in slope, one male (paratype), deposited in the MNHN, MNHN/PNI Guyane 2015 (APA 973-1), M. Pollet coll., 25/II/2015–3/III/2015.

Diagnosis. Species of small size compared to the average size of the other species within the genus (14.7 mm in total length for male holotype). General coloration yellow to brownish yellow with brown to dark brown variegated pigmented zones on the carapace, the tergites, and the appendages. Carapace yellow with dark brown spots on anterior, lateral and posterior edges; eyes surrounded by black pigment. Mesosoma yellow with confluent brownish zones on posterior and lateral edges of tergites. Venter yellow to pale yellow; coxapophysis and sternites infuscate. Metasomal segments I to V yellow; all segments marked with diffused brown spots. Vesicle yellow marbled with light brown zones; base of aculeus yellow, tip reddish. Chelicerae yellow with variegated blackish spots over the entire surface; fingers with blackish spots; teeth yellow. Pedipalps yellow; femur, patella, and chela strongly marked with dark brown spots; chela hand and fingers dark brown. Legs yellow, intensely marked with dark brown spots. Carapace with moderately to strongly marked granulation; anterior margin almost straight; all furrows moderate to weak. Tergites with moderately to strongly marked granulation, similar to that of carapace; median carina moderately to weakly marked on all tergites. Pectines small; pectinal tooth count 11–11 to 12–12 in male. Sternites smooth; only VII slightly granular; spiracles rather short; setation moderate; sternite VII with very weakly marked carinae and granulation. Metasomal segments I to III with ten crenulate carinae; segment IV with eight crenulate carinae; segment V slightly rounded and smooth, with vestigial carinae; intercarinal spaces moderately granular on all segments; dorsal and latero-dorsal carinae on segments II to IV with 3–4 posterior spinoid granules. Telson elon-

gate and smooth; aculeus short and weakly curved; subaculear tooth strongly marked and spinoid. Pedipalps moderately short; femur pentacarinata; patella and chela with weak to vestigial carinae; internal side of patella with only vestigial spinoid granules; all sides weakly granular, almost smooth; fixed and movable fingers with six, almost linear, rows of granules; two small external and one internal accessory granule present at the base of each row; three granules at the extremity of the fingers. Leg tarsus with very numerous, fine, median setae ventrally; tibial spurs strongly developed on legs III and IV.

Ananteris sabineae Lourenço, 2001

Fig. 7

References. Lourenço 2001b, Lourenço 2003a, Lourenço 2016b.

Material. Upper Ouarimapan river, trailhead camp of sentier indien, one female (holotype), MNHN-RS-6272, J. P. Gasc coll., VII/1972. Mitaraka Massif, layon D, in slope, winkler, one female, deposited in the MNHN, MNHN/PNI Guyane 2015 (MI15-0237-36), J. Orivel & F. PetitClerc coll., 23/II/2015–11/III/2015.

Diagnosis. Species of medium size when compared with the average size of the other species of the genus (27.7 mm in total length for female holotype). General coloration basically brownish yellow, symmetrically marbled with dark reddish brown, producing an overall spotted appearance. Carapace dark yellow, almost totally covered with brown spots; eyes surrounded by black pigment. Mesosoma yellowish brown with confluent brown stripes and two diffused longitudinal yellowish stripes. Venter yellowish; sternite VII reddish yellow. Metasomal segments I to IV reddish yellow, with a few brown spots; segment V reddish brown, with less marked spots. Vesicle reddish yellow without spots. Chelicerae yellowish without any spots over their entire surface; fingers reddish brown. Pedipalps yellowish with a few diffused spots better marked on the femur; chelae darker than patella; fingers yellowish with the rows of granules slightly reddish. Legs yellowish with diffused spots, better marked than on pedipalps. Carapace moderately granular; anterior margin with a slight median concavity; all furrows moderate to feeble. Tergites moderately granular; median carina moderate in all tergites. Pectinal tooth count 19–18 in female. Sternites smooth with moderately elongate stigmata; VII granulated with vestigial carinae. Metasomal segments with 10-8-8-8-5 crenulate carinae; intercarinal spaces moderately to weakly granular. Telson moderately granular with three ventral carinae and with a fairly short and moderately curved aculeus; subaculear tooth strong and spinoid. Pedipalp femur pentacarinata; patella and chelae with a few vestigial carinae; internal side of patella with eight to nine spinoid granules; all sides feebly granular, almost smooth; movable fingers with seven oblique rows of granules; two accessory granules present at the base of each row. Leg tarsus with very numerous fine median setae ventrally; tibial spurs strongly developed on legs III and IV.



Figure 7. *Ananteris sabineae*, female holotype from upper Ouarimapan river (photo MNHN / E.-A. Leguin).

Genus *Isometrus* Hemprich & Ehrenberg, 1828

Isometrus maculatus (DeGeer, 1778)

Fig. 8

References. DeGeer 1778, Lourenço 1983, Fet et al. 2000.

Material. Cayenne, four males and three females, MNHN-RS-0899, M. Richard coll. Cayenne, one male and two females, MNHN-RS-3315, E. Abonnenc coll. Charvein-Maroni river, one male, MNHN-RS-3323, F. Geay coll., 1903. Coswine river, under rotten wood, one female, MNHN-RS-8299, J. Fretey coll., 16/V/1977. Morne-Cépéron, one male, MNHN -RS-3324, F. Geay coll., 1902. St. Jean du Maroni, two males, three females and two immatures, MNHN-RS-3322, R. Benoist coll., 1914. St. Jean du Maroni, one male, MNHN-RS-7286, F. Geay coll., 1903. Disputed area between Oyapock and Amapa, one female, MNHN-RS-0925. D. Villecourt coll., 1899. Disputed area between Oyapock and Amapa, one male, MNHN-RS-0914, F. Geay coll., 1899. Disputed area between Oyapock and Amapa, five males, sic females and one immature, MNHN-RS-0893, Lafon coll., 1872.

Diagnosis. Species of medium to large size when compared with the average size of the other species of the genus, ranging from 50.1 mm (female) to 61.2 mm (male) in total length. General coloration yellowish to pale yellow, symmetrically marbled with blackish brown spots in both adults and juveniles. Carapace yellow-



Figure 8. *Isometrus maculatus*, female from St. Jean du Maroni.

ish with blackish brown patterns; eyes surrounded by black pigment. Mesosoma yellowish with symmetrical blackish brown stripes. Venter yellowish; sternites III–VII with symmetrical brown spots. Metasomal segments pale yellow, with some diffuse, brownish spots. Vesicle pale yellow with basis of aculeus yellowish and tip of aculeus reddish brown. Chelicerae pale yellow with brownish variegated spots; base of fingers pale yellow, rest of fingers blackish brown, teeth reddish. Pedipalps pale yellow with brownish spots; chela fingers reddish brown; rows of granules on dentate margins of fingers dark reddish. Legs yellowish with diffuse spots. Carapace coarsely granular with a few smooth patches; anterior margin strongly emarginated, with an open V-shaped angle; carinae weakly developed. Tergites moderately granular; median carinae weak to moderate on I–VI, tergite VII with two lateral pairs of carinae moderate to strong. Pectinal tooth count ranging from 16–19 in male and 17–19 in female. Sternites smooth and shiny, VII with four granular carinae. Metasomal segments with 10-10-8-8-5 crenulate carinae; intercarinal spaces very weakly granular to smooth. Telson very weakly granular, almost smooth, with one vestigial ventral carina; subaculear tubercle marked and triangular, with two granules on the ventral surface. Pedipalp femur with all carinae crenulate; patella with seven crenulate carinae; chela with vestigial carinae; dentate margins of fixed and movable fingers with six linear rows of granules. Leg tibia with few setae, without spurs; basitarsus with some setae and two lateral pedal spurs; tarsus ventrally with two rows of short setae.



Figure 9. *Jaguajir pintoï kourouensis*, female from Kourou (photo G. Molisani).

Genus *Jaguajir* Esposito, Yamaguti, Souza, Pinto da Rocha & Prendini, 2017

***Jaguajir pintoï kourouensis* (Lourenço, 2008)**

Fig. 9

References. Lourenço 1986, Lourenço and Pinto-da-Rocha 1997, Fet et al. 2000, Lourenço 2008, Esposito et al. 2017.

Material. Region of Kourou, forest patches of Degrad path, one male (holotype), MNHN-RS-8631, mission M. Boulard & P. Pompanon coll., VIII/1975.

Diagnosis. Large scorpion in relation to the species of the genus, with 89.7 mm in total length for the male holotype. Very dark coloration, uniformly blackish. Carapace and mesosoma blackish. Venter dark reddish to blackish. Metasomal segments I to V blackish. Vesicle dark reddish to blackish. Chelicerae dark reddish with a blackish thread; fingers dark. Pedipalps blackish; fingers reddish. Legs dark reddish, intensely spotted with blackish. Carapace strongly granular; anterior margin with a median concavity; anterior median and posterior median carinae strong; all furrows moderately deep. Tergites strongly granular; median carina strong in all tergites; tergite VII pentacarinata. Sternum triangular. Pectinal tooth count 24–25 in male. Sternites smooth with elongate spiracles; VII with four carinae and some lateral granulations. Metasomal segments I and II with ten carinae; III and IV with eight carinae; V with five carinae; inframedian carinae complete on II. Telson weakly

granular, with a long and strongly curved aculeus; dorsal surface smooth; ventral surface granular; subaculear tooth absent. Pedipalp femur pentacarinatate; patella with seven carinae; chela with nine carinae; internal side of patella with spinoid granules; all sides moderately to weakly granular; a very intense chaetotaxy can be observed in all segments; fixed and movable fingers with 9–10 oblique rows of granules; internal and external accessory granules strongly marked. Leg tarsus ventrally with numerous short fine setae.

Genus *Microananteris* Lourenço, 2003

Microananteris minor Lourenço, 2003

References. Lourenço 2003b, Botero-Trujillo and Noriega 2011, Lourenço 2012c.

Material. Central region, near the village of Saül, two km SW of the air field, dense humid forest at low altitude, in organic soil, extracted from Berlese method, one female (holotype), MNHN-RS-8602, J.M. Betsch leg., 19/III/1999.

Diagnosis. Very small species when compared with the average size of most species of micro-buthid genera (11.7 mm in total length for female holotype). General coloration brownish yellow, symmetrically marbled with darker brown, producing an overall spotted appearance. Carapace yellowish, almost totally covered with brown spots; eyes surrounded by black pigment. Mesosoma yellowish brown with confluent brown stripes. Venter pale yellow. Metasomal segments I to V yellowish, with several pale brown spots; segment V with more marked spots. Vesicle yellowish with pale brownish spots laterally and ventrally; aculeus reddish. Chelicerae yellowish with variegated spots over their entire surface; more marked anteriorly; fingers yellowish with reddish teeth. Pedipalps yellowish densely marked with brownish spots better marked on the femur and patella; chela paler than patella; fingers brownish with the rows of granules slightly reddish. Legs yellowish, densely marked with brownish spots. Carapace moderately granular; anterior margin with a very slight median concavity, almost straight; all furrows moderate to weak. Tergites moderately to weakly granular; median carina moderate to weak in all tergites; tergite VII pentacarinatate. Sternum subpentagonal. Pectines very small; pectinal tooth count 10–10 in female. Sternites smooth with short semi-oval spiracles; VII with a few granulations and vestigial carinae. Metasomal segments with 10-10-10-8-5 crenulate carinae; intercarinal spaces moderately to weakly granular. Telson with a pear-like shape, almost smooth with three ventral carinae; aculeus very short and moderately curved; subaculear tooth strong and almost rhomboid. Pedipalp femur pentacarinatate; patella and chela with a few vestigial carinae; internal side of patella with some vestigial granules; all sides feebly granular, almost smooth; movable fingers with 6/7 almost linear rows of granules; two accessory granules present at the base of each row; extremity of movable fingers with three accessory granules. Leg tarsus with very numerous fine median setae ventrally; tibial spurs developed on leg IV but reduced on leg III.



Figure 10. *Tityus gasci*, male holotype from Inini region (photo MNHN / E.-A. Leguin).

Genus *Tityus* C. L. Koch, 1836

***Tityus (Tityus) gasci* Lourenço, 1981**

Fig. 10

References. Lourenço 1981, Lourenço 1983, Fet et al. 2000, Lourenço 2008.

Material. Inini region, between Maripasoula and Antecume-Pata, one male (holotype), MNHN-RS-7921, J.P. Gasc coll., VII-IX/1972, leg., 1975.

Diagnosis. Species of medium size compared to the average size of the other species of the genus, with a total length of 63.4 mm for the male holotype. General coloration yellowish. Carapace yellowish with some shades of brownish; eyes surrounded with black pigment. Tergites yellowish with confluent pale yellow zones on tergites, making an incomplete rhomb on the tergite VII. Sternites dark yellow with a lighter triangular area on the posterior part of sternite V; sternum, genital operculum and pectines yellow ochre. Metasomal segments I to III yellowish, IV and V dark reddish. Vesicle dark reddish with basis of aculeus reddish yellow and tip of aculeus reddish black. Chelicerae yellowish with reddish teeth. Pedipalp femur and patella yellowish; chela reddish yellow with reddish fingers; base of movable finger dark, almost black. Legs yellowish with blackish pigment on carinae. Anterior margin of carapace moderately emarginated; carapace carinae weakly developed; anterior median carinae weak; intercarinal spaces weakly granular, almost smooth. Tergites almost smooth with only few granules on posterior area; tergites I-VI with one very weakly marked median carina; tergite VII

pentacarinata with weakly marked carinae. Pectinal tooth count 17–18 in male; basal middle lamella not dilated. Sternites with spiracles almost linear. Metasomal segments with 10-10-8-8-5 weakly marked carinae; dorsal carinae of segments I to IV with one distal slightly spinoid granule; intercarinal spaces almost smooth. Telson with aculeus almost as long as the vesicle, strongly curved; subaculear tubercle well developed, with two dorsal teeth. Pedipalp femur pentacarinata; patella with seven carinae; chelae with nine carinae; dentate margins of fixed and movable fingers composed of 15–15 rows of granules.

***Tityus (Archaeotityus) mana* Lourenço, 2012**

Fig. 11

References. Lourenço 1984, Lourenço 1992, Fet et al. 2000, Lourenço 2012d.

Material. Path between Mana and Les Hattes, very sandy soil, one male (holotype), MNHN-RS-8084, M. Boulard & P. Pompanou coll., 8/VIII/1975. Mana, Organabo river, one female and one male, deposited in the RNA, J. Chevalier & Q. Uriot coll., 28/VII/2017. East Couachi, Organabo road, dry forest, one female (paratype), deposited in the MNHN, W. Lourenço coll., 22/VI/1987. Awala Yalimapo, Kanawa path, two males and one immature, deposited in the RNA, J. Chevalier coll., 03/VIII/2017. Awala Yalimapo, RNA path, three females and three immatures, deposited in the RNA, J. Chevalier coll., 01/IX/2017. Sinnamary, path of the Pripris de Yiyi, seven females and two immatures, deposited in the RNA, J. Chevalier & P. Gallier coll., 05/VIII/2017. Iracoubo, Savanne Grand Macoua, one female and one male, deposited in the RNA, J. Chevalier & Q. Uriot coll., 28/VII/2017. Iracoubo, sand quarry Moticase, one female and one male, deposited in the RNA, J. Chevalier & Q. Uriot coll., 28/VII/2017.

Diagnosis. Small to moderate species when compared with the average size of the other species of the genus, ranging from 29.9 mm (male) to 38.5 mm (female) in total length. General coloration yellowish to pale yellow with only residual variegated pale brown spots over the body and appendages. Carapace yellowish with residual spots on the posterior and central zones; eyes surrounded with black pigment. Mesosoma yellowish with pale brown variegated spots on the posterior margins of tergites. Venter yellowish; sternites yellowish with pale brown variegated spots on the posterior margins; sternum, genital operculum and pectines pale yellow. Metasomal segments I to IV yellowish, V reddish yellow, with dark spots laterally and ventrally. Vesicle reddish to dark reddish; aculeus reddish. Chelicerae yellowish with variegated dark brown spots on the front part; fingers yellowish with dark brown spots at their basis; teeth reddish. Pedipalps yellowish with only some vestigial spots on the femur and patella of male. Legs yellowish with residual variegated spots on all segments. Anterior margin of carapace only moderately emarginated; carapace carinae weakly developed; all furrows weak; intercarinal spaces weakly granular. Tergites I–VI with one moderately marked median carina; tergite VII pentacarinata, lateral pairs of carinae moderately marked,



Figure 11. *Tityus mana*, female from Awala Yalimapo (photo J. Chevalier).

median carinae marked only on proximal third; intercarinal spaces weakly granular. Pectines small with moderate fulcra; basal middle lamella not dilated in female; pectinal tooth count ranging from 16–17 in male and 14–17 in female. Sternites surface with a residual granulation, almost smooth; carinae absent on III–VI, four weak to moderate carinae on VII; spiracles slit-like but short. Metasomal segments with 10–10–8–8–5 carinae; dorsal carinae of segments I to IV with one strong distal spinoid granule, better marked in female; intercarinal spaces weakly granular. Telson smooth in males; with one ventral and four vestigial lateral carinae in the female; aculeus shorter than vesicle, moderately curved; subaculear tubercle short and strongly rhomboid, with two dorsal teeth. Pedipalp femur pentacarinata; all carinae moderately to strongly crenulate; patella with seven carinae; internal carina with strong spinoid granules; chelae with 8–9 strongly marked carinae; all sides weakly granular; carinae and granules better marked in female; dentate margins of fixed and movable fingers composed of 13–14 oblique rows of granules. Ventral aspect of leg tarsi with numerous thin setae; tibial spurs absent; pedal spurs present but vestigial in all legs.

***Tityus (Atreus) obscurus* (Gervais, 1843)**

Figs 12–13

References. Gervais 1843, Pocock 1897, Lourenço 1983, Lourenço 1997b, Fet et al. 2000, Lourenço 2002a, Lourenço and Leguin 2008, Stockmann and Ythier 2010.



Figure 12. *Tityus obscurus*, adult female from Cayenne.

Material. Cayenne, one adult female (lectotype) and one immature female (paralectotype), MNHN-RS-3298, Mr. Leschenault & Mr. Doumerc coll. Cayenne, one female, MNHN-RS-0855, Noirot coll., 1890. Cayenne, one male and one female, MNHN-RS-0861, M. Melinon coll., 1877. Cayenne, three females, MNHN-RS-3297, M. Melinon coll., 1876. Cayenne, two females, MNHN-RS-3299, R. Pinchon leg., 1953. Cayenne, three males, MNHN-RS-3314, E. Abonnenc coll., two males, MNHN-RS-3317, E. Abonnenc coll., Inst. Pasteur leg. Cayenne, Montabo, in forest, one female, MNHN-RS-3319, III/1949. Cayenne, caught from a cat in a house, one female, MNHN-RS-3321, D. Destombes coll., VI/1950. Cayenne, one female, MNHN-RS-3325, F. Geay coll., 1902. Cayenne, one female, MNHN-RS-0846, St. Laurent coll., 1899. Border with Para, one male and one female, MNHN-RS-3286, 1900. Cayenne, Mt. St. Martin, forest, one female, MNHN-RS-7926, D. Quintero coll., 10/XII/1972. Cayenne, one male, MNHN-RS-8081, M. Condamin leg., 25/VI/1976. Cayenne, Mont Bourda, one immature, deposited in the RNA, J. Chevalier & B. Tan coll., 09/VII/2017. Cayenne region, one male, deposited in the MHNG, Freitag leg., IX/1987. Amarone-Baraquin, one male and one female, MNHN-RS-0849, 1900. Antecume-Pata, in forest, one female, MNHN-RS-6268, J.P. Gasc coll., 18/VII/1972. Antecume-Pata, in forest, one female, MNHN-RS-6269, J.P. Gasc coll., 18/VII/1972. Antecume-Pata, one female, MNHN-RS-7918, J.P. Gasc leg., 1975. Antecume-Pata, one male, MNHN-RS-7919, J.P. Gasc leg., 1975. Antecume-Pata, one female, MNHN-RS-7920, J.P. Gasc leg., 1975. Downstream from Saut Pararé on Arataye river, Approuague tributary, two males and one female, MNHN-RS-7389,

J.P. Gasc coll., IV-V/1979. Downstream from Saut Pararé on Arataye river, Approuague tributary, one male, MNHN-RS-7391, J.P. Gasc coll., IV-V/1979. Camopi, Oyapock valley, one male and one female, MNHN-RS-3393, mission E. Aubert de la Rüe coll., 18/XII/1948. Upper Approuague, in forest, one male, MNHN-RS-3301, III/1946. Upper Oyapock, between Mount Orière and Dégrad Galoupa, two females, MNHN-RS-3310, mission E. Aubert de la Rüe coll., 1948–49. Kaw, one female, MNHN-RS-8296, J. Lescure coll., 27–30/IV/1977. Mitaraka Massif, hand catch, one male, two females and one immature female, deposited in the MNHN, MNHN/PNI Guyane 2015, E. Poirier, P.H. Dalens & J. Touroult coll., 11–18/III/2015. Mitaraka Massif, camp, layon D, tropical moist forest, in plateau, winkler, two females, deposited in the MNHN, MNHN/PNI Guyane 2015, J. Orivel & F. PetitClerc coll., 23/II/2015–11/III/2015. Apatou, Crevette river, one male, one female and one immature male, deposited in the RNA, J. Chevalier & P. Gallier coll., 30/VI/2017. Sinamary, path of the Canceler river, under a palm tree's bark, one female and one male, deposited in the RNA, J. Chevalier & P. Gallier coll., 05/VIII/2017. Iracoubo, Savanne Grand Macoua, one female, deposited in the RNA, J. Chevalier & Q. Uriot coll., 28/VII/2017. Mounts of Montsinery, one female, MNHN-RS-5252, F. Geay coll., II/1902. Oyapock, two males, MNHN-RS-0845, F. Geay coll., 1900. Oyapock, one female, MNHN-RS-0862, F. Geay coll., 1900. Oyapock, one male, MNHN-RS-3305, mission E. Aubert de la Rüe coll., 1/XII/1948. Saül, one male and three females, MNHN-RS-5286, Balachowsky leg., 27/X/1969. Saül, Gros Arbres trail, one female, deposited in the RNA, J. Chevalier coll., 23/VIII/2017. Saül, Belvédère, one juvenile, deposited in the RNA, J. Chevalier coll., 21–22/VIII/2017. Saut Sabbat, one female, MNHN-RS-8208, D. Kopp coll., 8/VII/1976. Saut Sabbat, one immature female, deposited in the MNHN, E. Ythier coll., 03–11/XI/2010. St. Jean du Maroni, one female, MNHN-RS-0856, R. Benoist coll., 1914. Yanioué, upper Oyapock, upper Camopi, upstream waterfall, one male, MNHN-RS-3295, mission E. Aubert de la Rüe coll., II/1949. Cacao, four males and one immature, deposited in the MHNG, Chippaux leg., X/1983. Cacao, one male, deposited in the MHNG, W. Lourenço leg., II/1989. Cacao, one male, deposited in the MHNG, P. Soler leg., I/1992. Kourou, one male, deposited in the MHNG, R. Garrouste leg., 16/II/1995. Kourou, one male, deposited in the MHNG, Freitag leg., 9/X/1987. Petit-Saut, in canopy with radeau des cimes, one immature female, deposited in the MHNG, H.P. Aberlenc coll., 4/XI/1989. Trinité reserve, Aya river, pitfall trap, one immature female, deposited in the MNHN, C. Courtial coll., X/2009. Trinité reserve, Aya river, one immature male, deposited in the MNHN, C. Courtial coll., X/2008. Trinité reserve, Aya River, two males and one female, deposited in the MNHN, C. Courtial coll., XII/2010. Matoury, one male and one immature, deposited in the EYPC, EY0042, E. Ythier coll., 03–11/XI/2010. Salobroc, two immatures, MNHN-RS-0812. Guyane, three females, MNHN-RS-0810, M. Lafon coll., 1872. Guyane, two males and one female, MNHN-RS-0844, G. Dewer coll., 1897. Guyane, one female, MNHN-RS-0850, Viguiet coll., 1877. Guyane, one female, MNHN-RS-8250, D. Kopp coll., 3/VII/1976. Between Oyapock and Amapa (disputed area), one female, MNHN-RS-0852, Villecourt coll., 1899.



Figure 13. *Tityus obscurus*, juvenile from Saut Sabbat.

Between Oyapock and Mount Sociat-Marcel, on the ground, base camp, river bank, Eleuponsin, one female, MNHN-RS-8076, J. P. Gasc coll. III/1976. Parana, one female, MNHN-RS-8251, D. Kopp coll., 3/VIII/1976. Franco-brazilian region, two females, MNHN-RS-0839, F. Geay coll., 1899. Le Para (?), five males and five females, MNHN-RS-0854.

Diagnosis. Species of large size when compared with the average size of the other species within the genus, ranging from 75.7 to 100 mm in total length. General coloration uniformly dark brown to blackish. Carapace and mesosoma uniformly dark brown to blackish. Sternites with some pale zones; a triangular smooth testaceous area on the middle of the posterior border of the sternite III; pectines testaceous. Metasomal segments I to V and telson uniformly dark brown to blackish. In most cases the juvenile instars are yellowish or reddish yellow, with very numerous variegated spots, these spots being not visible in the adults as a result of the very marked sclerification of the cuticle. Chelicerae yellowish with variegated dark brown spots over the entire surface; fingers brownish; teeth dark reddish. Pedipalps dark reddish; chela fingers dark brown to blackish with tip yellowish. Legs yellowish almost entirely covered with brownish spots, except on telotarsus. Number of pectine teeth ranging from 18 to 22 teeth in both sexes; the basal middle lamellae strongly dilated in females. Metasomal segments I and II with ten carinae; segments III and IV with eight carinae; segment V with five carinae. Telson with a strong spinoid subaculear

tooth present that can be moderate in size or almost totally absent in very large specimens. Dentate margins of pedipalp chela fixed and movable fingers with 15–17 oblique rows of granules. Very strong sexual dimorphism; male pedipalps are longer and more slender than those of the females; metasoma of the male is also longer than the one of the female.

***Tityus (Archaeotityus) silvestris* Pocock, 1897**

Fig. 14

References. Pocock 1897, Lourenço 1983, Lourenço 1984, Lourenço 1988a, Lourenço 1992, Lourenço 1997b, Fet et al. 2000, Lourenço 2002a, Lourenço 2008, Stockmann and Ythier 2010.

Material. Downstream from Saut Pararé on Arataye River, Approuague tributary, one male, MNHN-RS-7390.1, J.P. Gasc coll., IV-X/1979. Ilet la Mère, one female, MNHN-RS-8298, J. Lescure coll., 25/VII/1977. St. Jean du Maroni, one female, MNHN-RS-3322, R. Benoist coll., 1914. Cacao, one male, deposited in the MHNG, Chippaux coll., X/1983. Mitaraka Massif, 433 m, tropical moist forest, in plateau, one male, deposited in the MNHN, MNHN/PNI Guyane 2015 (APA 973-1), M. Pollet coll., 2–8/III/2015. Mitaraka Massif, pointe Macaria, hand catch, one female, deposited in the MNHN, MNHN/PNI Guyane 2015 (APA 973-1), E. Poirier, P.H. Dalens & J. Touroult coll., 24–27/II/2015. Saül, Popote Kanawa, one immature, deposited in the RNA, J. Chevalier coll., 24/VIII/2017. Cayenne, Mont Bourda, two females and six immatures, deposited in the RNA, J. Chevalier coll., 09/VII/2017. Disputed area between Oyapock and Amapa, one female, MNHN-RS-0820, D. Villecourt coll., 1899.

Diagnosis. Small to moderate species when compared with the average size of the other species of the genus, with a very variable size ranging from 25 to 45 mm in total length. General coloration yellowish to pale yellow densely spotted with brownish to blackish pigmentation. Carapace yellowish with brownish yellow pigmentation and brownish spots; a conspicuous bright yellow T-shaped mark on the anterior part. Tergites yellowish with brownish yellow pigmentation and brownish spots. Sternites yellowish with brownish spots. Metasomal segments I–III yellowish with brownish spots, IV and V reddish yellow. Vesicle reddish brown; aculeus reddish brown at the base and blackish at the tip. Pedipalps yellowish with brownish spots; chela fingers reddish yellow. Legs yellowish with brownish spots. This species presents a very complex pattern of polymorphism. Number of pectine teeth ranging from 14 to 16 in male and 12 to 15 in female; basal middle lamellae of female pectines not dilated. Metasomal segments I to IV without any spinoid posterior granule; segments IV and V of males bigger than those of females. Telson with a strong and rhomboid subaculear tooth. Dentate margins of pedipalp fingers composed of 15–16 oblique rows of granules in both males and females; male patella and metasomal segments generally much more bulky than those of females.



Figure 14. *Tityus silvestris*, male (left) and female with juveniles (right) from Saül (photo A. Thillien).

Family CHACTIDAE Pocock, 1893

Genus *Auyantepuia* Gonzalez-Sponga, 1978

***Auyantepuia aluku* sp. n.**

<http://zoobank.org/5A303DD8-21BA-46BF-9F85-F25C43991E42>

Figs 15–16

Type material. French Guiana, Apatou, Crevette river, one female (holotype), deposited in the MNHN, J. Chevalier & P. Gallier coll., 30/VI/2017. Apatou, Crevette river, four females (paratypes), deposited in the EYPC, EY0094, J. Chevalier & P. Gallier coll., 30/VI/2017.

Etymology. The specific name refers to the ethnic group Aluku, living in the area where the new species was found.

Diagnosis. Total length ranging from 20.4 to 21.5 mm (20.9 mm in total length for female holotype; see morphometric values after the description). Coloration reddish brown, with carapace, chelicerae, pedipalps and legs marked with darker spots. Tergites brownish with confluent reddish yellow spots, on the sides and the middle of tergites, forming a yellowish longitudinal median stripe. Posterior half of ventral side of segments I to IV yellowish, without spots. Body and appendages almost smooth, shiny; chela weakly granulated, dorso-internal carina inconspicuous; ventral posterior spinoid granulations on metasomal segment V. Pectines of female holotype and paratypes with 5–6 to 6–6 teeth; male unknown. Trichobothrial pattern of type C neobothriotaxic ‘majorante’.



Figure 15. *Auyantepuia aluku* sp. n., female holotype from Apatou. Habitus, dorsal and ventral aspect.

Description based on female holotype. Coloration. General coloration reddish brown. Carapace reddish yellow, marked with brownish variegated spots around the ocular tubercle and on the anterior and posterior edges of the carapace; ocular tubercle darker, almost black. Tergites brownish with confluent reddish yellow spots, on the sides and the middle of tergites, forming a yellowish longitudinal median stripe. Venter and sternites yellowish; sternum yellowish with darker spots on the middle and anterior edge; genital opercle yellowish; pectines pale yellow. Metasomal segments reddish yellow, marked with variegated brownish spots on lateral and dorsal sides of segments I to V and on ventral side of segments IV and V; posterior half of ventral side of segments I to IV yellowish, without spots. Vesicle reddish yellow with basis of aculeus blackish and tip of aculeus reddish. Chelicerae yellowish, with variegated dark brown

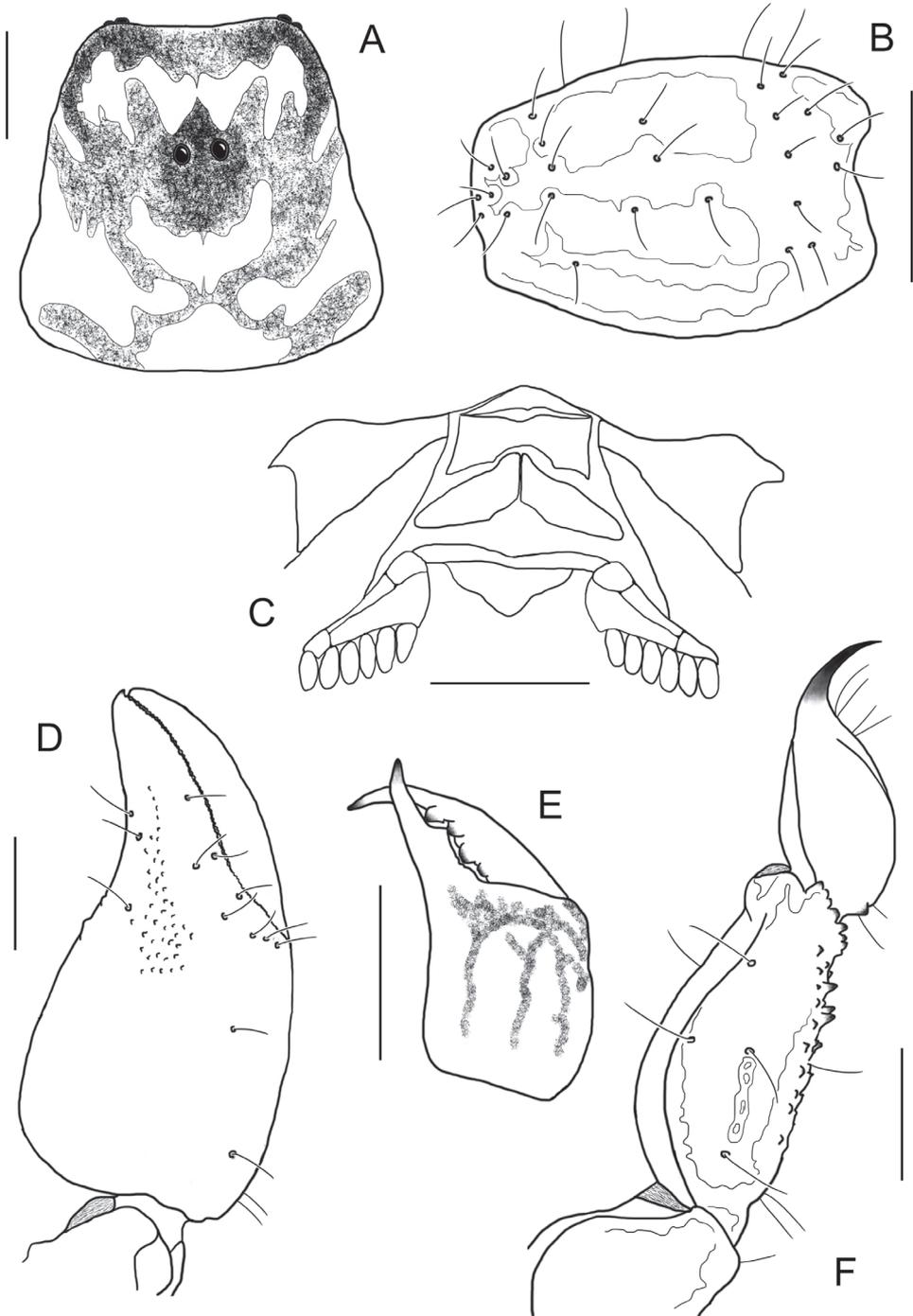


Figure 16. *Auyanteputia aluku* sp. n. female holotype. **A** Carapace **B** Patella, external aspect **C** Sternum, genital operculum and pectines **D** Chela, dorso-external aspect **E** Chelicera **F** Metasomal segment V and telson, lateral aspect. Scale bars: 1 mm except chelicera 0.5 mm (**E**).

spots; fingers reddish yellow; teeth reddish. Pedipalps reddish yellow, with longitudinal dark brown spots. Legs yellowish, intensely marked with brownish spots.

Morphology. Carapace acarinate, shiny, and almost smooth, with only some minute granulations on lateral edges; furrows shallow; anterior edge emarginate. Tergites acarinate, shiny, and almost smooth. Sternum pentagonal, wider than long. Pectinal tooth count 6–6 in female holotype (5–6 to 6–6 in females paratypes), fulcra absent. Sternites smooth and shiny, VII acarinate; spiracles rounded in shape. Only metasomal segments IV and V longer than wide; metasomal tegument almost lustrous, without granulation, and with a few punctations; segment V with posterior spinoid granulation ventrally; carinae on segments I–V vestigial or absent; only dorso-lateral carinae are weakly marked on segments I to IV. Pedipalp femur with dorsal internal, dorsal external and ventral internal carinae moderately marked, internal face weakly granular, other faces smooth; patella smooth, with vestigial carinae; chela weakly granulated, almost smooth, with dorso-internal carina weakly marked; dentate margins on fixed and movable fingers with six rows of granules. Chelicerae with dentition typical of the family Chactidae (Vachon, 1963), and with dense setation ventrally and internally. Trichobothriotaxy of type C; neobothriotaxic ‘majorante’ (Vachon, 1974). Morphometric values (in mm) of the female holotype. Total length including telson, 20.9. Carapace: length, 3.2; anterior width, 1.9; posterior width, 3.2. Mesosoma length, 7.2. Metasomal segments. I: length, 1.3; width, 2.0; II: length, 1.3; width, 1.7; III: length, 1.4; width, 1.5; IV: length, 1.7; width, 1.4; V: length, 2.6; width, 1.2; depth, 1.2. Telson: length, 2.2; width, 1.1; depth, 0.8. Pedipalp: femur length, 1.5, width, 0.9; patella length, 2.1, width, 1.0; chela length, 4.6, width, 2.1, depth, 1.7; movable finger length, 2.3.

Relationships. *Auyantepuia aluku* sp. n. can be readily distinguished from other species of the genus *Auyantepuia* and, in particular, from the three species occurring in the northern part of French Guiana and Suriname, by the following main features:

- *A. laurae* Ythier, 2015 (described from Saut Sabbat, Mana): (i) smaller size (27.5 to 28.2 mm in total length for *A. laurae*), (ii) tergites with confluent reddish yellow spots forming a yellowish longitudinal median stripe (no stripe in *A. laurae*), (iii) posterior half of ventral side of segments I to IV yellowish, without spots (ventral side of segments I to III entirely yellowish, without spots in *A. laurae*).
- *A. gaillardii* Lourenço, 1983 (described from Saint-Laurent-du-Maroni): (i) smaller size (26.9 mm in total length for the female of *A. gaillardii*), (ii) carapace, tergites, chelicerae, pedipalps and legs marked with darker spots (uniform coloration without darker spots in *A. gaillardii*), (iii) posterior half of ventral side of segments I to IV yellowish, without spots (all segments uniformly reddish in *A. gaillardii*).
- *A. surinamensis* Lourenço & Duhem, 2010 (described from Albina/Moengo, Suriname): (i) tergites with confluent reddish yellow spots forming a yellowish longitudinal median stripe (no stripe in *A. surinamensis*), (ii) posterior half of ventral side of segments I to IV yellowish, without spots (all segments reddish uniformly and intensely marked with brownish spots in *A. surinamensis*).

***Auyantepuia aurum* sp. n.**

<http://zoobank.org/71974C08-003E-4D34-9882-D4882268AF6B>

Figs 17–18

Type material. French Guiana, Saül, Gros arbres trail, one male (holotype), deposited in the MNHN, J. Chevalier, B. Tan & R. Legallic coll., 21–22/VIII/2017. Saül, Gros arbres trail, one male (paratype), deposited in the EYPC, EY0095, J. Chevalier, B. Tan & R. Legallic coll., 21–22/VIII/2017.

Etymology. The specific name is allusive to gold (Latin *aurum*) panning, for which the village of Saül (where the new species occurs) was founded at the beginning of the 19th century.

Diagnosis. Total length 25.2 mm for male holotype and 28.1 mm for male paratype (see morphometric values after the description). Coloration reddish brown, with carapace, chelicerae, pedipalps and legs marked with darker spots. Tergites brownish with confluent yellowish spots, on the sides and the middle of tergites, forming a yellowish longitudinal median stripe. Ventral side of segments I and II yellowish, without spots. Body and appendages weakly to moderately granulated; chela moderately granulated, dorso-internal carina inconspicuous; granulations on lateral sides of all metasomal segments and on ventral side of segments III to V, spinoid on V. Pectines of males holotype and paratypes with 7–7 and 5–7 teeth, respectively; female unknown. Trichobothrial pattern of type C neobothriotaxic ‘majorante’.

Description based on male holotype. Coloration. General coloration reddish brown. Carapace reddish yellow, marked with brownish variegated spots around the ocular tubercle and on the anterior and posterior edges of the carapace; ocular tubercle darker, almost black. Tergites brownish with confluent yellowish spots, on the sides and the middle of tergites, forming a yellowish longitudinal median stripe. Venter and sternites yellowish; sternum yellowish with darker spots on the middle and anterior edge; genital opercle yellowish; pectines pale yellow. Metasomal segments reddish yellow, marked with variegated brownish spots on lateral and dorsal sides of segments I to V and on ventral side of segments III, IV and V; ventral side of segments I and II yellowish, without spots. Vesicle reddish yellow with basis of aculeus blackish and tip of aculeus reddish. Chelicerae yellowish, with variegated dark brown spots; fingers reddish yellow with dark brown spots at their basis; teeth reddish. Pedipalps reddish yellow, with longitudinal dark brown spots. Legs yellowish, intensely marked with brownish spots.

Morphology. Carapace acarinate, with some fine granulations on central, lateral and posterior parts; furrows shallow; anterior edge emarginate. Tergites acarinate, with some fine granulations, stronger on their posterior edges. Sternum pentagonal, wider than long. Pectinal tooth count 7–7 in male holotype (5–7 in male paratype), fulcra absent. Sternites smooth and shiny, VII acarinate; spiracles rounded in shape. Metasomal segments III, IV and V longer than wide; metasomal tegument with medium size granulation on lateral sides of all segments and on ventral side of segments III to V, spinoid on V; carinae on segments I–V vestigial, only dorso-lateral carinae are



Figure 17. *Auyantepuia aurum* sp. n., male holotype from Saül. Habitus, dorsal and ventral aspect.

weakly marked on all segments. Pedipalp femur with dorsal internal, dorsal external and ventral internal carinae moderately marked, internal face weakly granular, other faces smooth; patella smooth, with vestigial carinae; chela moderately granulated, with dorso-internal carina weakly marked; dentate margins on fixed and movable fingers with six rows of granules. Chelicerae with dentition typical of the family Chactidae (Vachon, 1963), and with dense setation ventrally and internally. Trichobothriotaxy of type C; neobothriotaxic 'majorante' (Vachon, 1974). Morphometric values (in mm) of the male holotype. Total length including telson, 25.2. Carapace: length, 3.9; anterior width, 2.2; posterior width, 3.6. Mesosoma length, 7.7. Metasomal segments. I: length, 1.4; width, 2.0; II: length, 1.9; width, 2.0; III: length, 2.0; width, 1.7; IV: length, 2.3; width, 1.7; V: length, 3.3; width, 1.6; depth, 1.4. Telson: length, 2.7;

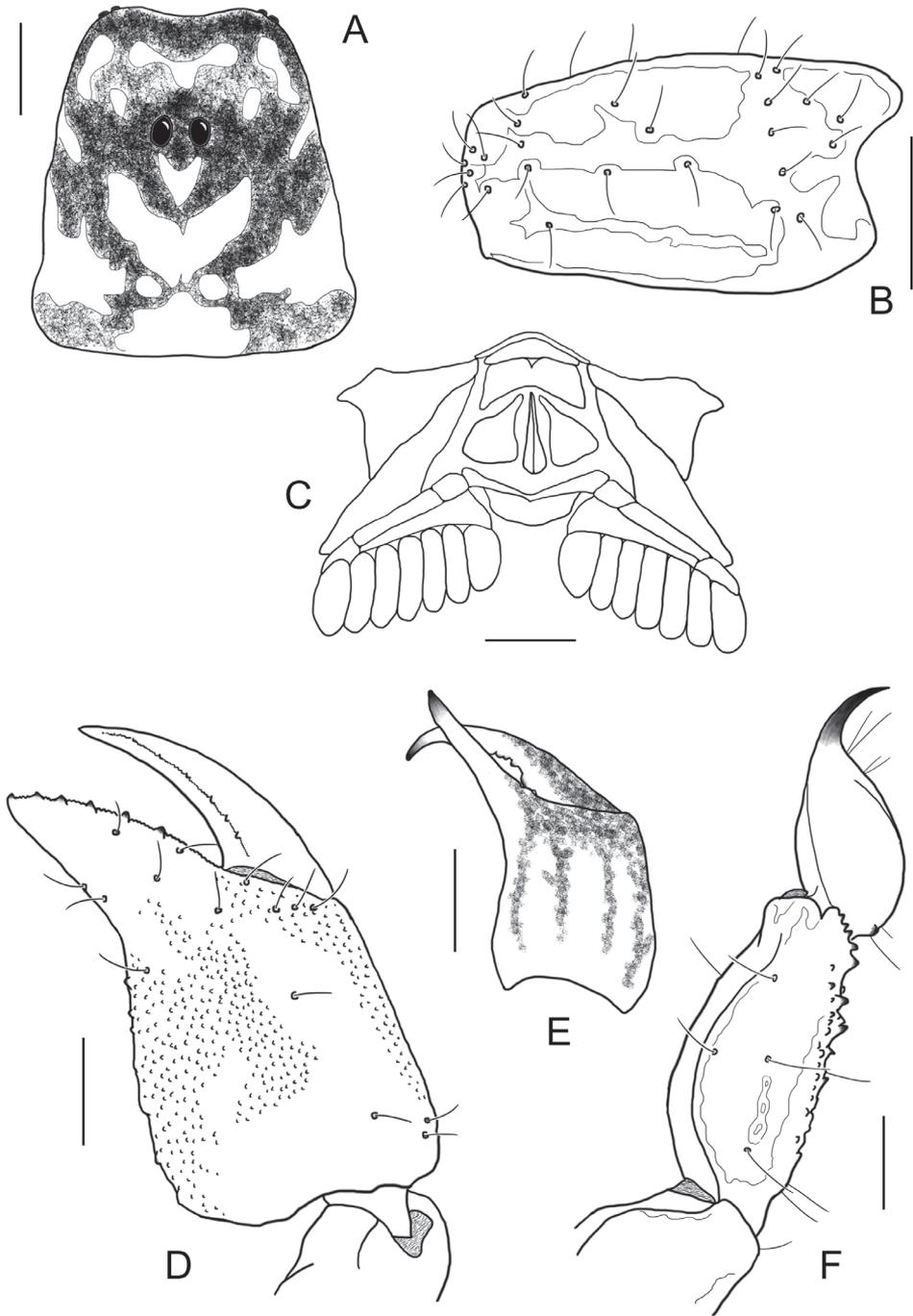


Figure 18. *Auyantepuia aurum* sp. n. male holotype. **A** Carapace **B** Patella, external aspect **C** Sternum, genital operculum and pectines **D** Chela, dorso-external aspect **E** Chelicera **F** Metasomal segment V and telson, lateral aspect. Scale bars: 1 mm except chelicera 0.5 mm (**E**).

width, 1.4; depth, 1.2. Pedipalp: femur length, 2.1, width, 1.0; patella length, 2.8, width, 1.1; chela length, 5.2, width, 2.3, depth, 1.8; movable finger length, 2.9.

Relationships. *Auyantepuia aurum* sp. n. can be readily distinguished from other species of the genus *Auyantepuia* and, in particular, from the three species occurring in the central and southern part of French Guiana, by the following main features:

- *A. fravalae* Lourenço, 1983 (described from Saut Pararé on Arataye river (Approuague tributary), and also found in Saül): (i) tergites with confluent yellowish spots forming a yellowish longitudinal median stripe (no stripe in *A. fravalae*), (ii) ventral side of segments I and II yellowish, without spots (brownish spots on ventral side of segments I to V and ventral side of segments I to II well pigmented in *A. fravalae*).
- *A. sissomi* Lourenço, 1983 (described from upper Oyapok): (i) general coloration reddish brown (yellowish in *A. sissomi*), (ii) metasomal tegument with medium size granulation on ventral side of segments III to V (only segment V is granulated ventrally in *A. sissomi*).
- *A. kelleri* Lourenço, 1997 (described from Cacao): (i) tergites with confluent yellowish spots forming a yellowish longitudinal median stripe (no stripe in *A. kelleri*), (ii) ventral side of segments I and II yellowish, without spots (all segments uniformly dark reddish in *A. kelleri*), (iii) ocular tubercle darker, almost black (clear in *A. kelleri*).

Auyantepuia fravalae Lourenço, 1983

Fig. 19

References. Lourenço 1983, Lourenço 1997b, Fet et al. 2000, Soleglad and Fet 2005, Prendini and Wheeler 2005, Lourenço and Qi 2007, Ythier 2015.

Material. Downstream from Saut Pararé on Arataye river, Approuague tributary, one male (holotype), MNHN-RS-8505, J.P. Gasc coll., IV/V/1979. Downstream from Saut Pararé on Arataye river, at the base of *Astrocaryum paramaca*, one female (allotype), MNHN-RS-8506, J.P. Gasc coll., I/1981. Saül, under dead wood, one female, deposited in the MHNG, P.K. Moritz coll., VIII/1987.

Diagnosis. Total length 28.8 mm for male holotype and 28.6 mm for female allotype. General coloration reddish brown. Carapace dark reddish brown with blackish spots around the ocular tubercle and on lateral edges of the carapace; ocular tubercle dark, almost black. Tergites reddish with several confluent lighter zones. Venter greyish yellow, the sternite VII darker; pectines and genital operculum yellow ochre. All metasomal segments reddish, slightly darker than the mesosoma; several reticular blackish spots on the ventral and lateral sides of segments I to V. Vesicle reddish yellow with several darker spots corresponding to granules; basis of aculeus reddish and tip of aculeus reddish black. Chelicerae dark yellowish with blackish spots starting at the basis of fingers and spreading along the chelicerae; fingers reddish. Pedipalps reddish with several longitudinal blackish spots on the three segments (femur, patella, and chela).



Figure 19. *Auyantepuia fravalae*, male holotype from Saut Pararé (photo MNHN / E.-A. Leguin).

Legs light yellow with several diffuse light brown spots. Carapace with a fine granulation with bigger granules on the anterior part; anterior edge very slightly concave, almost straight. Tergites with a medium size granulation, especially on the posterior part. Pectinal tooth count 8–8 in both sexes. Sternites smooth with spiracles rounded in shape. Ventral side of metasomal segments IV and V with medium size granulation on IV, important and spinoid on V; dorsal carinae weakly marked on segments I to IV; latero-dorsal carinae well-marked on segments I to IV and weakly marked on V; other carinae absent. Vesicle large and flattened, with medium size granulation on ventral and lateral sides; aculeus short. Pedipalp femur with four almost complete carinae; patella and chela with vestigial carinae; dorsal and internal sides of femur granular; chela strongly granulated dorsally, only few scattered granules internally; dentate margins on movable fingers with six rows of granules separated by bigger granules.

Auyantepuia gaillardi Lourenço, 1983

References. Lourenço 1983, Fet et al. 2000, Soleglad and Fet 2005, Prendini and Wheeler 2005, Lourenço and Qi 2007, Ythier 2015.

Material. St Jean du Maroni, one male (holotype), one female (allotype) and six females (paratypes), MNHN-RS-3311, R. Benoist coll., XII/1913. St Jean du Maroni, four females (paratypes), MNHN-RS-3307, R. Benoist coll., III-IV/1914. St Jean du Maroni, one male (paratype), MNHN-RS-3326, R. Benoist coll., 18/XII/1913.

Diagnosis. Total length 25.2 mm for male holotype and 26.9 mm for female allotype. General coloration reddish yellow. Carapace light reddish with yellowish spots on the posterior and lateral edges of the carapace; ocular tubercle blackish. Tergites yellowish with several confluent darker spots, greyish. Venter pale yellow, the sternite VII darker; pectines and genital operculum yellow ochre. All metasomal segments uniformly reddish, slightly darker than the prosoma. Vesicle of same coloration as metasomal segment V; aculeus dark reddish. Chelicerae uniformly yellowish; tip of fingers reddish. Pedipalps reddish, the femur slightly yellowish. Legs uniformly pale yellow. Carapace with a fine granulation in males, smooth in female; anterior edge very slightly concave, almost straight. Tergites with a fine granulation similar to the one on carapace in males, smooth in females. Number of pectine teeth ranging from seven to eight in male and six to seven in female. Sternites smooth with spiracles rounded in shape. Metasomal segment V with spinoid granulation ventrally; dorsal and latero-dorsal carinae on segments I to V weakly marked; other carinae absent. Vesicle with few scattered granules ventrally, other sides smooth; aculeus short. Pedipalp femur with dorsal internal, dorsal external and ventral internal carinae well-marked; internal side granular; patella and chela with vestigial carinae; chela weakly granular dorsally; dentate margins on movable fingers with six rows of granules separated by bigger granules.

Auyantepuia kelleri Lourenço, 1997

References. Lourenço 1997b, Fet et al. 2000, Soleglad and Fet 2005, Prendini and Wheeler 2005, Lourenço and Qi 2007, Ythier 2015.

Material. Cacao, one female (holotype), deposited in the MHNG, W. Lourenço leg., II/1989.

Diagnosis. General coloration brownish. Carapace brownish with darker spots on the anterior part of the carapace; posterior part and furrows lighter; ocular tubercle light. Tergites brownish with confluent yellowish spots. Venter yellowish brown. All metasomal segments uniformly dark reddish. Vesicle reddish with basis of aculeus reddish and tip of aculeus reddish black. Chelicerae yellowish red with greyish spots; fingers yellowish with reddish teeth. Pedipalps dark reddish, chela reddish. Legs yellowish with slightly variegated greyish spots. Carapace without granules, almost smooth; anterior edge very slightly concave. Tergites with few minute and scattered granules. Pectinal tooth count 6–6 in female. Sternites smooth with spiracles rounded in shape. Metasomal segment V with spinoid granulation ventrally; dorsal and latero-dorsal carinae on segments I to V weakly marked; other carinae absent. Vesicle flattened with few scattered granules ventrally; aculeus of medium size. Pedipalp femur with dorsal internal, dorsal external and ventral internal carinae well-marked; internal side granular; patella and chela with vestigial carinae; chela weakly granulated dorsally and with few scattered granules internally; dentate margins on movable fingers with five rows of granules separated by bigger granules.

***Auyantepuia laurae* Ythier, 2015**

Fig. 20

References. Ythier 2015.

Material. Near Saut Sabbat, 50 km South of Mana and 50 km East of Saint-Laurent-du-Maroni, under wood log, one female (holotype) and two females (paratypes), deposited in the MNHN, E. Ythier & G. Roy coll., I/2015. Mana, path of the Forêt des Sables Blancs, one female, deposited in the EYPC, EY0097, J. Chevalier & B. Tan coll., 08/VII/2017.

Diagnosis. Size ranging from 27.5 to 28.2 mm in total length for the females. General coloration reddish brown. Carapace reddish yellow, intensely marked with brownish variegated spots around the ocular tubercle and on the anterior and posterior edges of the carapace; ocular tubercle darker, almost black. Tergites reddish brown with confluent reddish yellow spots, on the sides and the middle of tergites, without forming a longitudinal stripe. Venter and sternites yellowish to reddish yellow; sternum reddish yellow with darker spots; genital operculum reddish yellow; pectines pale yellow. Metasomal segments reddish yellow, marked with variegated brownish spots on lateral and dorsal sides of segments I to V and on ventral side of segments IV and V; ventral side of segments I to III yellowish, without spots. Vesicle reddish yellow with basis of aculeus blackish and tip of aculeus reddish. Chelicerae yellowish, with variegated dark brown spots; fingers reddish yellow with dark brown spots at their basis, reddish teeth. Pedipalps reddish brown, with longitudinal dark brown spots. Legs yellowish, intensely marked with brownish spots. Carapace lustrous and acarinate, with some minute punctations; furrows shallow; anterior edge emarginated. Tergites acarinate, almost smooth and shiny, with only minute granulations on their posterior edges. Pectinal tooth count 5–6 to 6–6 in females. Sternites smooth and shiny, VII acarinate; spiracles rounded in shape. Only metasomal segments IV and V longer than wide; metasomal tegument almost lustrous, without granulation, and with a few punctations; segment V with spinoid granulation ventrally, weakly marked; carinae on segments I to V vestigial or absent; only dorso-lateral carinae are weakly marked on segments I to IV. Pedipalp femur with dorsal internal, dorsal external and ventral internal carinae moderately marked; internal side weakly granular; other sides smooth; patella smooth, with vestigial carinae; chela weakly granulated, almost smooth, with dorso-internal carina weakly marked; dentate margins on fixed and movable fingers with six rows of granules.

***Auyantepuia sissomi* Lourenço, 1983**

Fig. 21

References. Lourenço 1983, Fet et al. 2000, Soleglad and Fet 2005, Prendini and Wheeler 2005, Lourenço and Qi 2007, Ythier 2015.

Material. Upper Oyapock, between Montaquère junction and Dégrad Galoupa, equatorial forest, one female (holotype), MNHN-RS-3304 and one female (paratype), MNHN-RS-3309, mission E. Aubert de la Rüe coll., 10/I/1949.



Figure 20. *Auyantepuia laurae*, female holotype from Saut Sabbat.



Figure 21. *Auyantepuia sissomi*, female holotype from upper Oyapock (photograph MNHN / E.-A. Leguin).

Diagnosis. Total length 26.2 mm for female holotype. General coloration yellowish. Carapace yellowish with light brown spots around the ocular tubercle and on the lateral edges of the carapace; posterior part and furrows lighter; ocular tubercle dark, almost black. Tergites greyish with several confluent lighter spots, yellowish, forming a longitudinal stripe. Venter yellow ochre. All metasomal segments reddish yellow, with greyish spots on lateral sides of I to V and on ventral side of III to V; ventral side of segments I and II without pigmentation. Vesicle reddish yellow; basis of aculeus reddish and tip of aculeus reddish black. Chelicerae yellowish with greyish spots; fingers

yellowish with reddish teeth. Pedipalps reddish yellow with longitudinal light brown spots on the patella and chela, the dorsal side of the femur almost entirely covered with light brown spots; chela reddish. Legs pale yellow with several diffuse greyish spots. Carapace without granules, almost smooth; anterior edge very slightly concave. Tergites with few scattered fine granules. Number of pectine teeth ranging from six to seven in females. Sternites smooth with spiracles rounded in shape. Metasomal segment V with spinoid granulation ventrally; dorsal carinae weakly marked on segments I to IV; latero-dorsal carinae well-marked but incomplete on segments I to IV; other carinae absent. Vesicle flattened with few scattered granules ventrally; aculeus of medium size. Pedipalp femur with three carinae well-marked and almost complete; patella and chela with vestigial carinae; dorsal and internal sides of femur granular; dorsal side of chela granular, internal side with few scattered granules; dentate margins on movable fingers with six rows of granules separated by bigger granules.

Genus *Broteochactas* Pocock, 1893

***Broteochactas delicatus* (Karsch, 1879)**

Fig. 22

References. Karsch 1879, Pocock 1897, Lourenço 1983, Fet et al. 2000, Lourenço 2002a, Sogleglad and Fet 2005, Prendini and Wheeler 2005, Stockmann and Ythier 2010.

Material. Camopi, Oyapock Valley, one female, MNHN-RS-3300, mission E. Aubert de la Rüe coll., 20/XII/1948. Camopi, Oyapock Valley, one male and two females, MNHN-RS-3392, mission E. Aubert de la Rüe coll., 18/XII/1948. St Georges de l'Oyapock, one female, W. Lourenço leg., 20/VIII/1982. Inini, Institut Pasteur Station, in forest, one female, MNHN-RS-6271, J.P. Gasc coll., 16/VII/1972. Inini, Institut Pasteur Station, one female, MNHN-RS-6273, J.P. Gasc coll., 13/VII/1972. Saül, six males and six females, MNHN-RS-5287, A.S. Balachowsky coll., 27/X/1969. Saül, inselberg Dashine, under barks on the ground from the standing dead tree, one male, deposited in the MNHN, J.P. Mauries coll., 05/IV/1997. Saül, Gros Arbres trail, two females and eleven immatures, deposited in the RNA, J. Chevalier, B. Tan & R. Legallic coll., 23/VIII/2017. Saül, Belvédère, one female and four immatures, deposited in the RNA, J. Chevalier, B. Tan & R. Legallic coll., 21–22/VIII/2017. Saut Sabbat, one female and 17 immatures, MNHN-RS-8202, D. Kopp coll., 9/VII/1976. Saut Sabbat, one female, MNHN-RS-8204, D. Kopp coll., 15/VII/1975. Trinité reserve, Aya River, UV collected, one male, deposited in the MNHN, C. Courtial coll., XII/2010. Nouragues reserve, inselberg, UV collected on a dead trunk, one immature male, deposited in the MNHN, C. Courtial coll., 06–09/XII/2013. Cacao, one male and one female, deposited in the MHNG, W. Lourenço leg., II/1989. Cacao, one female, deposited in the EYPC, EY0030, E. Ythier coll., 03–11/XI/2010. Cacao, beginning of Molokoi path, one male and one female, deposited in the EYPC, EY0104, E. Ythier coll., 03–10/XI/2006. Maripasoula, one female, deposited in the MHNG,



Figure 22. *Broteocheactas delicatus*, male from Cacao.

Marty coll., X/1987. Mitaraka Massif, camp, one female, deposited in the MNHN, MNHN/PNI Guyane 2015, E. Poirier, P.H. Dalens & J. Touroult coll., 26/II/2015. Mana, path of the Forêt des Sables Blancs, two males and two females, deposited in the RNA, J. Chevalier & B. Tan coll., 08/VII/2017. Mana, path of the Forêt des Sables Blancs, three immatures, deposited in the RNA, J. Chevalier & B. Tan coll., 08/VII/2017. Guyane, one female, MNHN-RS-0755.

Diagnosis. Species of moderate to large size when compared with the average size of the other species within the genus, ranging from 44 to 50 mm in total length. General coloration reddish to dark reddish. Carapace reddish with some light brown zones on the anterior edge and around the ocular tubercle; the areas between the anterior edge and the ocular tubercle as well as areas of furrows almost without pigmentation; ocular tubercle dark, almost black. Tergites reddish with several yellowish reticular diffuse spots on all tergites. Sternites yellowish with brown spots on lateral edges, especially on sternites VI and VII; pectines and genital operculum yellow ochre. Metasomal segments of same color as the tergites. Vesicle reddish yellow with basis of aculeus reddish and tip of aculeus reddish black. Chelicerae yellowish with longitudinal brown spots; basis of fingers and fingers dark brown. Pedipalps reddish with diffuse and reticular light brown spots on femur and patella. Legs yellowish with diffuse light brown spots. Carapace slightly emarginated, almost straight; almost smooth, with few minute granules only on lateral areas. Tergites almost smooth, with scattered minute granulations. Pectinal tooth count ranging from seven to nine in male and 7–7 in female. Sternites smooth; spiracles oval to round in shape. All metasomal segments with

dorsal and latero-dorsal carinae well-marked; other carinae weakly marked or absent; segment V with spinoid granulations ventrally. Vesicle flattened, moderately granular; aculeus of moderate size compared to vesicle. Pedipalp femur with four well-marked carinae; patella with three carinae, chela with two carinae; femur and patella feebly granulated; chela well granulated on dorsal and internal sides, with granules arranged in four longitudinal wide series on external side; fingers about the same length as the chela and with dentate margins on movable fingers with six rows of granules, separated by stronger accessory granules.

Genus *Brotheas* C. L. Koch, 1837

Brotheas gervaisii Pocock, 1893

Fig. 23

References. Pocock 1893a, Pocock 1897, Lourenço 1983, Lourenço 1997b, Fet et al. 2000, Lourenço 2002a, Stockmann and Ythier 2010.

Material. Downstream from Saut Pararé on Arataye river, Approuague tributary, one female, MNHN-RS-7389, two males, MNHN-RS-7390, J.P. Gasc coll., IV-V/1979. Cayenne, La Chaumière, one male, MNHN-RS-8507, J. Orvoen coll., V/1977. Cayenne, Mont Bourda, one female, deposited in the RNA, J. Chevalier & B. Tan coll., 09/VII/2017. Coswine river, under flooded wood log, two males and five females, MNHN-RS-8297, J. Fretey coll., 16/V/1977. Upper Oyapock, Upper Camopi, Upstream Saül, Yanioué, one male, MNHN-RS-3295, mission E. Aubert de la Rüe coll., II/1949. Saül, one female, MNHN-RS-3320, mission E. Aubert de la Rüe coll. Saül, two females, MNHN-RS-5288, A.S. Balachowsky coll., 27/X/1969. Saül, one female, deposited in the MHNG, W. Lourenço leg., 23/VII/1987. Saül, one male juvenile, deposited in the MHNG, W. Lourenço leg., 16/VII/1986. Saül, Belvédère, one male, deposited in the RNA, J. Chevalier, B. Tan & R. Legallic coll., 21–22/VIII/2017. Saut Hermina, banks of Maroni River, three males, MNHN-RS-3316, H. Lourtau coll., 1901. St. Jean du Maroni, two males, one female and six immatures, MNHN-RS-3306, R. Benoist coll., 1914. Cacao, F-T-574, one male, deposited in the MHNG, T. Freitag coll., XII/1988. Cacao, one male and one female, deposited in the MHNG, W. Lourenço leg., II/1989. Cacao, one female, deposited in the MHNG, Chippaux coll., X/1983. Regina-St. Georges future road, DZ3, one male, deposited in the MHNG, Marty coll., I/1991. Trinité reserve, Aya river, UV collected, on the ground, three females, deposited in the MNHN, C. Courtial coll., XII/2010. Matoury, one female, deposited in the EYPC, EY0041, E. Ythier coll., 25/IX/2005. Matoury, one female and two immatures, deposited in the EYPC, EY0034, E. Ythier coll., 03–11/XI/2010. Fourgassier, one immature, deposited in the EYPC, EY0036, E. Ythier coll., 03–11/XI/2010. Rorota, one immature, deposited in the EYPC, EY0040, E. Ythier & G. Roy coll., 14–22/I/2015. Apatou, Crevette river, one male, deposited in the RNA, J. Chevalier & P. Gallier coll., 30/VI/2017. Awala Yalimapo, Kanawa



Figure 23. *Brotheas gervaisii*, male from Matoury.

path, three males, deposited in the RNA, J. Chevalier coll., XI/2017. Awala Yalimapo, Kanawa path, one male, deposited in the RNA, J. Chevalier coll., 03/VIII/2017. Mana, path of the Forêt des Sables Blancs, one male, deposited in the RNA, J. Chevalier & B. Tan coll., 08/VII/2017. Guyane, one male and one female, MNHN-RS-0741, Lafon coll., 1872. Guyane, one female, MNHN-RS-3308, Le Moutt coll., 1910. Guyane, one male, MNHN-RS-0747. Guyane, one male and one female, MNHN-RS0748. Guyane, one female, MNHN-RS-3011. Guyane, one female, MNHN-RS-0737, F. Geay coll., 1900. Guyane, one male, MNHN-RS-0739, Cavalier coll., 1889.

Diagnosis. Species of small to moderate size when compared with the average size of the other species within the genus, ranging from 50 to 57 mm in total length. General coloration brown to reddish brown. Carapace reddish brown with several black spots corresponding to the granules; ocular tubercle dark, almost black. Tergites paler than the carapace, with distal edge blackish. Sternites reddish with a lighter area, yellowish, at the center of sternites IV and V; pectines and genital operculum yellow ochre. Metasomal segments of same color as the tergites. Vesicle reddish yellow with basis of aculeus reddish and tip of aculeus reddish black. Chelicerae yellowish with longitudinal brown spots, weakly marked; fingers reddish. Pedipalps reddish with blackish pigmentation on carinae. Legs yellowish with several brown spots. Carapace slightly emarginated, almost straight; almost smooth, with few minute granules only on lateral areas; punctate. Tergites almost smooth, with scattered minute granulations. Pectinal tooth count ranging from eight to eleven in male and six to nine in female. Sternites smooth, punctate; spiracles linear, elongated. All metasomal segments with dorsal,

latero-dorsal and latero-ventral carinae well-marked; other carinae weakly marked or absent; intercarinal tegument punctate; segment V with spinoid granulations ventrally. Vesicle moderately granular; aculeus short compared to vesicle. Pedipalp femur with five well-marked carinae; patella with three carinae, chela with two carinae; femur and patella moderately granulated; chela well granulated on dorsal and internal sides; dentate margins on movable fingers with six slightly oblique rows of granules, separated by stronger accessory granules.

***Brotheas granulatus* Simon, 1877**

Fig. 24

References. Simon 1877, Lourenço 1983, Lourenço 1997b, Fet et al. 2000, Lourenço 2002a, Stockmann and Ythier 2010.

Material. Downstream from Saut Pararé on Arataye river, Approuague tributary, one male, MNHN-RS-6978, J.P. Gasc coll., VII-VIII/1970. Downstream from Saut Pararé on Arataye river, one male and two females, MNHN-RS-7390, J.P. Gasc coll., IV-V/1979. Downstream from Saut Pararé on Arataye river, one male, MNHN-RS-8279, J.P. Gasc coll., 12/VII/1977. Downstream from Saut Pararé on Arataye river, at the base of *Astrocaryum paramaca*, six males and four females, MNHN-RS-8508, J.P. Gasc coll., I/1981. Cayenne, one male and one female (types), MNHN-RS-0761. Upper Approuague, Culebane river, in forest, one female, MNHN-RS-3302, De Floch coll., III/1946. Inini, Institut Pasteur Station, under a wood log, one male, MNHN-RS-6267, J.P. Gasc coll., 13/VII/1972. Inini, Institut Pasteur Station, one male, MNHN-RS-6274, J.P. Gasc coll., 16/VII/1972. Inini, Institut Pasteur Station, one male, MNHN-RS-6275, J.P. Gasc coll., 14/VII/1972. Saül, one male, one female and six immatures, MNHN-RS-5288, A.S. Balachowsky coll., 27/X/1969. Saut Sabbat, one female, MNHN-RS-8203, D. Kopp coll., 9/VII/1976. Saut Sabbat, one male, MNHN-RS-8204, D. Kopp coll., 15/VII/1975. St. Elie (path), ORSTOM Station, one male and one female, MNHN-RS-7419, J. Lescure coll., 10/VII/1978. St. Jean du Maroni, five males and one female, MNHN-RS-3303, R. Benoist coll., 1916. Cacao, one female and one immature, deposited in the MHNG, W. Lourenço leg., II/1989. Cacao, one female, deposited in the MHNG, Chippaux coll., X/1983. Cacao, one male, deposited in the MHNG, T. Fretiag coll., XII/1988. Trinité reserve, inselberg, Aya River, five females and six immatures, deposited in the MNHN, C. Courtial coll., XII/2010. Trinité reserve, Aya River, one female and one male, deposited in the MNHN, C. Courtial coll., X/2009. Nouragues reserve, inselberg, UV collected, on a trunk, one female, deposited in the MNHN, C. Courtial coll., 06–09/XII/2013. Rorota, one female and two males, deposited in the EYPC, EY0026, E. Ythier coll., 28/IX/2005. Matoury, one female and 20 immatures, deposited in the EYPC, EY0035, E. Ythier coll., 03–10/XI/2006. Fourgassier, one male, deposited in the EYPC, EY0046, E. Ythier coll., 03–10/XI/2006. Tresor reserve, three males, deposited in the MNHN, C. Courtial coll., VI/2010. Cayenne and Maroni (?), two



Figure 24. *Brotheas granulatus*, male from Fourgassier.

females, MNHN-RS-3296, M. Noirot coll. Cayenne and Maroni (?), one male and one female, MNHN-RS-3312, E. Abonnenc coll. Cayenne and Maroni (?), one male, MNHN-RS-3318, M. Noirot coll. Guyane, one male, MNHN-RS-0743, F. Geay coll., 1900. Guyane, four females, MNHN-RS-3313, M. Tartaire coll., 1921. Guyane, two females, MNHN-RS-0749.

Diagnosis. Species of moderate to large size when compared with the average size of the other species within the genus, ranging from 58 to 68 mm in total length. General coloration brown to blackish brown. Carapace dark brown with several scattered black spots; ocular tubercle dark, almost black. Tergites of same color as the carapace; several paler confluent areas. Sternites brownish yellow, the sternite VII being darker; pectines and genital operculum dark yellowish. Metasomal segments of same color as the tergites; some blackish pigmentation over the carinae. Vesicle reddish yellow with basis of aculeus reddish and tip of aculeus reddish black. Chelicerae dark yellowish with reticular brown spots; basis of fingers and fingers dark browns. Pedipalps blackish brown; chela reddish with longitudinal blackish spots; fingers blackish with tip reddish. Legs yellowish brown with several diffuse dark spots. Carapace weakly emarginated, with strong granulation; ocular tubercle punctate. Tergites with strong granulation similar to the carapace, the tergites VI and VII with stronger granulation. Pectinal tooth count ranging from eight to eleven in male and seven to nine in female. Sternites punctate; spiracles linear, elongated. All metasomal segments with dorsal, latero-dorsal and latero-ventral carinae well-marked; ventral carinae absent on segment I and well-marked on other segments, with spinoid granules on segments IV and V; other cari-

nae incomplete; intercarinal tegument moderately punctate. Vesicle with four vestigial carinae on ventral side; lateral and ventral sides weakly granulated; aculeus long compared to vesicle, wide at its basis. Pedipalp femur with five well-marked carinae; patella with four carinae; chela with vestigial carinae; dorsal and internal sides of femur well granulated; patella and chela moderately granulated except on internal side of chela where there are stronger granules; dentate margins on movable fingers with six slightly oblique rows of granules, separated by stronger accessory granules.

Genus *Guyanochactas* Lourenço, 1998

Guyanochactas flavus Lourenço & Ythier, 2011

Fig. 25

References. Lourenço and Ythier 2011.

Material. Roura-Cacao, Montagne Tortue, at the end of forested road of Bélizon, PK-27, under litter and/or log in trail, one male (holotype) and one female (paratype), deposited in the MNHN, J.P. Mauries & J.M. Betsch coll. 1/II/1992. Montsinéry-Tonnegrande, Anamites, one female (paratype), deposited in the MNHN, E. Ythier coll., XI/2010.

Diagnosis. Total length 38.2 mm for male holotype and 35 mm for female paratypes. General coloration reddish yellow to pale yellow. Carapace yellowish with some reddish yellow zones. Tergites yellowish, slightly paler than carapace, with one longitudinal reddish yellow strip. Venter and sternites yellowish; pectines and genital operculum paler than sternites. Metasomal segments yellowish, with reddish yellow zones over carinae. Vesicle yellowish; aculeus reddish yellow at the base and reddish at the tip. Chelicerae yellowish, without spots; fingers reddish yellow with reddish teeth. Pedipalps yellow to reddish yellow with dark reddish zones over carinae. Legs yellow. Carapace slightly emarginated, with minute granulations and punctations; furrows shallow. Tergites acarinate, with only minute granulations and punctations. Pectinal tooth 9–9 in male and from 8–8 to 10–10 in female. Sternites smooth and punctate; VII acarinate; sternite III on female with a strong setation; spiracles oval in shape. Metasomal segments I to III wider than long; metasomal tegument with moderately marked granulations and a few punctations; segment V with spinoid granulations ventrally; carinae on segments I–V moderately to strongly marked; ventral carina vestigial on segment I, weakly marked on II, moderately marked on III and strongly marked on IV. Pedipalp femur with dorsal internal, dorsal external and ventral internal carinae moderately to strongly marked; ventral internal carina with spinoid granules; ventral external carina weakly marked; all aspects with minute granulations; patella with minute granulations and punctations; dorsal internal, ventral internal, ventral external and external carinae moderately marked; other carinae vestigial; chela with weakly to moderately marked granulations; ventral and dorsal median carina moderately marked; other carinae weakly marked; internal aspect with spinoid granules; dentate margins on movable and fixed fingers with five rows of granules.



Figure 25. *Guyanochactas flavus*, female paratype from Anamites.

***Guyanochactas gonzalezspingai* (Lourenço, 1983)**

Fig. 26

References. Lourenço 1983, Fet et al. 2000, Lourenço & Pinto-da-Rocha 2000, Sologlad and Fet 2003, Prendini and Wheeler 2005, Stockmann and Ythier 2010, Lourenço and Ythier 2011.

Material. Antecume-Pata, in forest, one male (holotype), MNHN-RS-6276, one male (paratype), MNHN-RS-6270, one male (paratype) MNHN-RS-6277, one male (paratype) MNHN-RS-6278 and one female (allotype), MNHN-RS-6266, J.P. Gasc coll., 18/VII/1972.

Diagnosis. Species of large size compared to the average size of the other species within the genus (45.8 mm in total length for male holotype and 49.7 for female allotype). General coloration reddish yellow. Carapace dark reddish with several blackish spots, more concentrated in the central part of carapace; ocular tubercle dark, almost black. Tergites reddish, slightly paler than carapace, with several confluent lighter spots. Sternites reddish yellow, the last two ones darker; pectines and genital operculum yellow ochre. Metasomal segments reddish, with some blackish pigmentation on carinae. Vesicle reddish yellow; aculeus reddish at the base and reddish black at the tip. Chelicerae yellowish with longitudinal light brown spots; basis of finger and fingers dark brown. Pedipalps dark reddish with blackish pigmentation over carinae and chela fingers. Legs yellowish with diffuse light brown spots. Carapace slightly emarginated, the anterior third part strongly reduced; minute to medium granulation. Tergites with



Figure 26. *Guyanochactas gonzalezspingai*, male holotype from Antecume-Pata (photograph MNHN / E.-A. Leguin).

minute granulations; -several granules on posterior part, especially on sternite VII. Pectinal tooth 11–11 in male and 10–10 in female. Sternites smooth; spiracles oval in shape, almost rounded. All metasomal segments with dorsal, latero-dorsal and latero-ventral carinae well-marked; ventral carinae well-marked on segments III to V, weakly marked on II and absent on I; segment V with spinoid granulations ventrally. Vesicle flattened with ventral and lateral sides well granulated; aculeus short compared to vesicle. Pedipalp femur with five well-marked carinae; patella with four carinae; chela with weakly marked carinae; internal and dorsal sides of femur moderately granular; patella feebly granular; internal side of chela granular, other sides almost smooth; dentate margins on movable fingers with six rows of granules, separated by stronger granules.

Genus *Hadrurochactas* Pocock, 1893

Hadrurochactas cristinae sp. n.

<http://zoobank.org/D2AA5704-CB0C-462B-9487-688CA66B4327>

Figs 27–28

Type material. Roura, Stoupan, in litter, one male (holotype), deposited in the MNHN, Q. Uriot & S. Uriot coll., 2017.

Etymology. The specific name honours Dr. Cristina Benros-Ythier, Romanèche-Thorins, France, in recognition of her support for the study of scorpions.



Figure 27. *Hadrurochactas cristinae* sp. n., male holotype from Roura. Habitus, dorsal and ventral aspect.

Diagnosis. Total length 18.9 mm for male holotype (see morphometric values after the description). Coloration yellowish brown, densely spotted on the carapace, the tergites and the appendages. Mesosoma yellowish, densely spotted with confluent brown to dark brown spots, without yellowish longitudinal median stripe. Chelicerae yellowish with variegated brownish spots over the entire surface. Legs tarsal segments yellowish with diffused brownish pigmentation. Pectines with 9–9 teeth on male holotype; female unknown. Trichobothrial pattern of type C, neobothriotaxic (majorante) ‘major neobothriotaxy’.

Description based on male holotype. Coloration. General coloration yellowish brown, densely spotted on the carapace, the tergites and the appendages. Prosoma yellowish with brownish variegated spots on anterior, lateral and posterior edges; eyes surrounded by black pigment. Mesosoma yellowish, densely spotted with confluent brownish spots, darker on the posterior edge of the tergites; the remaining yellowish coloration does not form a confluent longitudinal median stripe. Sternites yellowish, the VII slightly darker; coxapophysis and sternum yellowish; genital operculum and pectines pale yellow. Metasomal segments yellowish to reddish yellow with brownish spots. Telson reddish yellow with brownish spots; aculeus reddish. Chelicerae yellowish with variegated brownish spots over the entire surface; fingers yellowish almost entirely covered with brownish spots; teeth reddish yellow. Pedipalps reddish yellow with brownish longitudinal stripes on femur, patella, and chela; femur darker than the other segments. Legs with femur, patella, and tibia yellowish with brownish longitudinal stripes; basitarsus and telotarsus yellowish with diffused brownish pigmentation.

Morphology. Carapace weakly granular to smooth; anterior margin very weakly emarginated; carinae absent; all furrows weakly pronounced; postero-median furrow finely granular; median ocular tubercle distinctly anterior to the center of the carapace; two pairs of small lateral eyes. All tergites with minute granulation and a few indistinct bigger granules on the posterior margin. Pectinal tooth count 9–9 in male holotype, fulcra absent. Sternites smooth and shiny except VI and VII which have some minute granulations; spiracles rounded; carinae absent; genital operculum longitudinally divided, each half with a sub-triangular shape. Dorsal carinae granular on metasomal segments I–IV, absent on segment V; dorsolateral carinae granular on all segments; ventrolateral and ventral carinae weakly pronounced or absent on all segments; dorsal surface smooth on all segments; lateral surfaces weakly granular to smooth on all segments; ventral surface smooth on segments I to IV; with some thin granules on V. Telson with small-sized spine-like granules and one larger spinoid granule under the aculeus; dorsal side smooth; aculeus relatively short and weakly curved. Pedipalp femur pentacarinata, moderately granular; patella and chela with weakly marked to un conspicuous carinae; fixed and movable fingers with seven rows of linear granules. Legs with long thin setae. Cheliceral dentition characteristic of the family Chactidae (Vachon, 1963). Trichobothriotaxy of type C, neobothriotaxic (majorante) ‘major neobothriotaxy’ (Vachon, 1974). Morphometric values (in mm) of the male holotype. Total length including telson, 18.9. Carapace: length, 2.3; anterior width, 1.3; posterior width, 2.4. Mesosoma length, 4.8. Metasomal segments. I: length, 0.9; width, 1.9; II: length, 1.2; width, 1.9; III: length, 1.2; width, 1.9; IV: length, 2.0; width, 1.9; V: length, 3.4; width, 2.2; depth, 1.4. Telson: length, 3.1; width, 0.9; depth, 0.6. Pedipalp: femur length, 1.9, width, 0.9; patella length, 2.3, width, 0.8; chela length, 3.7, width, 1.2, depth, 1.2; movable finger length, 2.2.

Relationships. *Hadrurochactas cristinae* sp. n. can be readily distinguished from the other species of the genus *Harurochactas* and, in particular, from *H. schaumii* (the only other species described from French Guiana), by the following main features: (i) smaller general size (21.1 to 26.5 mm in total length for *H. schaumii*), (ii) male

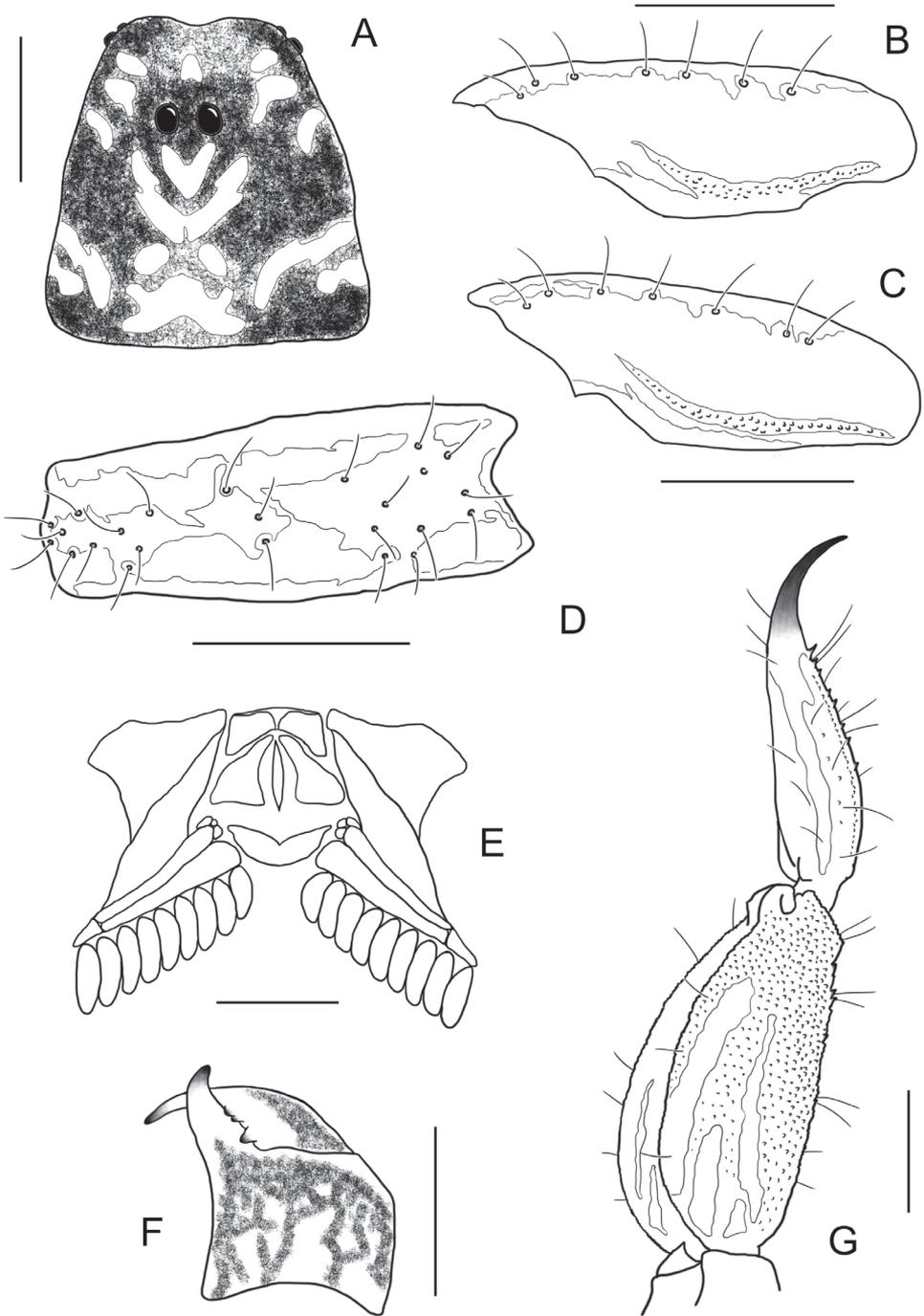


Figure 28. *Hadrurochactas cristinae* sp. n., male holotype. **A** Carapace **B–C** Patella, dorsal aspect of *H. cristinae* (**B**) and *H. schaumii* (**C**) **D** Patella, external aspect **E** Sternum, genital operculum and pectines **F** Chelicera **G** Metasomal segment V and telson, lateral aspect. Scale bars: 1 mm except chelicera 0.5 mm (**F**).

pectines with only 9–9 teeth (ranging from 10–11 in *H. schaumii*), (iii) general coloration yellowish brown (reddish brown in *H. schaumii*) without confluent yellowish longitudinal median stripe on mesosoma (reddish yellow longitudinal median stripe in *H. schaumii*), (iv) chelicerae yellowish with variegated brownish spots over the entire surface (without spots in *H. schaumii*), (v) legs tarsal segments yellowish with diffused brownish pigmentation (no pigmentation in *H. schaumii*), (vi) trichobothria on ventral side of pedipalp patella (V1 to V7) situated at different positions.

Hadrurochactas schaumii (Karsch, 1880)

Fig. 29

References. Karsch 1880, González-Sponga 1978, Lourenço 1988b, Fet et al. 2000, Monod and Lourenço 2001, Lourenço 2002a, Stockmann and Ythier 2010, Lourenço 2010.

Material. Downstream from Saut Pararé on Arataye River, Approuague tributary, one male and one female, MNHN-RS-7389, one female, MNHN-RS-7390, J.P. Gasc coll., IV/V/1979. Downstream from Saut Pararé on Arataye River, at base of *Astrocaryum paramaca*, two females, MNHN-RS-8509, J.P. Gasc coll., I/1981. Kaw, road to Kaw, Patawa, one female, deposited in the EYPC, EY0026, E. Ythier coll., 30/IX/2005. Cacao, beginning of Molokoi path, one male, deposited in the EYPC, EY0104, E. Ythier coll., 03–10/XI/2006. Mana, Laussat, white sand, leaf litter, pitfall, two males, deposited in the MNHN, LA15-0284-12, LA15-0304-18, J. Orivel, M. Fichaux, Jackie & N. Milhomme coll., 01/X/2015. Mana, Laussat, white sand, leaf litter, pitfall, two immatures, deposited in the MNHN, LA15-0151-13, LA15-0223-18, J. Orivel, M. Fichaux, Jackie & N. Milhomme coll., 28/VIII/2015. Saint Eugène Research station, on the Courcibo stream, tributary of Sinnamary River, two males and two females, deposited in the MNHN, J.-C. de Massary leg.

Diagnosis. Species of medium size when compared with the average size of the other species of the genus, ranging from 21.1 mm (male) to 26.5 mm (female) in total length. General coloration reddish brown. Carapace reddish with reddish brown spots. Tergites reddish brown with a confluent reddish yellow longitudinal median stripe. Venter and sternites light reddish brown; pectines yellowish. Metasomal segments reddish with brownish spots. Vesicle reddish; aculeus reddish at the base and black at the tip. Chelicerae yellowish without variegated spots over their entire surface, and with only a dark thin zone at the base of the fingers; fingers yellowish with reddish teeth. Pedipalps reddish brown with reticular brownish spots forming longitudinal stripes. Legs with femur, patella and tibia yellowish brown with dark brown spots; tarsal segments yellowish. Carapace densely covered with minute granulation with bigger granules in furrows and smooth areas mainly between the ocular tubercle and lateral eyes. Tergites with minute granulation in male, VII with bigger granules; tergites I–IV smooth and shiny in female. Pectinal tooth count ranging from 10–11 in male and from 8–10 in female. Sternites III/IV smooth and shiny in male, others with minute granulations; all sternites smooth



Figure 29. *Hadrurochactas schaumii*, male from Cacao.

and shiny in female; spiracles small and semi-oval in shape. Metasomal segments very strong in relation to the body; carinae only on dorsal and latero-dorsal sides; ventral side of metasomal segment I-IV in female and I-III in male smooth, the IV with fine granulation in male; segment V with ventral and lateral sides smooth in female and with granules in male. Telson smooth dorsally, granular with spinoid granules on lateral and ventral sides; aculeus weakly curved with a spinoid subaculear tooth. Pedipalp femur smooth in female and with granules on lateral sides in male, with five carinae; patella smooth and shiny, with three carinae; chela smooth and shiny, without granules and carinae; fingers about the same length as chela; fixed and movable fingers with seven rows of linear granules. Legs smooth, without granules and carinae.

Genus *Spinochactas* Lourenço, 2016

***Spinochactas mitaraka* Lourenço, 2016**

Fig. 30

References. Lourenço 2016a.

Material. Mitaraka South, 640 m, one female (holotype), deposited in the MNHN, J.M. Betsch leg., 15/III/2001.

Diagnosis. Total length 12.9 mm for female holotype. General coloration yellow to reddish yellow; only carapace and tergites are slightly marbled with brownish. Venter



Figure 30. *Spinobactas mitaraka*, female holotype from Mitaraka massif (photograph MNHN / E.-A. Leguin; 2016 Elsevier Masson SAS).

and sternites yellow; pectines pale yellow. Metasomal segments yellow. Chelicerae yellow without spots; fingers yellow with reddish teeth. Pedipalps yellow to reddish yellow. Legs pale yellow. Carapace lustrous and slightly punctate; carinae absent; furrows shallow. Tergites acarinate, with minute granulations only. Pectinal tooth count 6–6 in female. Sternites smooth and shiny; spiracles strongly reduced and rounded. Metasomal segments I to IV wider than long; metasomal tegument punctate except for some granulations on the ventral surface of segment V; ventral carinae absent from segments I to V; metasomal segments II to IV with dorsal and dorso-lateral carinae ending by a strong spinoid granule. Telson globular with a short aculeus; subaculear tooth or spine absent; some granulations present including on the dorsal side. Pedipalps slender with fingers strongly curved; femur with dorsal internal, dorsal external and ventral internal carinae moderately marked; ventral external carina vestigial; dorsal and ventral sides with minute granulations; internal side weakly granular; patella smooth and lustrous; dorsal internal, ventral internal, ventral external and external carinae weakly marked; other carinae vestigial; chela smooth and lustrous; carinae vestigial; internal side with granulations better marked on the base of fixed fingers; dentate margins on fixed and movable fingers with seven almost linear rows of granules, separated only by reduced internal accessory granules; edge of movable finger with three granules.

Family HORMURIDAE Laurie, 1896

Genus *Opisthacanthus* Peters, 1861

***Opisthacanthus heurtaultae* Lourenço, 1980**

References. Lourenço 1980, Lourenço 1983, Fet et al. 2000, Lourenço and Fé 2003, Lourenço 2017.

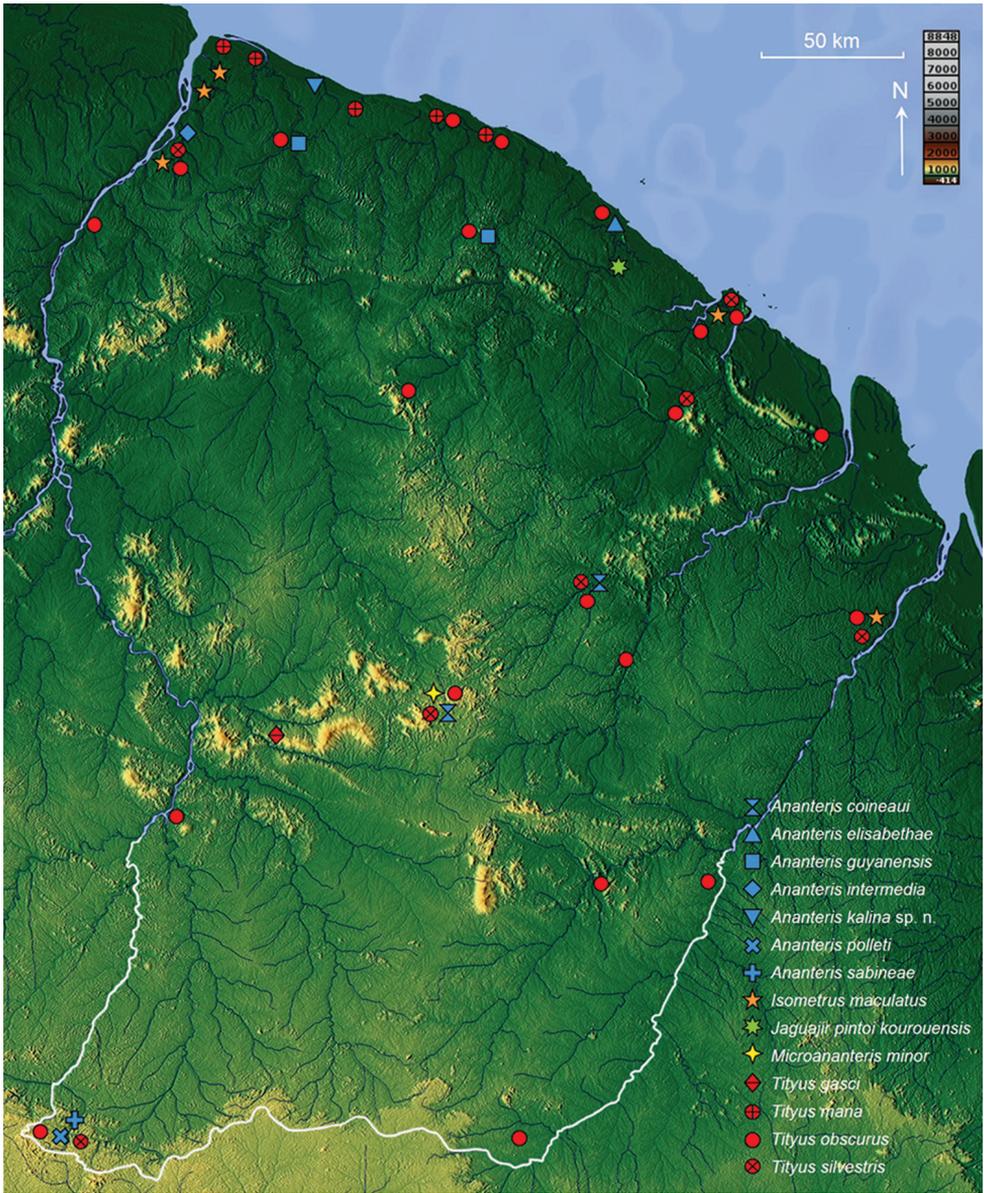


Figure 31. Topographic map of French Guiana showing the distribution of species of the family Buthidae.

Material. Degrad Saramaca, surroundings of Kourou, forest patches of Degrad path, one male (holotype), MNHN-RS-8085, mission M. Boulard & P. Pompanon coll., 18/VIII/1975.

Diagnosis. Total length 63.9 mm for male holotype. General coloration reddish brown. Carapace dark brown with some lighter zones; ocular tubercle slightly darker. Tergites dark brown with some lighter zones in the middle of tergites. Sternites greyish

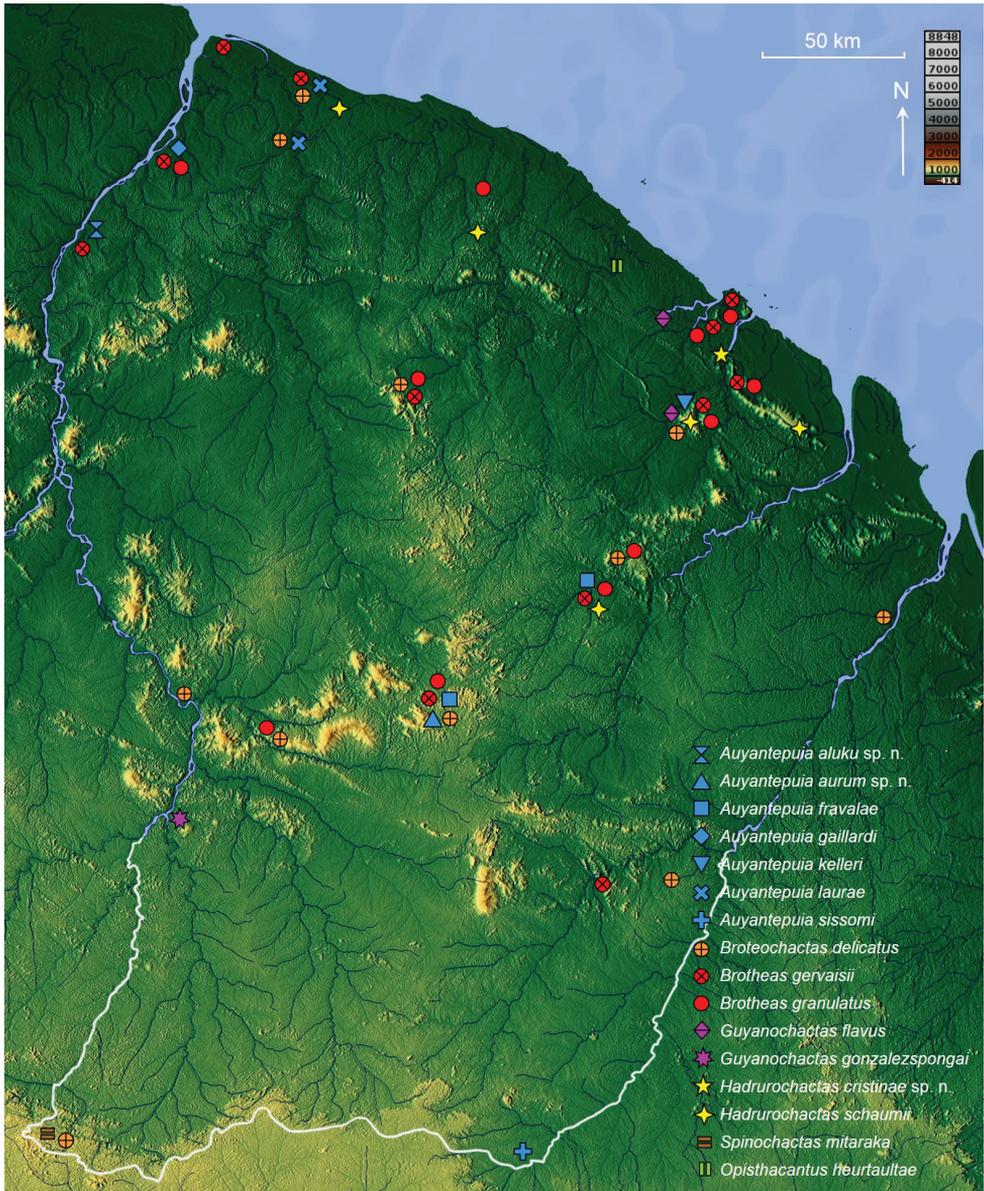


Figure 32. Topographic map of French Guiana showing the distribution of species of the families Chactidae and Hormuridae.

yellow, the VII darker; pectines and genital operculum greyish yellow, lighter than the sternites. Metasomal segments dark reddish brown with some lighter zones forming reddish yellow spots. Vesicle yellowish, darker around the articulation with metasomal segment V; aculeus yellowish at the base and reddish at the tip. Chelicerae dark yellow with reddish fingers. Pedipalps reddish brown with some darker zones; fingers darker. Legs reddish brown with some lighter spots, yellowish. Carapace strongly emarginated,

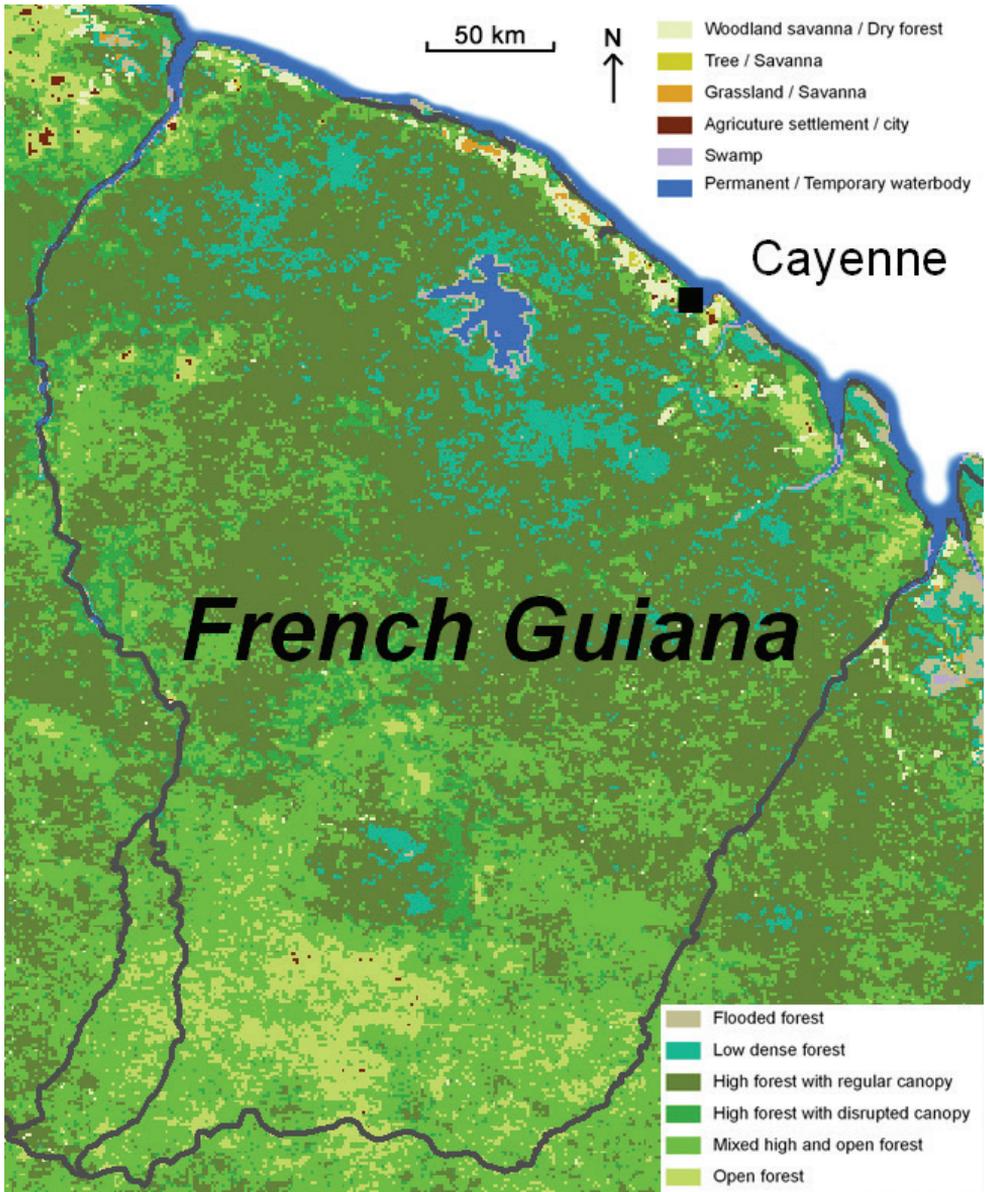


Figure 33. Vegetation map of French Guiana (modified from Gond et al. 2011).

with moderate granulation. Tergites with moderate granulation, better marked posteriorly. Pectinal tooth count 11–10 in male. Sternites smooth; spiracles linear. Metasomal segments rounded, all carinae weakly marked; segment V with spinoid granulations ventrally. Telson elongate, without any carinae; aculeus quite short compared to vesicle. Pedipalp femur with five carinae, four well-marked and one vestigial, intercarinal space smooth; patella and chela with several big granules forming incomplete carinae;



Figure 34. Lowland tropical rainforest habitat (Montsinéry-Tonnegrade, French Guiana).



Figure 35. Altitude tropical rainforest habitat (Saül, French Guiana).



Figure 36. Coastal dry forest habitat (Mana, French Guiana). Photograph J. Chevalier.



Figure 37. Coastal savanna habitat (Sinnamary, French Guiana).

chela long and flattened, dorsal and ventral sides smooth and shiny, lateral sides with strong granulations; fingers smooth, movable finger with a basal lobe. Numerous reddish yellow setae on the body, pedipalps, legs, and vesicle.

Key to the species of scorpions described from French Guiana

The following key is proposed for the 30 species described from French Guiana and presented in this work. This key is based on previous keys proposed by Lourenço (1983, 2002b). This key must be considered as imperfect, provisional and susceptible to possible exceptions, hence it is to be used with caution and should not be the only tool for identifying a specimen. If there is any doubt, more thorough diagnoses presented in this paper or even detailed descriptions (see publications indicated in the references) should also be consulted.

- 1 Sternum subtriangular; pedipalp tibia without ventral trichobothria.....
..... **Family Buthidae: 3**
- Sternum subpentagonal **2**
- 2 Retrolateral pedal spurs absent; anterior margin of carapace with a strong
concavity; three lateral eyes; three ventral trichobothria on the tibia.....
..... **Family Hormuridae, Genus *Opisthacanthus*, *O. beurtaultae***
- Retrolateral pedal spurs present; anterior margin of carapace without a strong
concavity; two lateral eyes in most species; four to seven ventral trichobothria
on the tibia **Family Chactidae: 16**
- 3 Dentate margins of pedipalp chela fingers composed of 6/7 longitudinal rows
of granules, without supernumerary granules **4**
- Dentate margins of pedipalp chela fingers composed of 8 to 17 oblique rows
of granules **12**
- 4 Presence of fulcra in the pectines..... **Genus *Isometrus*, *I. maculatus***
- Pectines without fulcra..... **5**
- 5 Small species; very small pectines (pectinal tooth count 10–10) with distal
teeth rounded **Genus *Microananteris*, *M. minor***
- Small to large species; pectines small to long (pectinal count ranging from 11
to 19), distal teeth not rounded **Genus *Ananteris*: 6**
- 6 Chelicerae with reticular pattern **7**
- Chelicerae without reticular pattern..... **10**
- 7 General coloration yellow to pale yellow; very small species (9 mm)
..... ***A. intermedia***
- Darker general coloration, brownish yellow; larger species (14–33mm) **8**
- 8 Chelicerae reticular pattern incomplete, only a dark brown spot anteriorly at
the base of fingers ***A. coineau***
- Reticular pattern complete, over the entire surface of the chelicerae **9**
- 9 Small pectines with only 11 to 12 teeth in males ***A. polleti***
- Pectinal tooth count 17–17 in males ***A. kalina* sp. n.**

- 10 General coloration pale yellow without spots or pigmented zones on the body and its appendages; movable fingers with six linear rows of granules..... ***A. elisabethae***
- General coloration brownish yellow marbled with dark reddish brown spots; movable fingers with seven linear rows of granules..... **11**
- 11 Movable fingers with one accessory granule present at the base of each row
.....***A. guyanensis***
- Movable fingers with two accessory granules present at the base of each row
.....***A. sabineae***
- 12 Dentate margins of pedipalp chela fingers composed of 8/9 oblique rows of granules, with supernumerary granules present in the adults.....
..... **Genus *Jaguajir*, *Jaguajir pinto* *kourouensis***
- Dentate margins of pedipalp chela fingers composed of 12 to 17 oblique rows of granules, without supernumerary granules **Genus *Tityus*: 13**
- 13 Small species ranging from 25 to 45 mm in total length with variegated pigmentation and a very rhomboidal subaculear tooth..... **14**
- Species of medium or large size, ranging from 63 to 100 mm in total length; pigmentation varying from yellowish to brown and black; spinoid subaculear tooth **15**
- 14 Dorsolateral keels of metasomal segments I to IV with a moderate spinoid posterior granule..... ***T. mana***
- Dorsolateral keels of metasomal segments I to IV without a spinoid posterior granule..... ***T. silvestris***
- 15 Species of medium size (63 mm in total length); coloration rather pale varying from yellowish to reddish brown or brownish, never black; basal middle lamellae of female pectines not dilated ***T. gasci***
- Large species, ranging from 75 to 100 mm in total length; pigmentation blackish in the adult and yellowish/variegated in immature individuals; basal middle lamellae of female pectines dilated ***T. obscurus***
- 16 Spiracles linear; tarsus with two rows of spines **Genus *Brotheas*: 28**
- Spiracles oval or round; tarsus with setae or rows of spines **17**
- 17 Tarsus with setae **18**
- Tarsus with rows of spines **Genus *Guyanochactas*: 29**
- 18 Small scorpions, from 13 to 28 mm in total length; spiracles round **19**
- Scorpions of medium size, from 44 to 50 mm in total length; spiracles round to round/oval **Genus *Broteochactas*, *B. delicatus***
- 19 Metasomal segments stocky in relation to the body, especially segments IV-V; fingers about the same length as chela hand **Genus *Hadrurochactas*: 20**
- Metasomal segments moderately stocky in relation to the body **21**
- 20 General coloration reddish brown, with a confluent yellowish longitudinal median stripe over the tergites; chelicerae yellowish without spots; male pectinal tooth count ranging from 10–11 ***H. schaumii***
- General coloration yellowish brown, without confluent yellowish longitudinal median stripe; chelicerae with variegated brownish spots over the entire surface; male pectinal tooth count 9–9 ***H. cristinae* sp. n.**

21 Pedipalp chela stocky; fingers shorter than chela hand...**Genus *Auyantepuia*: 22**
 – Pedipalp chela slender with fingers strongly curved; spinoid granules on dorsal and dorso-lateral carinae of metasomal segments II-IV.....
 **Genus *Spinochactas*, *S. mitaraka***
 22 Pedipalps with chelae weakly granulated, almost smooth **23**
 – Pedipalps with chelae moderately to strongly granulated **26**
 23 Ventral side of several metasomal segments yellowish, without spots **24**
 – Ventral side of all metasomal segments well pigmented, brownish to dark reddish..... **25**
 24 Posterior half of ventral side of segments I to IV yellowish, without spots; confluent yellowish longitudinal median stripe on tergites ***A. aluku* sp. n.**
 – Ventral side of metasomal segments I to III yellowish, without spots; no median stripe on tergites..... ***A. laurae***
 25 Body, pedipalps, legs and chelicerae without variegated brownish spots
 ***A. gaillardi***
 – Body, pedipalps, legs and chelicerae marked with variegated brownish spots.....
 ***A. kelleri***
 26 Ventral side of metasomal segments I to II yellowish, without spots; confluent yellowish longitudinal median stripe on tergites **27**
 – Ventral side of all metasomal segments well pigmented, brownish to dark reddish; no median stripe on tergites ***A. fravalae***
 27 General coloration reddish brown; metasomal tegument with medium size granulation on ventral side of segments III to V..... ***A. aurum* sp. n.**
 – General coloration yellowish; only metasomal segment V granulated ventrally ***A. sissomi***
 28 Carapace and tergites strongly granular; general coloration blackish brown...
 ***B. granulatus***
 – Carapace feebly granular; tergites punctate; general coloration reddish brown ***B. gervaisii***
 29 General coloration reddish yellow with some blackish spots; chela fingers with six rows of granules ***G. gonzalezspongai***
 – General coloration pale yellowish, without any dark spots; chela fingers with five rows of granules..... ***G. flavus***

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Descriptions of immature stages of *Octodonta nipae* (Maulik) (Coleoptera, Chrysomelidae, Cassidinae, Cryptonychini)

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Abstract

Octodonta nipae (Maulik, 1921), a hispid that damages several species of palm trees, was introduced accidentally into China in 2001. The egg, larva, prepupa and pupa of *O. nipae* are illustrated and described in detail and compared with another invasive species, *Brontispa longissima* (Gestro, 1885); the scanning electron micrographs of the head capsule, antenna, maxilla, labium and lateral scoli are provided, as well as photos of body of all larval instars and pupa. It is the second description of immature stages in the genus *Octodonta* Chapuis.

Keywords

comparative diagnosis, invasive species, morphology, SEM

* Joint first authors, these two authors contributed equally to the work.

Introduction

The genus *Octodonta* Chapuis, 1875 belongs to the tribe Cryptonychini (Chrysomelidae: Cassidinae), which contains eight species distributed in Southeast Asia and one species in Pupa New Guinea. *Octodonta nipae* (Maulik, 1921) is an invasive species which was introduced accidentally into Hainan, China in 2001 (Sun et al. 2003), and spread to Fujian in 2007 (Hou and Weng 2010, Hou et al. 2011, Tang et al. 2014a, 2014b, Tang and Hou 2017). *O. nipae* mainly attacks palm tree (Vassiliou et al. 2011, Staines 2017), such as *Nypa fruticans* Wurmb, *Areca catechu* Linn., *Metroxylon sagu* Rottb., *Washingtonia filifera* (Lindl.) H. Wendl. and *Phoenix canariensis* Chabaud, etc. (Maulik 1937, Sun et al. 2003, Li et al. 2014, 2016, Meng et al. 2016). In most cases the beetle feeds on young leaves that do not open or on those that open widely (Steiner 2001, Hou et al. 2014a, 2014b). This causes the young stems to shrink, curl, or die (Zhang 2003). Effective pest control is hard to achieve, because the pest lives within the leaves of the palm and is therefore hard to reach with contact insecticides (Hou and Weng 2010, Hou et al. 2011, Xu et al. 2011, Xi et al. 2013, Feng and Hou 2015).

Many larvae and pupae in the subfamily Cassidinae have been described in detail (Maulik 1938, Gressitt 1960a, 1960b, Ford and Cavey 1985, Borowiec and Świętojańska 2003, Świętojańska et al. 2005, 2006, 2013, 2015, Świętojańska and Borowiec 2007, Świętojańska and Kovac 2007, Świętojańska and Medeiros 2007, Świętojańska and Windsor 2008, Liao et al. 2018), in the genus *Octodonta*, larvae of *O. korthalsiae*, *O. subparallela*, *O. maffinensis* were keyed and described by Gressitt (1960a); and preimaginal stages of *O. depressa* were described by Zaitsev (2006). As the only *Octodonta* species in China, the immature stage of *O. nipae* is still not described in detail, and we found *O. nipae* resembles another invasive species, *Brontispa longissima* (Gestro), especially in the immature stages. Although the morphological and molecular characteristics between *B. longissima* (Gestro) and *O. nipae* were compared (Chen et al. 2015, Zhang et al. 2015) immature stages of these species have not yet been compared. Here we describe the egg, larva and pupa of *O. nipae*, and pupa of *B. longissima*, in order to provide diagnostic characters for the identification of this invasive species which will allow us to differentiate it from *B. longissima* and other species of *Octodonta*.

Material and methods

Adults of *O. nipae* were initially collected from Fuqing Entry-Exit Inspection and Quarantine Bureau, Fujian Province, China in October, 2007 (Hou and Weng 2010). Subsequently, a colony was established in a laboratory at the College of Plant Protection, Fujian Agriculture and Forestry University. The beetles were reared on center leaves of *Trachycarpus fortunei* (Hook.) H. Wendl. in plastic bottles (diameter 70mm, height 105mm; Jiafeng Horticultural Products Co. Ltd, Fuzhou, China) with moist filter paper to minimize desiccation stress. So far 21 generations have been reared in the laboratory. Larvae of *B. longissima* were collected from Zhangzhou, Fujian Province,

China in November 2017. 165 *O. nipae* (eggs, larvae, prepupae, and pupae) and 31 prepupae of *B. longissima* were examined.

The descriptions and illustrations of *O. nipae* egg, larva, prepupa and pupa are based upon laboratory reared individuals. Seta of head description follow Borowiec and Świętojańska (2003), forms of description follow Świętojańska and Kovac (2007) and Świętojańska et al. (2015). Photographs of the specimens were made using a Leica MC170 HD digital camera attached to a Leica M165C microscope. Images were produced using the software Zerene Stacker (Zerene Systems LLC, USA). Drawings were traced from images captured with the camera, then edited with the software Photoshop CS2. For the SEM scanning, the specimens were cleared in xylene for 5 hours, then washed in distilled water. Before dehydration through a graded ethanol series, they were cleaned in an ultrasonic cleaner for one minute, then put in a critical point-drier and held using double-sided adhesive tape and coated with gold in a sputter coater. Examinations were done with a JEOL JSM-6380 LV SEM and HITACHI SU3500.

Measurements are given in millimeters as mean \pm SD. Data were analyzed with the SPSS Statistics Version 13.0 for Windows (Table 1).

Results

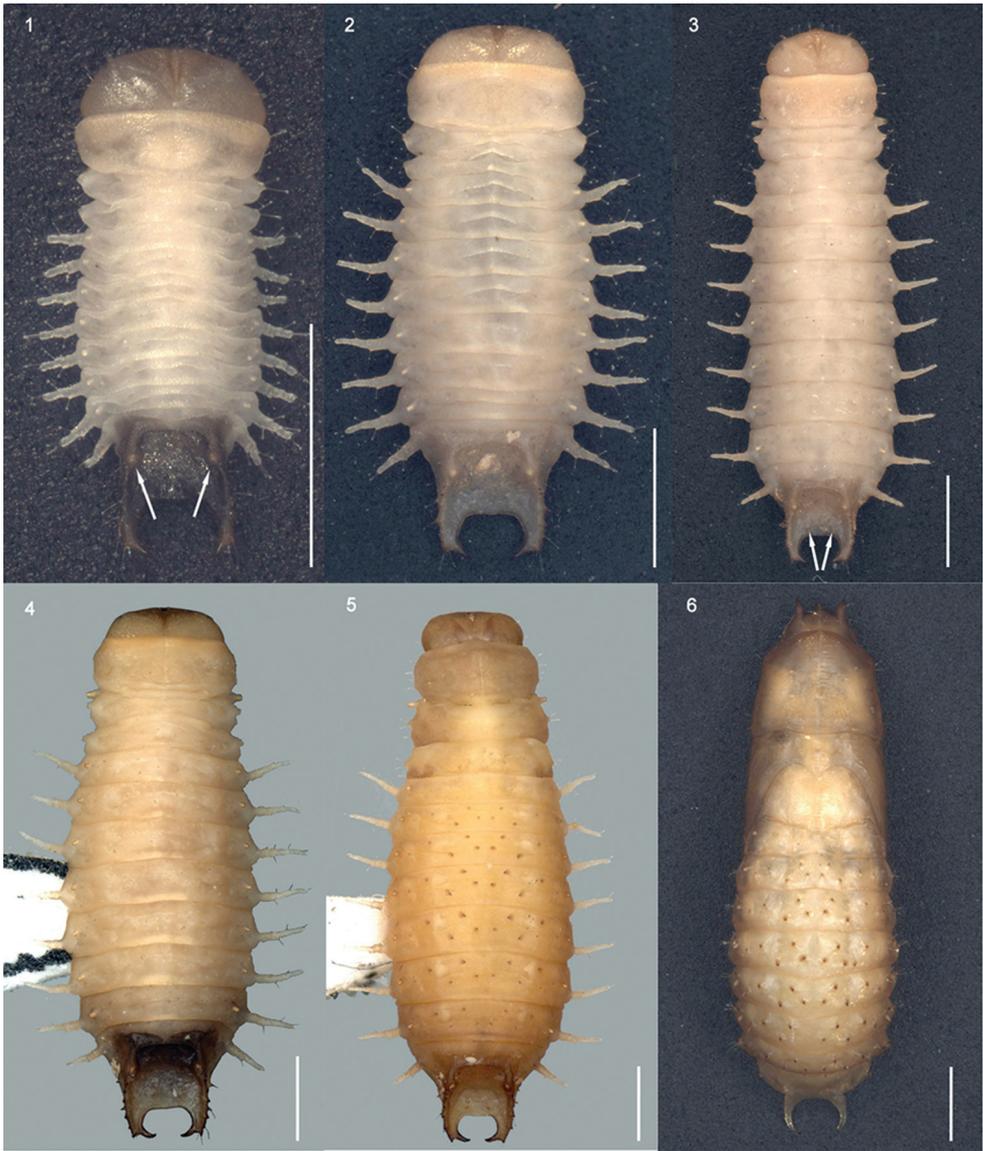
Egg of *O. nipae* (Figs 7–9)

Length 1.4 ± 0.31 mm, width 0.5 ± 0.21 mm. The female adults usually lay eggs in pairs, rarely in triplets or as a single egg. The eggs are surrounded by a sticky secretion and covered with debris and excrement. The newly laid eggs are generally ivory-white, covered with a milky-white soft secretion. After several hours, the eggs turn brown and the secretion becomes sclerotized (Fig. 7). Egg are elongate-oval. The egg chorion is covered with raised networks of ridges (Fig. 8), and the two adjoining polygonal cells share the same ridge (Figs 8–9). The anterior pole of the chorion has smaller cells and taller ridges than the lateral chorion (Fig. 8).

First instar of *O. nipae* (Figs 1, 10)

Length 3.0 ± 0.53 mm, width 1.2 ± 0.26 mm. Body flattened dorso-ventrally, lateral margins moderately paralleled, the widest (without lateral scoli) across prothorax (Fig. 1), body surface finely granulate. Head light brown, mandibles dark brown, each lateral side of head with five stemmata and small pigmented spot. Three stemmata distinct round and black placed near antenna, other two partly pigmented (Fig. 10); thorax and abdominal segment I to VII translucent-white, abdominal segment VIII brown or dark brown (Fig. 1).

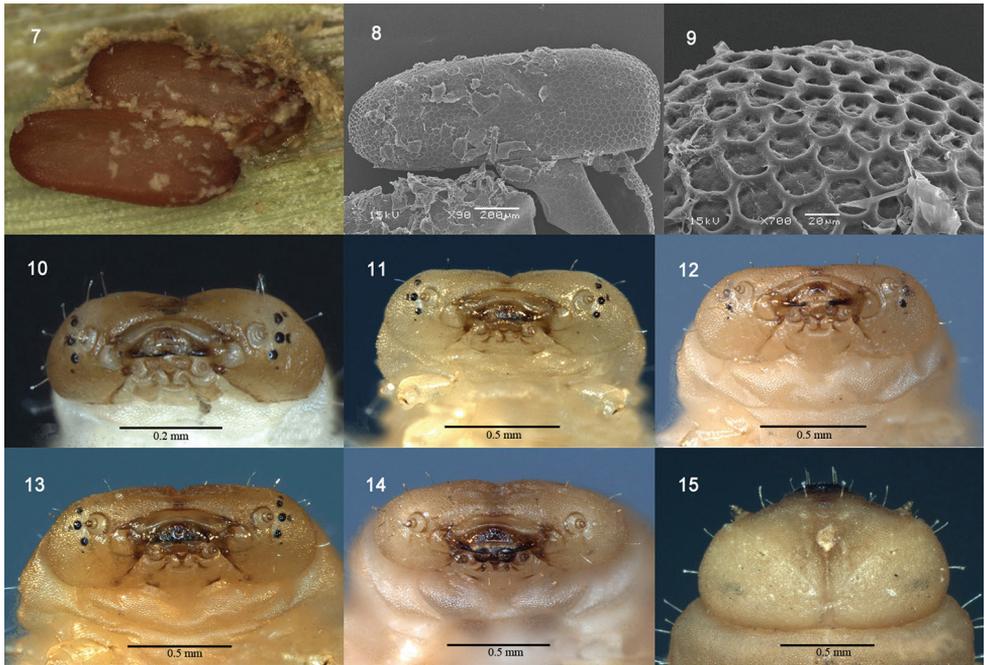
Abdomen with eight pairs of lateral scoli on segments I to VIII, and a single pair of supra-anal processes. All lateral scoli not branched, slender and tapering, bearing six



Figures 1–6. *Octodonta nipae* (Maulik) body dorsal view. **1** first instar (spiracles are indicated) **2** second instar **3** third instar (tubercles are arrowed) **4** fourth instar **5** prepupa **6** pupa. Scale bar: 1mm.

club-like setae. Distal segment with supra-anal processes caliper-like hooked, slightly sclerotized, curving slightly inward, each hook with three to four upward directed tiny teeth from base to apex, each teeth with a club-like seta apically.

Spiracles distinctly elevated, round; abdominal spiracles much smaller than meso-thoracic spiracle, spiracle of abdominal segment VIII located in inner flank of carina (Fig. 1, arrows indicated).



Figures 7–15. *Octodonta nipae* (Maulik). **7** eggs **8** egg **9** surface of egg **10** head of first larva, front view **11** head of second instar, front view **12** head of third instar, front view **13** head of fourth instar, front view **14** head of prepupa, front view **15** head of prepupa, dorsal view.

Table 1. Measurements (mean value) of each life stage of *O. nipae* and prepupae of *B. longissima*.

Life stage	Number of specimens	Length of body (mm)	Width of body (mm)
Eggs	37	1.4 ± 0.3	0.5 ± 0.2
1 st -instar larvae	17	3.0 ± 0.5	1.2 ± 0.3
2 nd -instar larvae	29	4.5 ± 1.0	1.9 ± 0.5
3 rd -instar larvae	24	6.8 ± 0.7	2.8 ± 0.3
4 th -instar larvae	28	7.7 ± 0.4	3.2 ± 0.2
Prepupae	17	7.3 ± 0.1	3.2 ± 0.3
Pupae	13	8.6 ± 0.5	2.9 ± 0.3
Prepupae of <i>B. longissima</i>	31	8.99 ± 0.4	2.3 ± 0.2

Prothorax transverse, slightly wider than head, anterior margin convex, surface lightly sclerotized and finely granular; five short setae positioned at lateral margin, three long setae inserted at each ventro-lateral margin. Mesothorax much shorter than prothorax; lateral bulge distinct, bearing two long club-like setae, another long club-like seta on each postero-lateral side (Fig. 1); spiracle elevated, visible in ventral view. Metathorax as long as mesothorax, without spiracle, lateral bulge distinct (Fig. 1).

Head well sclerotized, slightly narrower than prothorax, partially retracted into prothorax (Fig. 1). Epicranial stem absent; median endocarina complete and wide ex-

tending between two distinct frontal arms, from close to the center of the posterior margin up to the position of the antenna; fronto-clypeal suture present, clypeo-labral suture present. Clypeus distinct, much wider than long. Antenna very short, three-segmented set in membranous ring, anterolaterally directed; segment I and II ring-like, one large sensorial appendage inserted ventrally on segment II, below segment III; segment III parallel-sided and as long as the sensorial appendage (Fig. 10). Five stemmata positioned behind the antenna, four of them in a row, another one positioned further back, pigmented spot placed below row of four distinctly marked stemmata (Fig. 10). Labrum sclerotized, wider than long, six setae positioned dorsally, anterior part with thick stout curve spines.

Second to fourth instar of *O. nipae* (Figs 2–4, 11–13)

Body length 4.5–7.7 mm, width 1.9–3.2 mm (Table 1). Abdomen wider than head and thorax. Head capsule much wider than long, anterior margin convex and evenly rounded laterally, finely granular. Supra-anal processes strongly carinate and sclerotized, curving slightly inward, each dorsal carina with four to six upward directed large teeth from base to apex, lateral carina bearing with two to four large teeth; two setae positioned on tiny tubercle near inner margin of processes (Fig. 3, arrow indicated).

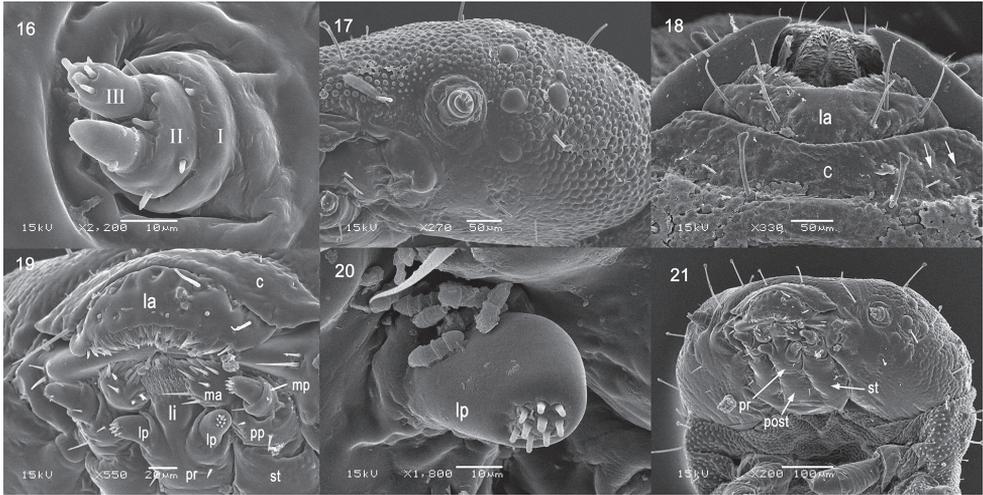
Prepupa of *O. nipae* (Figs 5, 14, 15, 16–45)

Length 8.0 ± 0.42 mm, width 3.4 ± 0.32 mm. Head light brown, mandibles black, labrum dark brown, stemmata concolorous with surrounding area, no pigment (Fig. 14); thorax and abdominal segment I to VII light brown, anterior margin and lateral scoli of abdominal segment VIII brown, last segment brown or dark brown (Fig. 5); each abdominal tergum II to VII with ten dark brown sclerotized spines (Fig. 5).

Body flattened dorso-ventrally, elongate-oval, widest across abdominal segment V. Abdomen with eight pairs of lateral scoli and a pair of short supra-anal processes (Fig. 5). Lateral scoli slender and tapering, finely denticulate (Figs 5, 33) and bearing six long club-like setae (Fig. 25). Supra-anal processes caliper-like hooked, strongly carinate and sclerotized, each dorsal carina with five to six upward directed large teeth from base to apex, lateral carina bearing three to four large laterally directed tubercles with setae at apex, two setae positioned on tiny tubercle near inner margin of processes (Fig. 34, arrow indicated).

Setae of head club-like, blunt apically or pointed, club-like setae more or less of the same length with scoli setae, but some setae of head very short (Figs 22, 23, 27, 28). Setae of tergites short and pointed (Figs 35–38). Setae of legs club-like or long pointed (Fig. 43).

Dorsal side of prothorax with five pairs of tiny pointed setae (Figs 35, 44), four pairs arranged in row near posterior margin, one pair near middle of tergite; three



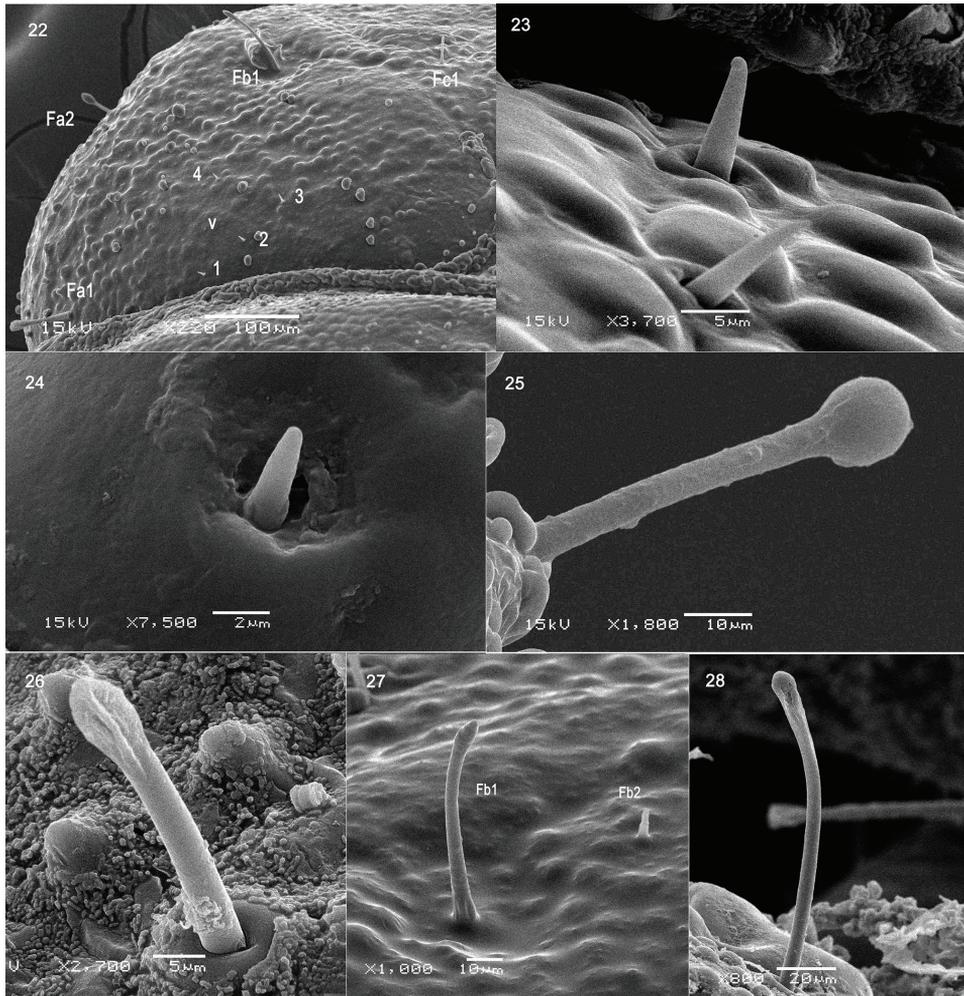
Figures 16–21. Prepupa of *Octodonta nipae* (Maulik). **16** antenna **17** head, latero-front view **18** clypeus and labrum **19** mouthpart, ventral view **20** labial palp **21** head, ventral view. Abbreviations: c – clypeus; la – labrum; lp – labial palp; li – ligula; ma – mala; mp – maxillary palp; post – postmentum; pp – palpifer; pr – prementum; st – stipes.

pairs of blunt apical setae near anterior margin; five pairs of club-like setae along lateral margin. Dorsal side of mesothorax with five pairs of tiny pointed setae arranged in row along posterior margin (Figs 36, 44); three blunt apical setae near bulge and spiracle; three long club-like setae along lateral margin, two of them on the bulge and one behind the bulge. Dorsal side of metathorax with nine pairs of tiny pointed setae (Figs 37, 38, 44), two pairs positioned antero-quarterly of anterior margin, four pairs arranged in row along middle of tergite, three pairs of tiny pointed setae and one blunt apical setae arranged in row along postero-lateral margin; four pairs of club-like setae along lateral margin. Terga II to VII with ten setae placed on tubercles (Figs 5, 44): one pair near spiracle, two pairs near anterior margin, one pair near posterior margin, and another pair positioned centrally.

Nine pairs of spiracles (Fig. 5): one pair on the mesothorax and eight on abdomen. Mesothoracic spiracle tubular and distinct (Figs 5, 29), positioned laterally just behind prothorax; abdominal spiracles small, inner wall of spiracles finely granulate, entrance opened (Figs 30, 31). Spiracle of last segment abdomen round, larger than other abdominal spiracle, located in inner flank of dorsal carina (Figs 32, 34).

Head (Figs 14, 15, 17, 44) well sclerotized, shallowly retracted into prothorax, distinctly wider than long, but narrower than prothorax, lateral margin strongly rounded; dorsal surface finely granular, median endocarina well developed, widening and deepening from posterior margin to clypeal posterior margin, frontal arms extending from close to the center of the posterior margin up to the position of the antenna.

Stemma (Figs 14, 17). Position of stemmata similar with younger instars. All the stemmata concolorous with surrounding area, pale brown (Fig. 14).

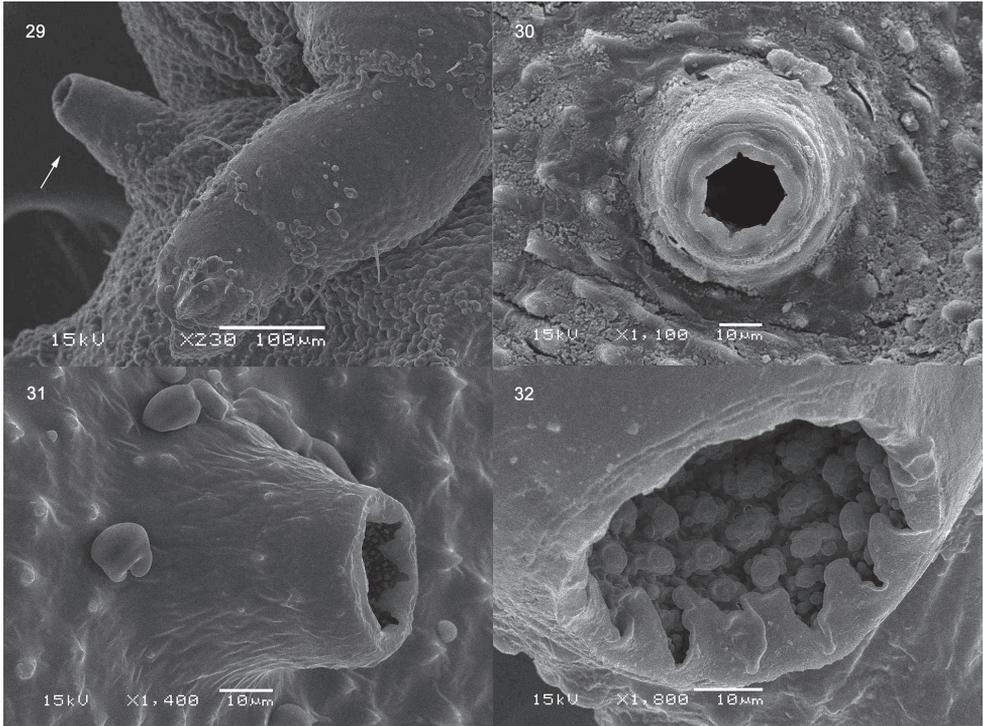


Figures 22–28. Prepupa of *Octodonta nipae* (Maulik). **22** part of head, dorsal view **23** vertical setae of head **24** setae of antenna **25** seta of scolus **26** seta of abdomen **27** seta of head (Fb1, Fb2) **28** seta of head (Fc2). Abbreviations: Fa/b/c – frontal setae, row a/b/c; v – vertical setae.

Head with numerous setae, distribution of setae as shown in Figure 40.

Antenna (Figs 16, 24, 41). Antenna very short, three-segmented, anterolaterally directed set in membranous ring; segment I ring-like, with one tiny seta placed laterally (Figs 16, 41); segment II slightly wider than long, with one large conical sensory appendix apically, three setae laterally (Fig. 24) and one small peg-like sensillum placed between sensory appendage and antennal segment III; segment III as long as segment II, apical portion with six peg-like sensilla (Figs 16, 41).

Labrum bent down (Figs 18, 19), connected with the anterior clypeal margin, narrower than clypeus. Anterior margin with tufted setae, outer surface of labrum with six long pointed setae (Fig. 18).



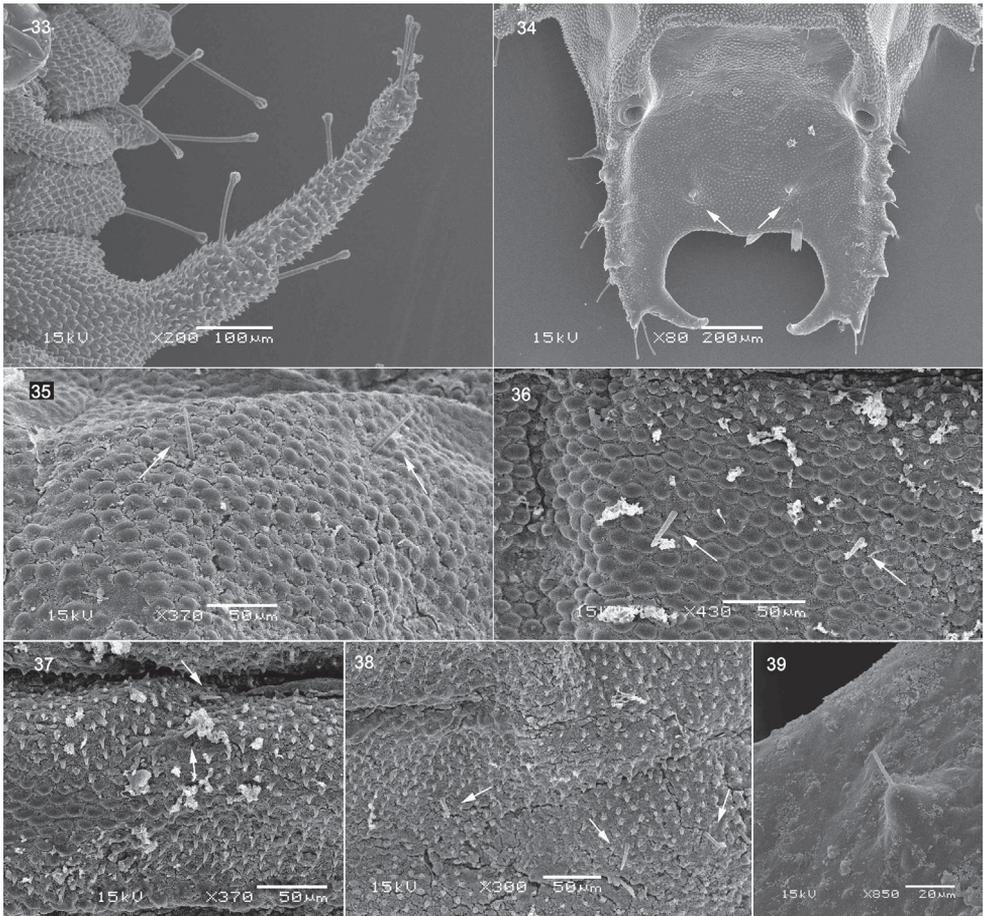
Figures 29–32. Prepupa of *Octodonta nipae* (Maulik). **29** proleg and spiracle of mesothorax **30** spiracle of abdomen **31, 32** spiracle of last abdominal segment.

Clypeus narrow and wide (Fig. 18), moderately sclerotized, arched in front view, anterior and posterior margin parallel. One blunt apical seta and one tiny pointed seta positioned latero-posterior (Fig. 18, arrows pointed).

Mandible heavily sclerotized (Figs 18, 42), triangular, short and compact, with three apical teeth; inner side of mandible sharp, dorsal side of mandible convex, dorso-lateral side with one long and one short pointed seta (Figs 19, 42).

Maxilla with stipes long (Fig. 19), bearing two lateral setae. Mala larger than maxillary palp (Fig. 19), directing buccal cavity, with a large cluster of setae apically, seven long pointed setae below the cluster setae. Palpifer short (Fig. 19), with two setae, medial seta distinctly longer than lateral one. Maxillary palp short (Fig. 19), segment I cylindrical, with two setae, segment II conical, longer than segment I, three setae positioned flank, apical area with 11 sensilla. Labial palp one segmented (Figs 19, 20), finger-like, apex with a group of nine peg-like sensilla. Hypopharynx apex covered with numerous spines (Fig. 19). Submentum and mentum fused with basal portion of maxilla, one pair of setae near lateral margin of postmentum (Fig. 21). Prementum narrow with two short pointed setae (Fig. 21). Postmentum with two long pointed setae (Fig. 21).

Leg three-segmented (Figs 29, 43); coxa much wider than long, with setae arranged in three rows: first with two setae, second with three setae, third with two setae



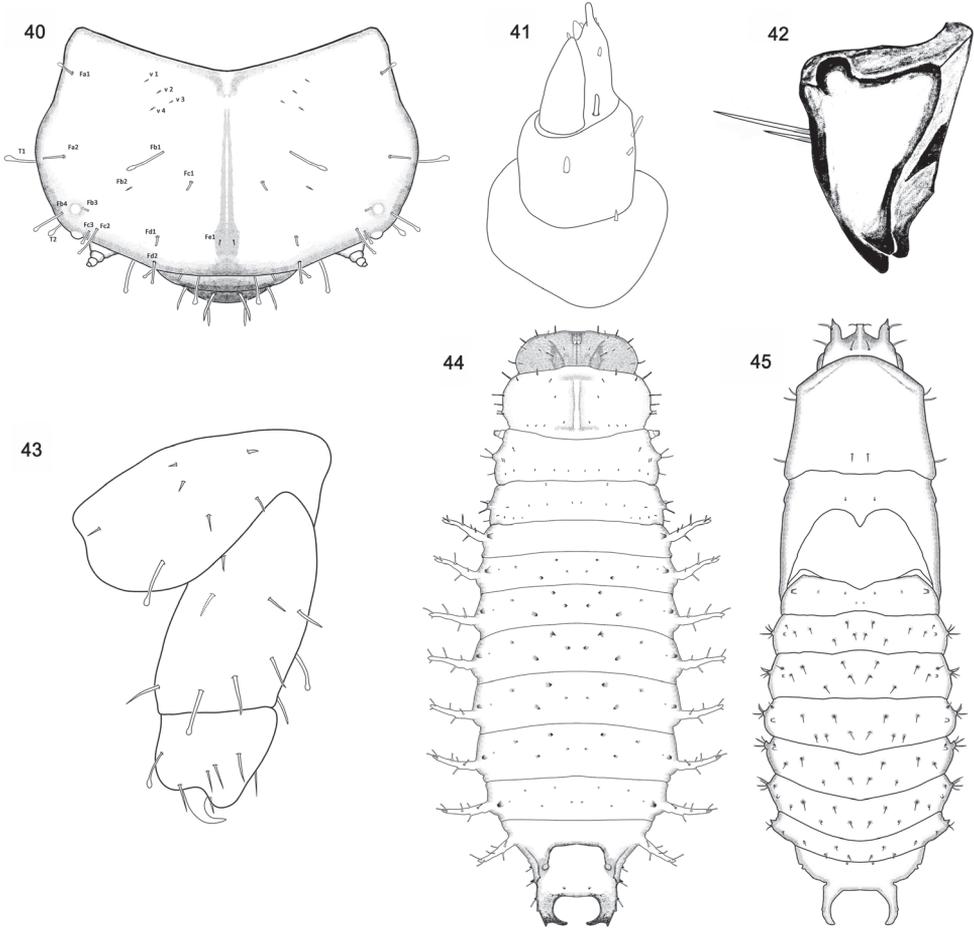
Figures 33–39. Prepupa of *Octodonta nipae* (Maulik). **33** scolus; **34** supra-anal process (showing the setae) **35** setae of prothorax **36** setae of mesothorax **37, 38** setae of metathorax **39** seta of supra-anal process.

and one club-like seta; femur 1.6 times longer than wide, with seven long setae, two club-like setae, and one short seta close to the base, as show in figure 43; tibiotarsus stout, apically with one heavily sclerotized and curved single claw, armed apically six long setae around claw, and one club-like seta at middle.

Pupa of *O. nipae* (Figs 6, 45–47)

Length 8.6 ± 0.51 mm, width 3.6 ± 0.34 mm. Body long oval, exarate, flattened dorso-ventrally; body straight from apex of head to abdominal segment III, bent ventrally at abdominal segment IV (Figs 46, 47). Color light brown, eyes dimly black (Fig. 47).

Head with three stout processes in dorsal view, one central process with apex truncated and bearing two lateral setae (Fig. 45); two lateral processes positioned laterally,

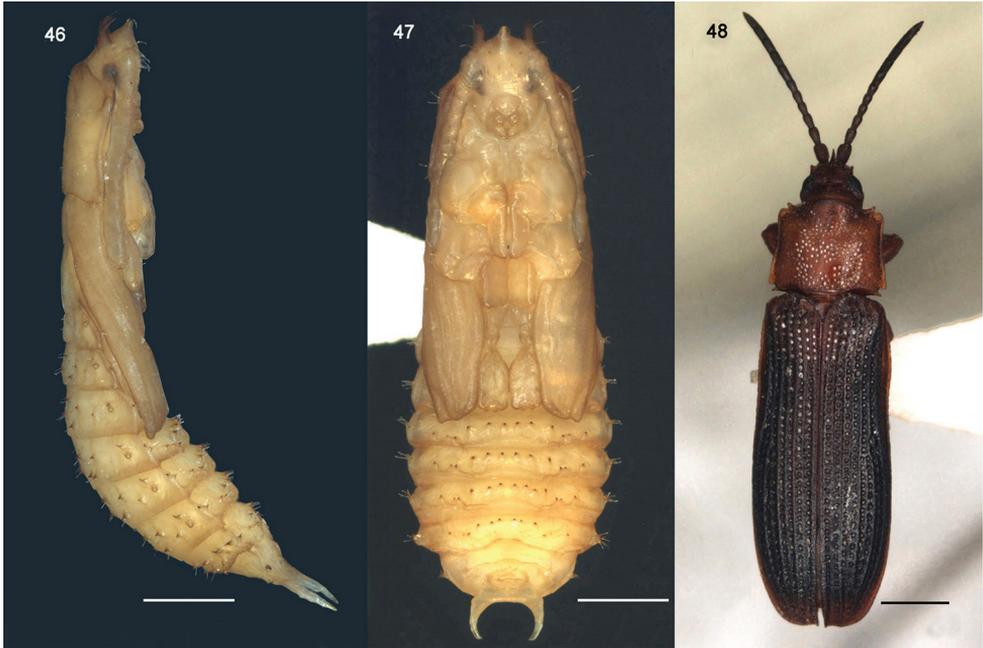


Figures 40–45. *Octodonta nipae* (Maulik). **40** frontal side of head **41** antenna **42** mandible **43** leg **44** prepupa, dorsal view **45** pupa, dorsal view.

with apex acute and bent ventrally, one lateral setae inserted near apex (Fig. 45). In ventral view, eyes, antennae, labrum, mandibles, and maxilla discernible (Fig. 47).

Pronotum large, shield like, anterior margin convex, lateral margin truncate with three setae, two anterior and one posterior, posterior margin slightly sinuate; one pair of setae positioned centrally on posterior disc (Fig. 45). Mesonotum with lateral margin slightly sinuate, elytral theca closely appressed with wing theca, curved ventrally around body, extending to abdominal segment IV (Figs. 6, 45–47). Leg theca stout, closely appressed with body, metapedes not extending beyond apex of elytral theca (Fig. 47).

Abdominal segment I to VIII visible in dorsal view, each segment with one pair of spiracles, and a large number of hooked spines and setae (Figs 6, 45). Tergum of first segment with six small spines (Fig. 45). Tergum II to VII marked with eight pairs of hooked



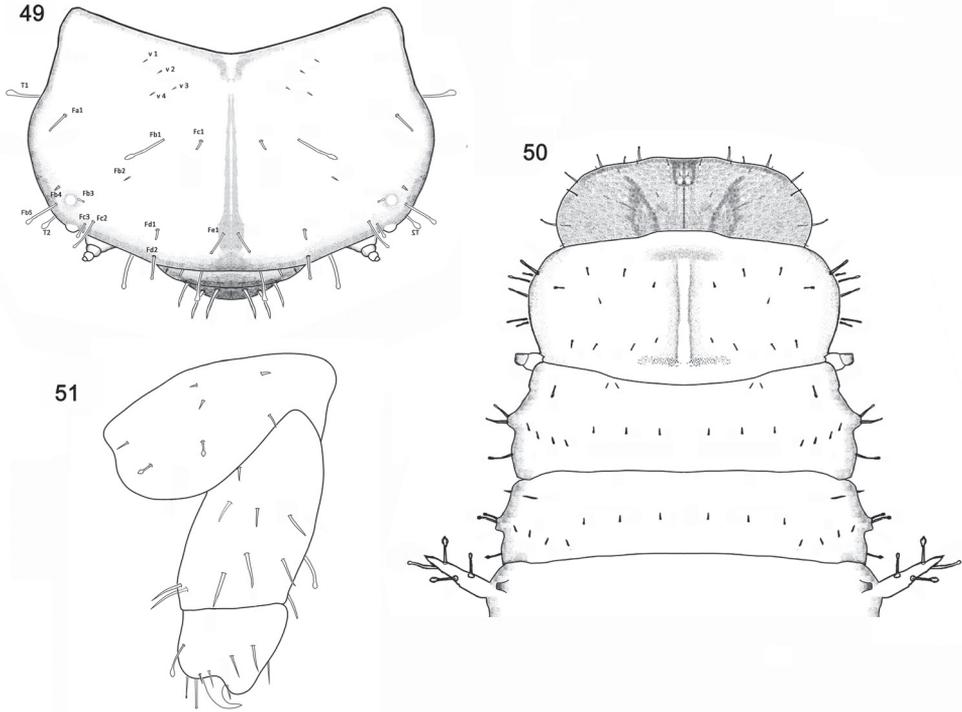
Figures 46–48. *Octodonta nipae* (Maulik). **46** pupa, lateral view **47** pupa, ventral view **48** adult, dorsal view.

spines, five pairs located between two spiracles, each spine bearing one seta (Fig. 45); one pair of spines near spiracle which bears one seta (Fig. 45); two pairs of spines positioned on the lateral margin of tergum, one directed dorsally and one directed ventrally, each of them bearing two setae (Fig. 45). Tergum VIII with supra-anal processes long hooked (Fig. 45), spiracles of tergum VIII in same locality as in larva. Sternum IV to VIII visible, sternum IV to VII bearing 12 hooked spines; sternum VIII without spine, anus positioned centrally, transverse and oval shape, last abdominal segment slim and soft (Figs 45–47).

Prepupa of *B. longissima* (Figs 49–60)

Body elongate, flattened dorso-ventrally. Abdomen with eight pairs of lateral scoli and a pair of short supra-anal processes (Fig. 59). Lateral scoli short and tapering, finely denticulate and bearing four long club-like setae (Fig. 58). Supra-anal processes caliper-like hooked, strongly carinate and sclerotized, each dorsal carina with five to seven upward directed large teeth from base to apex, lateral carina bearing three to four large laterally directed tubercles with setae at apex (Fig. 59).

Most setae of head hair-like or club-like, blunt apically or pointed, but some setae of head very short (Fig. 57). Setae of tergites short or long, pointed, blunt or club-like (Fig. 52). Setae of legs club-like or long pointed, two setae positioned on tiny tubercle at inner margin of processes (Fig. 59)

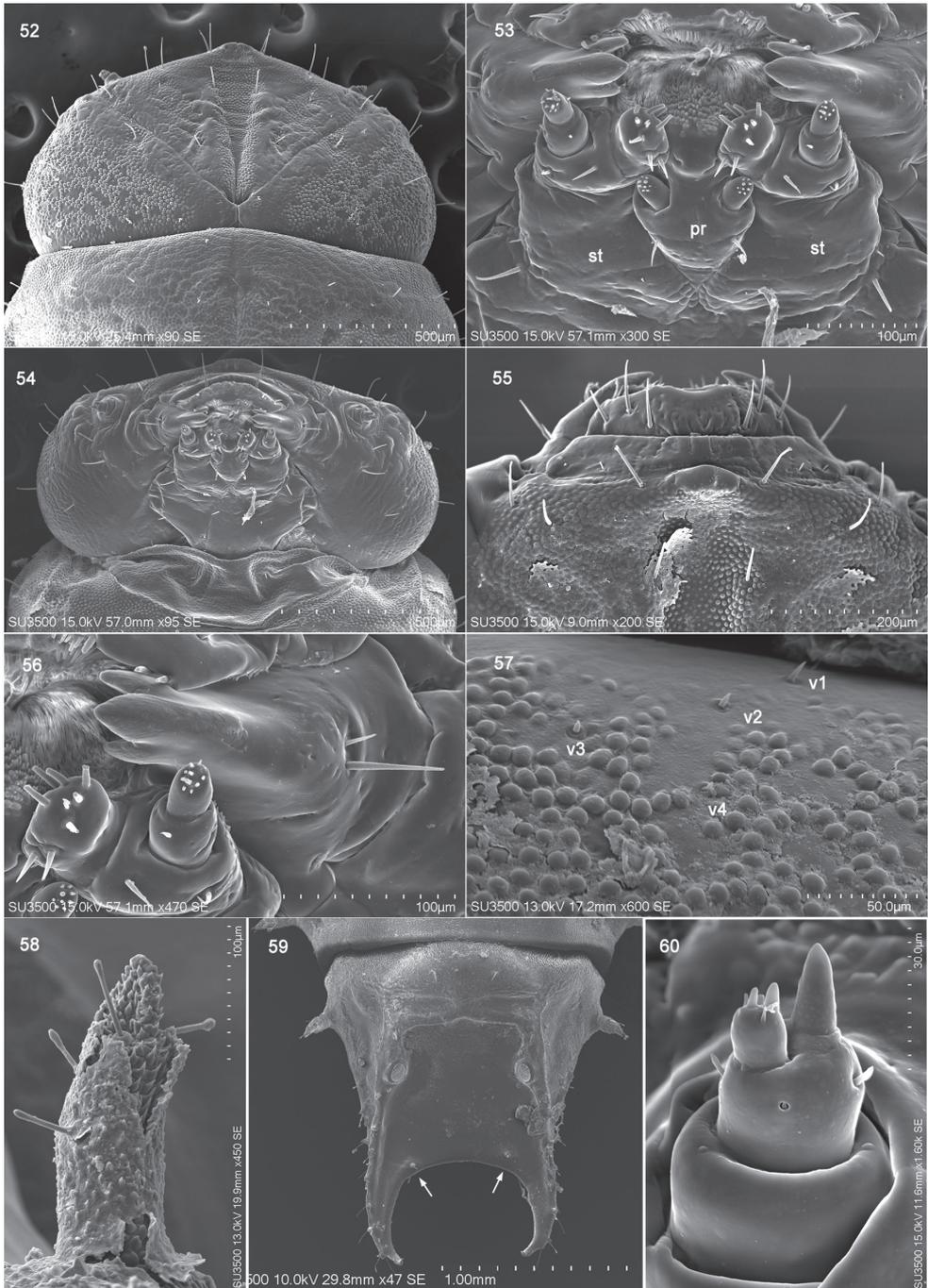


Figures 49–51. *Brontispa longissima* (Gestro). **49** frontal side of head **50** head, thorax and 1st segment of abdomen, dorsal view **51** leg.

Dorsal side of prothorax with four pairs of pointed setae arranged in row near posterior margin, one pair near middle of tergite; four pairs of blunt apical setae near anterior margin; six pairs of club-like setae along lateral margin (Fig. 50). Dorsal side of mesothorax with four pairs of pointed setae arranged in row posterolaterally; three pairs of pointed setae arranged in row near middle of tergite; two pairs of tiny pointed setae near anterior margin; one pair of blunt apical setae positioned anterolaterally; three long club-like setae along lateral margin, two of them on the bulge and one behind the bulge (Fig. 50). Dorsal side of metathorax with seven pairs of tiny pointed setae (Fig. 50), four pairs arranged in row posterolaterally; three pairs arranged in row along middle of tergite; one pair of blunt apical setae positioned near anterolaterally; three pairs club-like setae and one pointed seta along lateral margin (Fig. 50).

Nine pairs of spiracles: one pair on the mesothorax and eight on abdomen. Mesothoracic spiracle tubular and distinct (Fig. 50) laterally positioned between pro- and mesothorax; abdominal spiracles small. Spiracle of last segment abdomen round, larger than other abdominal spiracle, located in inner flank of dorsal carina (Fig. 59).

Head (Figs 49, 52) distinctly wider than long, but narrower than prothorax; dorsal surface finely granular, median endocarina well developed, widening and deepening from posterior margin to clypeal posterior margin, frontal arms extending from close to the center of the posterior margin up to the position of the antenna (Fig. 51).



Figures 52–60. *Brontispa longissima* (Gestro). **52** head, dorsal view **53** mouthpart, ventral view **54** head, ventral view **55** clypeus and labrum **56** mandible **57** vertical setae of head **58** scolus **59** supra-anal process **60** antenna. Abbreviations: pr – prementum; st – stipes; v – vertical setae.

Head with numerous setae (Figs 49, 51), distribution of setae as shown in Figure 49.

Labrum bent down (Figs 54, 55), connected with the anterior clypeal margin, almost as wide as clypeus. Anterior margin with tufted setae (Fig. 53), outer surface of labrum with six long pointed setae (Fig. 55).

Clypeus narrow (Fig. 55), moderately sclerotized, arched in front view, anterior and posterior margin parallel. Two pairs of tiny pointed seta positioned laterally (Fig. 55).

Mandible heavily sclerotized (Figs 53, 56), short and compact, with three apical teeth; inner side of mandible sharp, dorsal side of mandible convex, dorsolateral side with one long and one short pointed setae (Fig. 56).

Maxilla with stipes long (Figs 53, 54), bearing two lateral setae. Mala larger than maxillary palp (Fig. 53), directing buccal cavity, with eight long pointed setae and two short pointed setae. Palpifer short (Fig. 53), with two pointed setae. Maxillary palp short (Fig. 53), segment I cylindrical, with two setae, segment II conical, as long as segment I, one setae positioned flank, apical area with 11 sensilla. Labial palp one segmented, short (Fig. 53), apex with a group of nine peg-like sensilla. Hypopharynx apex covered with numerous spines (Fig. 53). Submentum and mentum fused with basal portion of maxilla, one pair of setae near lateral margin of postmentum (Figs 53, 54). Prementum triangular with two short pointed setae (Fig. 54). Postmentum triangular with two long pointed setae (Fig. 54).

Leg three-segmented (Fig. 51); coxa wider than long, with setae arranged in three rows: first with two pointed setae, second with two pointed setae and one club-like seta, third with one pointed seta and one club-like seta; femur longer than wide, with 11 long pointed setae, one club-like setae, as show in figure 51; tibiotarsus stout, apically with one heavily sclerotized and curved single claw, armed apically nine long setae around claw.

Discussion

The first-instar larva of *Octodonta nipae* with the combined length of head and thorax make up more than one-third of body length, while in the other larval instars head and thorax account for no more than one-third of body length. The mesothoracic spiracles are invisible in dorsal view in the first and second instar larvae, but the third and fourth instar larvae and prepupa have remarkably long tubular mesothoracic spiracles, which are dorsally visible. The first-instar larva with the supra-anal processes slightly sclerotized and only bearing one to three small teeth; older larvae have a strongly carinate and sclerotized supra-anal processes and more teeth; the last abdominal segment of the pupa is very soft and narrower than in the prepupa (Fig. 1), wrapped closely with crimping exuvium. The third and fourth instar larvae and prepupa have two tubercles which are positioned at the inner margin of the last abdominal segment (Figs 3–5); the first and second instar larvae lack tubercles and only have two tiny setae, which are almost invisible (Figs 1, 2).

The egg and larva of *Brontispa longissima* were described in detail by Maulik (1938), in his description we found several diagnostic characters distinguishing the immatures

of *O. nipae* and *B. longissima*. Eggs of both species are elongate and ellipsoidal; similar in size and sculpture. The first instar larva of *B. longissima* has all lateral scoli bearing two setae while in *O. nipae* lateral scoli have six club-like setae; the last abdominal segment of *B. longissima* is caliper-like hooked and has a series of five or six hairs along dorsal margin, but in *O. nipae* the dorsal margin has three to four club-like setae.

According to our observation, the mature larva of *O. nipae* resembles the larva of *B. longissima*, but there are many differences:

- 1) The body length of *O. nipae* (7.32 ± 0.06 mm) shorter than *B. longissima* (8.99 ± 0.38 mm).
- 2) The setae distribution of head is different as shown in pictures, row of Fa of *B. longissima* is only with one seta Fa1, but row of Fa of *O. nipae* with two setae; row of Fb of *B. longissima* is with five setae, but row of Fb of *O. nipae* with four setae.
- 3) Scoli of *O. nipae* are conical and slender, bearing six club-like setae; but *B. longissima* has the scoli which bearing four long club-like setae, and are shorter than the scoli of *O. nipae*;
- 4) The setae distribution of thorax is different (Figs 44, 50).
- 5) The setae distribution of leg is different (Figs 43, 51).
- 6) The supra-anal processes all caliper-like hooked, *O. nipae* with two small pointed setae positioned near inner margin of processes (Fig. 34, arrows indicated), but these two setae of *B. longissima* are closer to the inner margin (Fig. 59, arrows indicated). We also found some different from the description of Maulik (1938), in his description the mandibles of *B. longissima* are with two teeth, but we found the mandible of *B. longissima* with three teeth (Fig. 56) as *O. nipae*; Maulik said “*B. longissima* with the spiracle of mesothorax is not visible dorsally”, but according to our observation the spiracles of mesothorax are visible dorsally (Fig. 50).

Gressitt (1960a) keyed and simply described larvae of *O. korthalsiae*, *O. subparallela*, and *O. maffinensis*. Compared with his descriptions, *O. nipae* resembles *O. korthalsiae*, they all have long and slender scoli, last abdominal segment strongly arched and toothed; but the scoli of *O. korthalsiae* are as long as length of head, in *O. nipae* the scoli are 1.8 times as long as head.

The larva of *O. depressa* was described and figured by Zaitsev (2006), the mandible is triangular, with one tooth and a sharp inner edge, outer side has one seta; antennae are three-segmented, segment II has one small triangular sensillum apically and segment III long and slender; scoli have seven setae; last abdominal segment with each dorsal carina have five sharp teeth from base to apex, each lateral carina only have one laterally directed tooth near apex. The mandible of *O. nipae* larva has three teeth at inner side, outer side has two long setae; antennae are three-segmented, but segment II has a large conical sensory appendix apically and one small peg-like sensillum, segment III is conical and apically bearing with six peg-like sensilla; scoli have six setae; last abdominal segment with each dorsal carina have five to six teeth, and each lateral carina have three to four teeth laterally directed.

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Taxonomic revision proves *Trachusa pubescens* (Morawitz, 1872) sensu lato to be a complex of allopatric and sympatric species in South-Eastern Europe and Western Asia (Hymenoptera, Apoidea, Anthidiini)

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Abstract

Trachusa pubescens (Morawitz, 1872) s. l. has a distribution extending from south-eastern Europe over Anatolia and the Caucasus to Iran and Turkmenistan, and was formerly regarded as a species with high intraspecific variation. By means of an examination of 208 specimens from all parts of the distribution area, covering structural features of the head (mandibles, clypeus), the apical terga and the genitalia, the colouration pattern as well as a morphometric analysis of 26 body measurements with multivariate statistical methods (Principal Component Analysis, Discriminant Analysis), it was possible to assign the material to five species of which two are new to science (*Trachusa balcanica* sp. n. and *T. hakkariensis* sp. n.). Two taxa which had previously been described as “variations” or subspecies are elevated to species rank: *T. verhoeffi* (Mavromoustakis, 1955), stat. n. and *T. maxima* (Friese, 1931), stat. n. Additionally, some populations can be distinguished by their colouration pattern or by subtle differences in size or body shape, but these features are apparently of no taxonomic significance at the species level. *Trachusa balcanica* sp. n. and *T. verhoeffi* have distribution areas which do not overlap with any of the other members of the species group and can thus be characterised as allospecies. By contrast, the distribution areas of the other three species, *T. pubescens*, *T. maxima* and *T. hakkariensis* sp. n., overlap to a certain extent and they co-exist at least to some degree in sympatry. While they have been found in the same region, they have so far never been found together at exactly the same location and it is suggested that species divergence occurred in parallel with ecological

differentiation. Niche partitioning such as flower preferences is a mechanism which may be invoked to explain this. Some specimens with intermediate characters were found, particularly in contact zones, and it is thought that some hybridisation may occur. A partly melanistic individual of *T. balcanica* **sp. n.** was found, which is probably the first described melanistic individual in the tribe Anthidiini.

Keywords

Anthidiini, *Anthidium*, Apoidea, Balkans, Middle East, new species, new status, Palaeartic region, taxonomy, *Trachusa*

Introduction

Trachusa pubescens (Morawitz, 1872) is a relatively large species of bee belonging to the tribe Anthidiini, originally described in the genus *Anthidium* and with a characteristic wasp-like black-yellow colouration pattern. It was first described from the Caucasus and has since been found in south-eastern Europe, Anatolia, Iran and the Levantine countries. Several “varieties” and subspecies have been described (Morawitz 1872; Mocsáry 1879, 1884; Friese 1931; Mavromoustakis 1955). Pasteels (1969) wrote about the “*pubescens* group” comprising three species, while Warncke (1980) considered *pubescens* as the only species with two subspecies. This opinion has been shared in various recent publications (e.g. Ascher and Pickering 2016, Kuhlmann 2016, Grace 2010, Kasperek 2017a).

While males of *Trachusa pubescens* s. l. can easily be identified by their characteristic tripod-shaped apical tergum which is unique in anthidiine bees (Warncke 1980, Kasperek 2017a), a high degree of variation in size, shape, and colouration makes it difficult to decide what is intraspecific variation and what is of taxonomic significance for delimiting taxa. In addition to a classical approach relying on structural and colouration features, I thus also used a morphometric analysis of a series of body measurements. Multivariate statistical methods such as Principal Component Analysis and Discriminant Analysis, which may reveal possible subtle morphometric differences in three-dimensional morphological structures, are still rarely used in the taxonomy of solitary bees but have recently been introduced into anthidiine taxonomy (Kasperek 2017b). For this study I worked with a relatively large number of specimens from all parts of the distribution range, assembled from several public and private collections.

Taking into account the fact that the West Palaeartic *Trachusa* bees include further instances of complex and taxonomically little understood forms (e.g. *Trachusa interrupta* s. l.), the case of *T. pubescens* s. l. may provide a model for use in other groups.

Materials and methods

Altogether 208 specimens (60 females, 148 males) of *T. pubescens* s. l. have been examined from 17 countries (Table 1). Material deposited in the Senckenberg Deutsches Entomologisches Institut, Müncheberg (Germany), Senckenberg Museum Frankfurt (Germany), Oberösterreichisches Landesmuseum, Linz (Austria), Snow Entomological

Table 1. Material of *Trachusa pubescens* s. l. examined from the countries in the distribution area.

	Female	Male	Total
Armenia	0	6	6
Bulgaria	2	2	4
Greece	9	15	24
Hungary	2	5	7
Iran	4	6	10
Israel	2	3	5
Jordan	0	2	2
Lebanon	0	2	2
Macedonia (Former Yugoslav Republic)	1	3	4
Palestine, State of	0	1	1
Romania	1	0	1
Russia	0	2	2
Serbia	2	4	6
Syria	1	0	1
Turkey	34	81	115
Turkmenistan	0	1	1
Ukraine	2	15	17
TOTAL	60	148	208

Collection, University of Kansas, Kansas (United States of America), Ivan I. Schmalhausen Institute of Zoology of the National Academy of Sciences, Kiev (Ukraine), and Museum für Naturkunde Berlin (Germany) as well as in the collection of George A. Mavromoustakis at the Ministry of Agriculture, Nicosia (Cyprus), and the private collections of Maximilian Schwarz, Ansfelden (Austria), Werner Arens, Bad Hersfeld (Germany), Alireza Monferad, Yasouj (Iran) and the author were examined. Additionally, material deposited in the Hungarian Natural History Museum, Budapest, was used for the distributional analysis, and type and other material deposited in the Zoological Institute of the Russian Academy of Sciences, St. Petersburg (Russia) was examined by means of photographs.

Clustering of the material. The material was grouped into Operational Units (OU) defined on the basis of morphological features and/or geographic occurrences. Due to sympatric occurrences, OUs are not necessarily identical with geographically defined populations.

Species concept. As *T. pubescens* s. l. exhibits a high degree of variation, a clear taxonomic concept is required which enables a decision to be made as to whether an OU corresponds to the rank of a species or subspecies. In principal, I follow the “Guidelines for assigning species rank” developed by the British Ornithologists’ Union (Helbig et al. 2002). Two OUs are considered distinct species if they maintain phenotypic integrity in sympatry. Geographic replacement species are considered as distinct species if their contact zone consists of an abrupt transition with little phenotypic intergradation. Subtle morphological differences in size and/or shape, as revealed for example by

morphometric analysis (Discriminant Analysis), are not considered as being sufficient for assigning these populations to different taxa if these differences are not further supported by colour or other features. Two forms separated by a cline are considered as belonging to the same species as gene flow is limited only through isolation by distance, not as a result of an intrinsic barrier. Following Mayr (1975), clines are therefore not given nomenclatural recognition. This principle was also applied in cases where the available material did not allow a decision whether there is a continuous or a stepped cline (and hence whether possibly different species are involved).

Distinguishing characters. The morphological characters which are presented here for distinguishing the members of the *pubescens* species complex mostly refer to males, with the shape of the clypeus and mandibles and of the two apical abdominal segments being the most relevant ones. Females are not only less differentiated, but they are also rarer than males in collections. Of 208 specimens examined, 60 (28.8%) are females and not all of them could be unambiguously attributed to one of the species. The identification key is therefore confined to males only. The diagnosis of the members of the species complex presented below is confined to distinguishing characters. Within the species descriptions, emphasis is placed on individual variation and on differences between populations.

Measurements. In order to discover morphological differences, 26 morphological measurements were taken (Fig. 1, Table 2). Measurements were taken with an ocular micrometer placed in the eye-piece of a Stereozoom microscope at different magnifications between 1.0x and 4.5x. The divisions of the ocular micrometer were converted to millimetres (mm) with the help of an objective micrometer. Measurements related to the ocelli and the clypeus and mandibles were photographed and measured with TSVIEW7 (version 7.3.1.7) software. For obtaining exact measurements, it is crucial that the points of reference are equidistant from the lens of the microscope. This is challenging because of the three-dimensional shape of the specimens and needs some experience on the part of the observer. In order to reduce errors, many of the measurements were taken twice. Furthermore, all measurements were taken by the same person and with the same instruments. Due to sexual dimorphism and the lower number of females available, the morphometric analysis was confined to males. Terminology follows Michener (2007).

Statistical treatment. Multivariate statistical procedures were applied for analysing morphometric data. In principal, the analysis was conducted in two steps: First, an assessment was made as to whether the specimens analysed could be grouped in certain clusters. This was done with a Principal Component Analysis (PCA), which was used here as a tool for exploratory data analysis. In a second step, a Discriminant Function Analysis (DFA) (= Canonical Variate Analysis, CVA) was performed to determine whether a set of body measurements is effective in predicting category membership. An important difference between PCA and DFA is that PCA examines datasets where membership of a particular Operational Unit (OU) is not known, while DFA classifies datasets whose OU has been previously determined. Based on the assumption that all

Table 2. List of measurements taken from the body of *Trachusa pubescens* for the morphometric analysis.

Head	
HL	Head length (from upper edge of clypeus to preoccipital ridge)
HW	Head width (at height of antennal sockets)
CW-W	Clypeus width (at widest point)
CW-U	Clypeus width (at upper end)
CL	Clypeus length (along middle line; excluding the dark crenulated apical margin)
EL	Eye length
IOD-L	Lower interocular distance (at widest point of clypeus)
IOD-U	Upper interocular distance (at the height of the centres of the posterior ocelli)
OCD	Ocellar-clypeal distance (from upper edge of clypeus to outer margin of anterior ocellus)
IOCD	Interocellar distance (from inner margins of posterior ocelli)
IAD	Interantennal distance
OOD	Ocello-ocular distance (shortest distance, which can be found after some rotation)
AOD	Antennocellar distance (from antennal socket to margin of anterior ocellus)
MdW	Mandible width
Mesonotum	
MW	Width of mesonotum (at widest point)
Metanotum	
T1	Width of T1 (at distal margin)
T2	Width of T2 (at distal margin)
T3	Width of T3 (at distal margin)
T4	Width of T4 (at distal margin)
Wing	
MC-L	Length of marginal cell (from inner proximal edge to inner distal edge)
SM1-L	Length of 1 st submarginal cell
SM2-L	Length of 2 nd submarginal cell
VSM2-L	Length of vein of 2 nd submarginal cell
MC1-L	Length of 1 st medial cell
MC1V-L	Length of vein of 1 st medial cell

measurements are normally distributed, the parametric one-way ANOVA (Analysis of Variance) was used to determine whether there are statistically significant differences between the means of three or more OUs. In order to find out which OU means (compared with each other) are different, the Tukey test was applied. The test compares all possible pairs of means.

The statistical tests were performed with XLSTAT Version 2015.6.0123990, which is a statistical software package for Microsoft Excel, and PAST (PAleontological STatistics), Version 3.16 (2017) (Hammer et al. 2001).

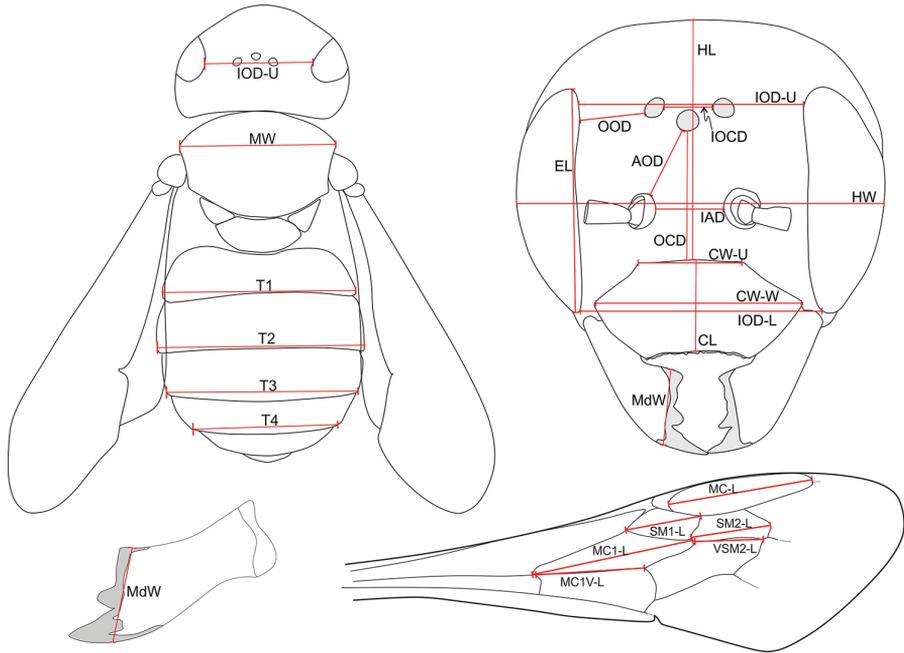


Figure 1. Measurements taken for the morphometric analysis. Note that the measurements were taken from positions in which both points of reference become equidistant from the lens of the microscope. This is not necessarily the perspective shown in the drawing.

Abbreviations and Acronyms

- DIE** Senckenberg Deutsches Entomologisches Institut (Germany)
OLL Oberösterreichisches Landesmuseum Linz (Austria)
SEMC Snow Entomological Collection, University of Kansas, Kansas (United States of America)
SIZK Ivan I. Schmalhausen Institute of Zoology of the National Academy of Sciences, Kiev (Ukraine)
SMF Senckenberg Museum Frankfurt (Germany)
ZISP Zoological Institute, Russian Academy of Sciences, St. Petersburg (Russia)
ZMB Museum für Naturkunde Berlin (Germany)
cAM Collection Alireza Monferad, Yasouj (Iran)
cMK Collection Max Kasperek, Heidelberg (Germany)
cMS Collection Maximilian Schwarz, Ansfelden (Austria)
cMAV Collection George A. Mavromoustakis, Ministry of Agriculture, Nicosia (Cyprus)
cWA Collection Werner Arens, Bad Hersfeld (Germany)
OU Operational Unit
S1, S2, etc. first, second, etc., metasomal sternum
T1, T2, etc. first, second, etc., metasomal tergum

Results

Trachusa Panzer, 1804

Trachusa (*Archianthidium*) Mavromoustakis, 1939

The *Trachusa pubescens* species complex

Trachusa pubescens s.l. has been assigned to the subgenus *Trachusa* (*Archianthidium*), which to date comprises six species (Kasperek 2017a, 2017b) and is characterised by the position in which the second recurrent vein enters the second submarginal cell and the presence of a projection on tergum T7 of the male (Michener 2007). A series of characters support the view that the genus *Trachusa* is sister to the rest of Anthidiini (Litman et al. 2016).

Descriptions of *T. pubescens* s. l. are given by Morawitz (1872), Friese (1931), Mavromoustakis (1955), Pasteels (1969), Kasperek (2017a), and others. The males of all members of the species complex are characterised by a typical tripod-shaped T7, and the females by broad black mandibles in combination with an entirely yellow clypeus and yellow markings in the genal area. *Trachusa pubescens* s. l. is known as being highly variable. When Morawitz (1872) described the species from the Caucasus, he mentioned three “varieties” according to differences in the colouration of the scutum (var. a), scutellum (var. b) and T6 (var. c). Mocsáry (1879) added two more “variations” from Hungary: “Variat. a” with entirely black antennal scape, and “Variat. b” without a yellow spot on mesepisternum (mesopleurum). Friese (1931) described the “var. *maximum*” from Turkey, which is twice the size of specimens from Hungary but with only minor structural differences. Mavromoustakis (1955) added the subspecies *verhoeffi* from the Levant, with a distinct colouration and some differences in the form of T6. Pasteels (1969) recognised [*Archianthidium*] *pubescens*, *maximum* and *verhoeffi* as valid species, while Warncke (1980) synonymised *maximum* with the nominate form and recognised *verhoeffi* as the only valid subspecies in addition to the nominate subspecies. This opinion has been shared in various recent publications including the Discover Life web presentation (Ascher and Pickering 2016), the Checklist of the Western Palearctic Bees (Kuhlmann 2016), a biogeographic study of the bees of the Eastern Mediterranean and Near East (Grace 2010) and a recent review of the genus by Kasperek (2017a).

For an initial characterisation of the *T. pubescens* complex, a Principal Component Analysis (PCA) was conducted based on the correlation matrix of 26 morphometric data (Fig. 2). The first two eigenvalues represent 78.34% of the initial variability of the data, and this relatively high value shows that the first two factors are a good quality projection of the initial multi-dimensional table. All variables throughout have factor loadings >0.6 in the first component F1, while variables related to the wing also have high factor loadings in component F2. The PCA further shows a clear separation of two groups of individuals that can be identified as the *balcanica* OU and the *maxima* OU (Fig. 2). This can be taken as the first evidence that these differences are of taxonomic significance. Within the *maxima* OU, one specimen from central Iran is different from the others in both its F1 and F2 values and needs to be further examined (see below).

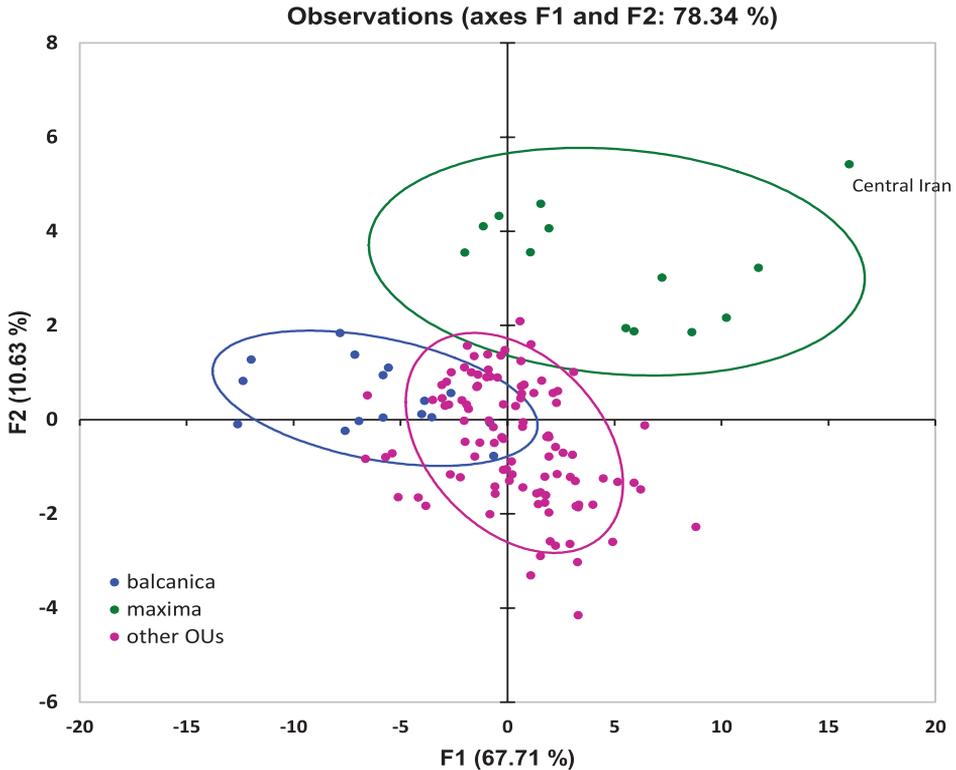


Figure 2. Principal Component Analysis (PCA) of 26 morphometric variables of males of *Trachusa pubescens* s. l. (N = 132). Individuals subsequently assigned to *T. balcanica* sp. n. and *T. maxima* are shown here in a different colour. All other OUs are shown here in the same colour. One specimen from central Iran is significantly different from all other specimens of the group. The confidence ellipses show a confidence interval of 80%.

In order to refine the results, another PCA was carried out on the morphometric data of only those specimens which are characterised by a combination of an emarginate clypeus with subacute lateral projections of T6: the data clearly cluster in five groups (Fig. 3), and these groups reflect the taxa *balcanica* sp. n., *maxima*, and *hakkariensis* sp. n. Within *T. maxima*, the OUs from Turkey, Armenia and Iran can be distinguished (for Iran, only one specimen is available). As the PCA clusters the specimens without knowing their group membership, a DA was conducted after having assigned the material to these three taxa. Fig. 16 shows that all specimens are well separated on the species level without overlapping cases, while *maxima* from Turkey cannot be distinguished from *maxima* from Armenia. A confusion matrix shows that all specimens (100%) are assigned correctly to the three taxa *balcanica* sp. n., *maxima*, and *hakkariensis* sp. n.

The size of the mandible shows considerable variation, and the average values were compared for the various OUs. Mandible width is on average greater in *T. maxima* than in all other groups of the complex (Figs 5, 14). All pairwise comparisons of the

Table 3. Comparison of the mandible width and the index clypeus length / mandible width among the five species of the *Trachusa pubescens* complex. The table gives the significance values for differences according to Tukey's pairwise test. The upper part above the diagonal (grey cells) gives the p values for mandible width, the lower part the values for the index.

	<i>balcanica</i>	<i>hakkariensis</i>	<i>maxima</i>	<i>pubescens</i>	<i>verhoeffi</i>
<i>balcanica</i>	–	0.977	<0.001	0.501	0.843
<i>hakkariensis</i>	<0.001	–	<0.001	0.185	0.992
<i>maxima</i>	<0.001	<0.001	–	<0.001	<0.001
<i>pubescens</i>	<0.001	0.999	<0.001	–	0.066
<i>verhoeffi</i>	<0.001	<0.001	<0.001	<0.001	–

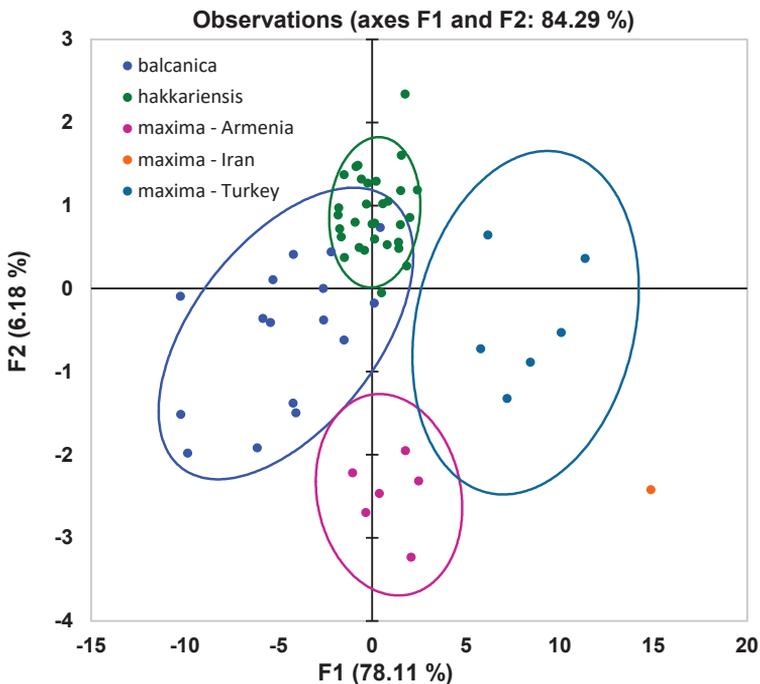


Figure 3. Principal Component Analysis (PCA) of 26 morphometric characters (males) of those OUs of the *Trachusa pubescens* complex whose members are characterised by an emarginate clypeus and subacute lateral projections on T6.

mandible width of the five species were tested with the parametric Tukey's test (based on the assumption of normally distributed data) and it was shown that *T. maxima* has highly significantly ($p < 0.001$) wider mandibles than all other species (Table 3), but that the other species do not show significant differences among themselves ($p > 0.05$). The large mandible is therefore regarded as a unique character of *T. maxima*.

As *T. maxima* is also larger than the other species, a further test investigated how mandible size relates to clypeus size. In this way, the possibility that the large mandible

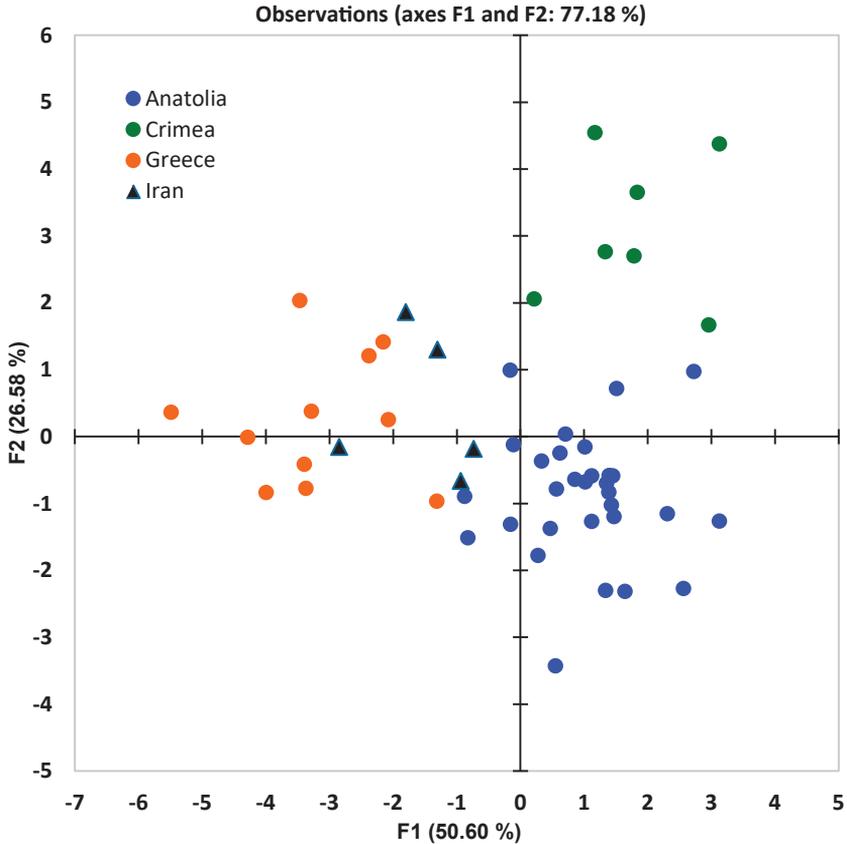


Figure 4. Results of a Discriminant Analysis of the Operational Units (OU) assigned to *Trachusa pubescens* s. str. based on 26 morphometric characters of the male.

size is merely a consequence of the large body size can be excluded. For this purpose, a pairwise comparison among all five species was applied to the index clypeus length / mandible width (Table 3). *Trachusa maxima* has again the relatively biggest mandible as compared to all other species. However, significant differences ($p < 0.001$) are also found among all the other species with the exception of the pair *T. hakkariensis* sp. n. / *T. pubescens* whose index did not differ at a significant level ($p > 0.05$).

A further test investigated whether the members of the *Trachusa pubescens* complex show differences in the shape of the clypeus, and for this purpose the clypeus index (index clypeus width to clypeus length) was compared (Fig. 6). The results show that *T. maxima* and *T. hakkariensis* sp. n. have the relatively widest clypeus and that there are no significant differences between these two species (Table 4). *Trachusa balcanica* sp. n. and *T. pubescens* take a medium position with regard to the clypeus index, and again these two species do not differ significantly in this character. *Trachusa verhoeffi* has the relatively narrowest clypeus and it is significantly narrower than in all other species (Table 4).

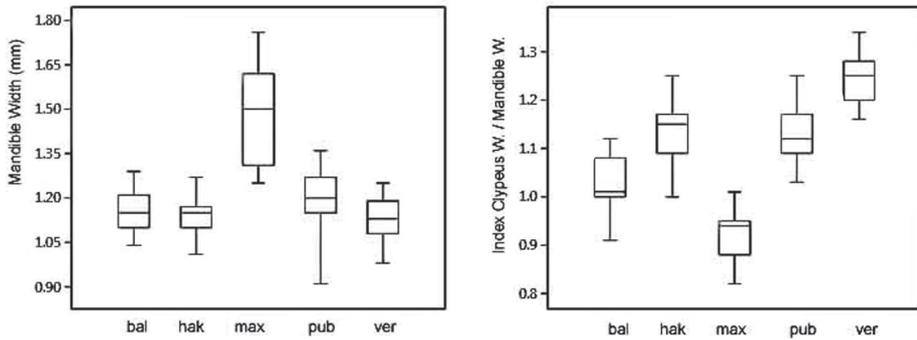


Figure 5. Mandible width (left) and index clypeus length / mandible width in males of the five species of the *Trachusa pubescens* complex. Abbreviations: bal = *T. balcanica* sp. n.; hak = *T. hakkariensis* sp. n.; max = *T. maxima*; pub = *T. pubescens*; ver = *T. verhoeffi*.

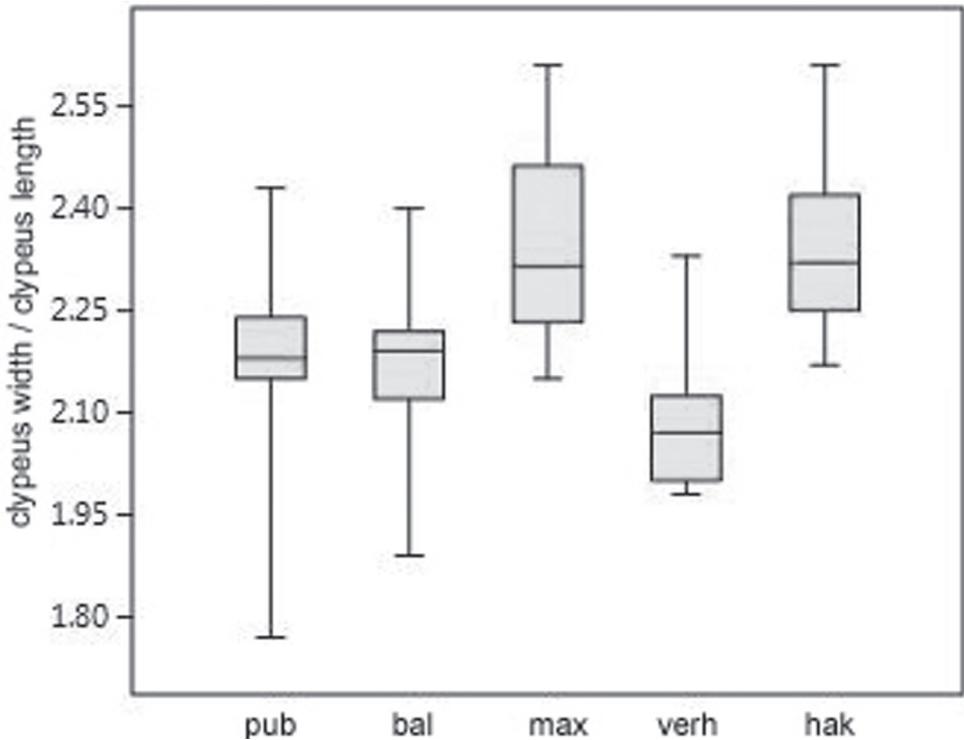


Figure 6. Comparison of the clypeus index (clypeus width / clypeus length) in males of the five species of the *Trachusa pubescens* complex. Abbreviations: bal = *T. balcanica* sp. n.; hak = *T. hakkariensis* sp. n.; max = *T. maxima*; pub = *T. pubescens*; ver = *T. verhoeffi*.

Considerable differences were found in the shape of the apical terga (T6 and T7) in the males of the five species (Figs 7, 8, 15), which are described under the species descriptions below.

Table 4. Comparison of the clypeus index (clypeus width / clypeus length) of the five species of the *Trachusa pubescens* complex. The table gives the significance values for differences according to Tukey's pairwise test.

	<i>balcanica</i>	<i>hakkariensis</i>	<i>maxima</i>	<i>pubescens</i>	<i>verhoeffi</i>
<i>balcanica</i>	–	<0.001	<0.001	0.536	<0.010
<i>hakkariensis</i>		–	0.932	<0.001	<0.001
<i>maxima</i>			–	<0.001	<0.001
<i>pubescens</i>				–	<0.001
<i>verhoeffi</i>					–

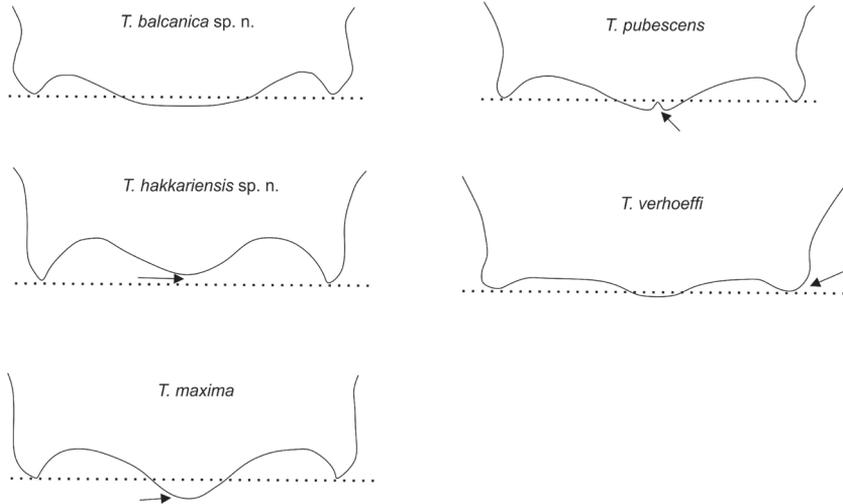


Figure 7. Dorsal view of the apical margin of T6 in the five species of the *Trachusa pubescens* complex. The dotted line is added to show the relative length of the median projection in relation to the lateral projections. Arrows indicate distinguishing features.

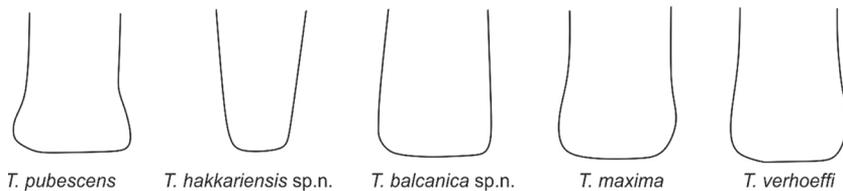


Figure 8. Dorsal view of the apex of the median projection of T7 in the five species of the *Trachusa pubescens* complex.

The apices of the penis valves are almost straight and subacuminate in *T. pubescens* (genitalia of three specimens from Greece, one from Tatvan/Eastern Turkey, and one from Iran examined) while they are slightly elongated and bent ventrad hook-like in the other four species: *T. balcanica* sp. n. (one specimen examined), *T. maxima* (four specimens from Armenia examined), *T. hakkariensis* sp. n. (seven specimens examined), and *T. verhoeffi* (one specimen from Israel, one from Lebanon, and eight from SW Turkey examined) (Figs 9, 10).

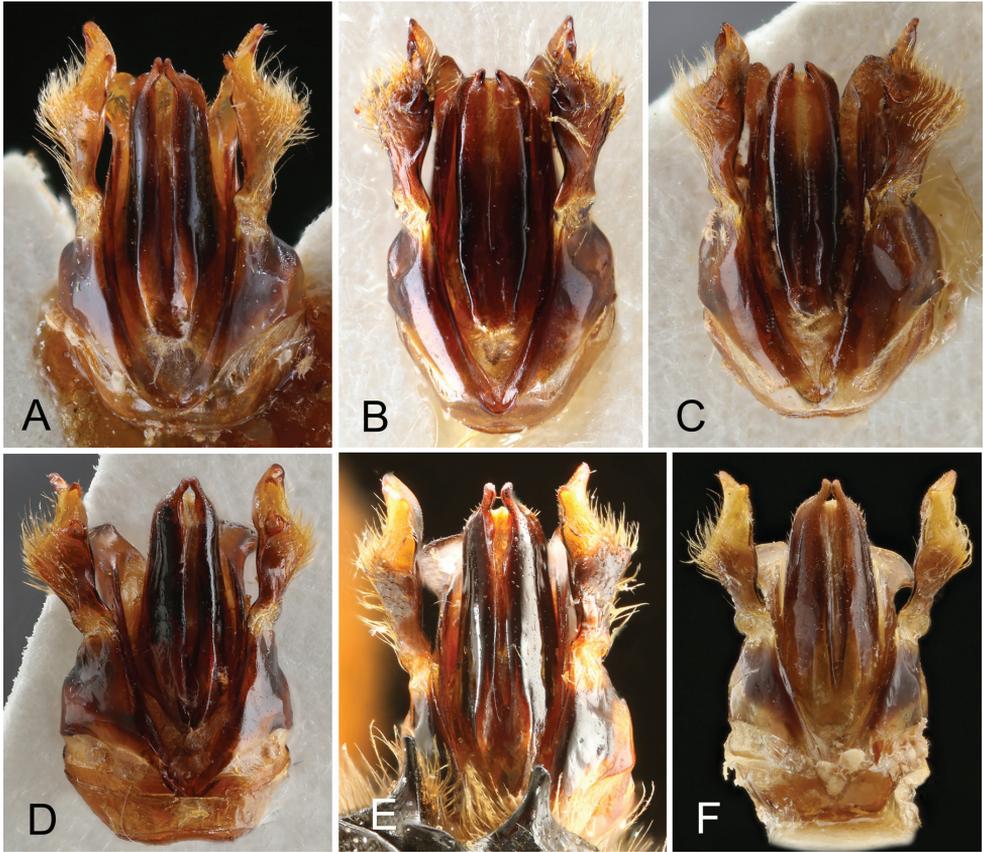


Figure 9. Male genitalia of the five species of the *Trachusa pubescens* complex. **A** *Trachusa balcanica* sp. n. (FYR of Macedonia) **B–C** *T. pubescens* (two different specimens from Greece) **D** *T. maxima* (Armenia) **E** *T. verhoeffi* (SW Turkey) **F** *T. verhoeffi* (Israel).

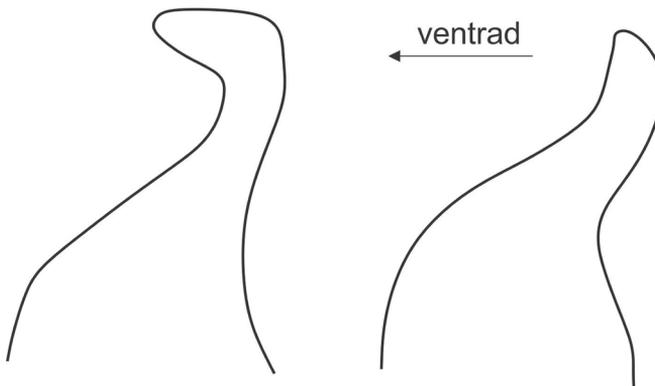


Figure 10. Apices of the penis valves in the *Trachusa pubescens* complex. Hook-shaped apices (left) are found in *Trachusa balcanica* sp. n., *T. maxima*, *T. hakkariensis* sp. n., and *T. verhoeffi*. The apices of the penis valves are straight only in *T. pubescens* (right).

***Trachusa balcanica* sp. n.**

<http://zoobank.org/AB35EA8B-470E-43BD-836C-ABD1F1AAFFDC>

Figs 11, 12, 13, 14, 15

Material. Holotype: Male. **BULGARIA:** Sandanski (Blagoevgrad Province, southwestern Bulgaria), June 1972, K. Poláček leg. (cMS). – Paratype (1): **BULGARIA:** male, same location as holotype, 26.-31.5.1967, Kocourek leg. (cMS).

Further material examined (21): **BULGARIA:** 1♀, Sandanski, 26.–31.5.1967 (cMS); 1♀, *ibid.*, 1.–8.06.1967 (cMS). **GREECE:** 1♀ 1♂, 35 km NE Kalambaka, 15.05.2005, J. Halada / M. Kadlecová leg. (cMS); 1♂, Hellas, Kastoria, Aposkepos (850 m), 06.vii.1967, J. Reinig leg. (SMF); 1♂, Koupaki (38°30'N, 22°01'E), northwestern part of Phocis, central Greece, 21.05.1990, H. Malicky leg. (cMS). **HUNGARY:** 2♂, Hungary, E. Frivaldski leg. (ZMB); 1♂, South Hungary, ex coll. Schmedeknecht (ZMB); 1♀ 1♂, central Hungary, ex coll. Alfken (ZMB); 1♀ 1♂, Budapest, A. Mocsáry leg. (ZMB). **MACEDONIA** (Former Yugoslav Republic): 2♂, Prilep, 01.06.1968, K. Warncke leg. (OLL). **SERBIA:** 1♀, 1♂, Deliblat, 23.07.1886, H. Friese leg. (SMF); 1♀, 3♂, same data (ZMB).

Material not examined: The Hungarian Natural History Museum holds 11 female and 27 male specimens labelled as “*Trachusa pubescens*” which according to the collection localities can most probably be assigned to *T. balcanica*: Deliblat (Serbia), Budapest (Hungary), Grebenac (Serbia), Kecskemét (Hungary), Halas [=Kiskunhalas] (Hungary), Peszér [=Kunpeszér] (Hungary), Kecel (Hungary), and “Hungariae centralis”. Some males have no locality label at all.

Differential diagnosis. The smallest species of the *T. pubescens* complex (mostly 13–16 mm versus mostly 16–20 mm). Males are separated from *T. pubescens*, the only other European species of the complex, by the conspicuously emarginate apex of the clypeus (almost straight in *T. pubescens* s. str.), with 8–11 small tubercles in the emargination (indistinguishable or hardly distinguishable tubercles in *T. pubescens*). *Trachusa balcanica* sp. n. shares this feature with the remaining members of the species group.

Both sexes have a yellow stripe on vertex, sometimes attenuated in the middle or reduced to small remnants. This stripe is absent in *T. pubescens* s. str. which also occurs on the Balkans. Yellow maculation in the genal area in *T. balcanica* sp. n. is usually confined to the upper half (usually one-third); in only two out of 23 males, the genal maculation extends slightly on to the lower half, but never reaches the lower end of the eye as in *T. hakkariensis* sp. n. and *T. maxima*, or extends over most of the genal area as in *T. pubescens* and *T. verhoeffi*. In eight females examined, the yellow maculation extends in three cases slightly onto the lower half but is confined to the upper half in the other cases.

T6 of males has a broad, usually rounded median projection; apex rounded or at most truncated but never emarginate as in *T. pubescens* (Figs 7, 15). Lateral projections subacute. Punctuation of T6 finer and more scattered in comparison with *T. pubescens*. Median projection of T7 parallel-sided, apex truncated (Figs 8, 15).

Pubescence on thorax dense and relatively long; pubescence on vertex and dorsal side of mesosoma reddish brown. Pubescence in the other species of the complex is

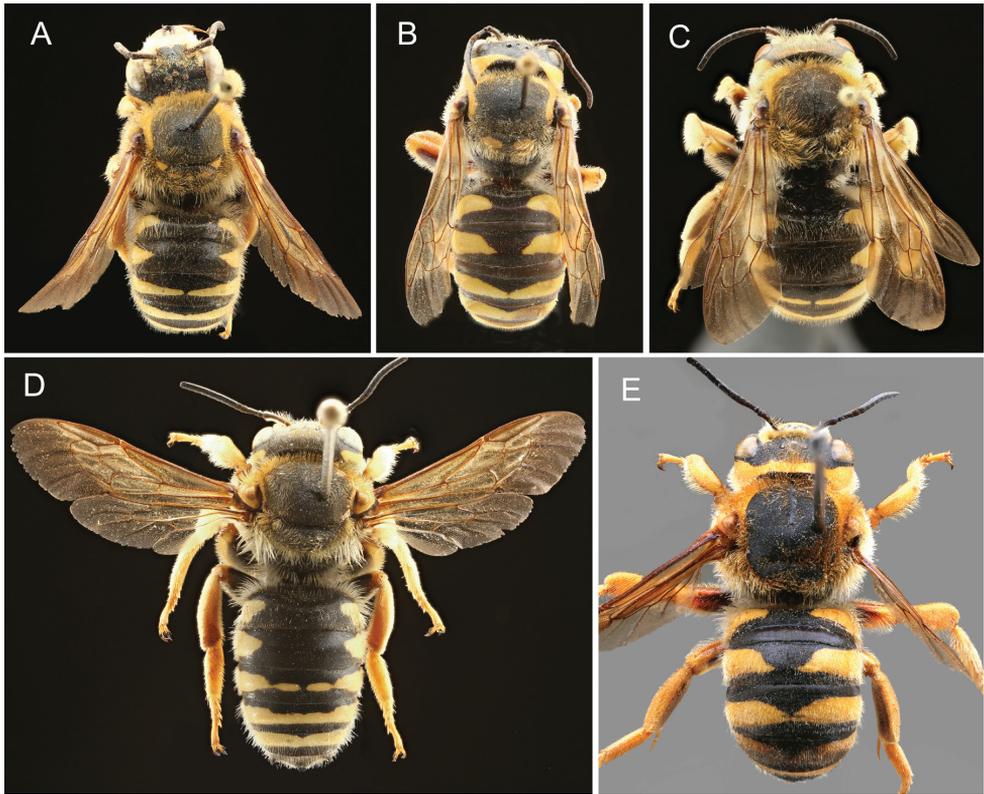


Figure 11. Males of the five species of the *Trachusa pubescens* complex in dorsal view: **A** *T. balcanica* sp. n. **B** *T. hakkariensis* sp. n. **C** *T. maxima* **D** *T. pubescens* **E** *T. verhoeffi*.

inclined to be dull white to yellow-brown, but this difference can only be seen when series of specimens are compared.

Variability. One of the males examined from Greece shows a colouration pattern which is different from all other specimens: The integument is shining black (not dull black), the paraocular area yellow (yellow maculation not reaching top of eye); one very small yellow spot on vertex and narrow yellow remnants of the anterolateral L-shaped band on the scutum; one small yellow lateral spot on each side of T1–T4, and additionally two small yellow median spots on T3 and T4 (no bands). While all yellow colouration is thus much reduced on the body, this specimen shows elongate light brown stripes on fore- and middle tibiae and one dark brown stripe on each hind tibia. While this colour pattern is entirely different from all other specimens examined in the *T. pubescens* complex, the size, the form of the clypeus, and the shape of T6 and T7 are in conformity with *T. balcanica* sp. n., and it is thought that this specimen belongs to this species.

Derivatio nominis. The name is derived from the Balkans.

Distribution. The distribution area of *Trachusa balcanica* sp. n. extends from central Hungary (Budapest) in the north over central Serbia to western Bulgaria. In the

southwestern part of its range, it extends over Macedonia to northern and central Greece. Countries of occurrence are: Bulgaria, Greece, Hungary, Macedonia (F.Y.R.), and Serbia. Records from Romania (a female from Tulcea, 1895, J. J. Mann leg., cMAV, and a female listed by Calefariu 2017) and Moldova (Stratan and Andreev 2015) could not be examined, or not to the extent necessary to allow an unambiguous assignment to this species (*T. pubescens?*).

Flower preference. Mocsáry (1884) found the species in central Hungary in July 1878 abundantly at *Stachys germanica*. Friese (1898) collected it at *Genista* in Serbia.

Remarks. On 01.06.1965 and Prilep, FYR Macedonia, K. Warncke collected three males and a female of *T. pubescens* s. l., apparently together. While two males can be unambiguously attributed to *T. balcanica* sp. n. (shape of clypeus, in one male also shape of genitalia examined), the third male has the apical margin of the clypeus as in *T. pubescens* s. str. and was attributed to that species.

Trachusa hakkariensis sp. n.

<http://zoobank.org/0BB022FC-2246-4427-830C-F0946B672D72>

Figs 11, 12, 14, 15

Material. Holotype: Male. **TURKEY:** Hakkâri province: Cilo Dağı (W Serpil), 1800 m, 8.08.1982, K. Warncke leg. (OLL). Paratypes: 9♂, same data as holotype (OLL).

Other material: **TURKEY:** 14♂, Hakkâri province: Cilo Dağı (W Serpil), 1800 m, 8.08.1982, K. Warncke leg. (OLL); 1♂, Hakkâri province: Cilo Dağı (2000 m), M. Kühbandner leg. (cMS); 2♂, Van province: Gevaş, 2.07.2000, Ma. Halada leg. (cMS); 1♂, Malatya province: 15 km E Malatya, 27.06.2000, Ma. Halada leg.; 1♀, 3♂, Hakkâri province: 10 km NE Dağlıca (= Oramar) (1700 m), 29.06.1985, M. Schwarz leg. (cMS).

Differential diagnosis. Males are similar in colouration to *T. maxima* but are clearly distinguished by the size of their mandibles (not enlarged as in *T. maxima*), the median projection of T6 which does not project beyond the lateral projections, and the on average smaller body size (16–18 mm versus 17–19 mm). In a few individuals the apex of the median projection of T6 is truncated (but never emarginate). The median projection of T7 normally tapers apically (usually parallel-sided in *T. maxima*). In the mandible index (clypeus length / mandible width), *T. hakkariensis* sp. n. resembles *T. pubescens* s. str. The average value is statistically significantly lower than in *T. verhoeffi* and higher than in *T. balcanica* sp. n. and *T. maxima* (Table 3).

Trachusa hakkariensis sp. n. has a shallowly emarginate clypeus with a crenulated apical margin. It shares this character with *T. balcanica* sp. n., *T. maxima*, and *T. verhoeffi*. By contrast, *T. pubescens* has a straight margin.

Derivatio nominis. Named after the Turkish province of Hakkâri, where the type locality of the new species is located.

Distribution. The species is known from eastern and south-eastern Turkey; records are available from the provinces of Hakkâri, Van and Malatya. The distribution areas thus

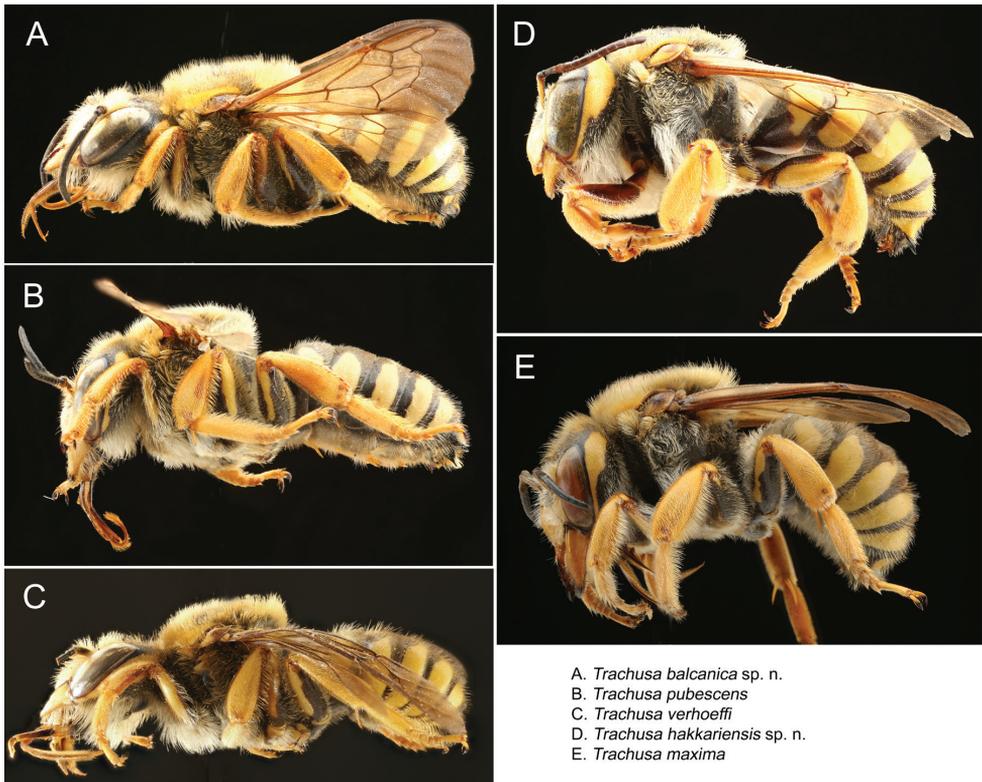


Figure 12. Males of the five species of the *Trachusa pubescens* complex in lateral view.

overlap with *T. pubescens*, although these two species have never been found at the same location. The distribution areas of *T. hakkariensis* sp. n. and *T. maxima* are subcontiguous.

Flower preference. No information available.

***Trachusa maxima* (Friese, 1931), stat. n.**

Figs 11, 12, 14, 15

Anthidium pubescens var. *maximum* Friese, 1931: 37–38.

Note. Warncke (1980) believed that *Anthidium pubescens* var. *maximum* Friese, 1931 was synonymous with the nominate *Anthidium pubescens* with some more yellow colouration and longer lateral projections of T6.

Material. Holotype: Male. **TURKEY:** “Asia Minor Taurus pisd., 1928 / Type / *Anthidium pubescens* v. *maximum* Friese det. 1925 / Lectotype *Anthidium maximum* Männchen Friese 1931 (nec 1922) det. v. d. Zanden 1994” [see remark on collection locality below].

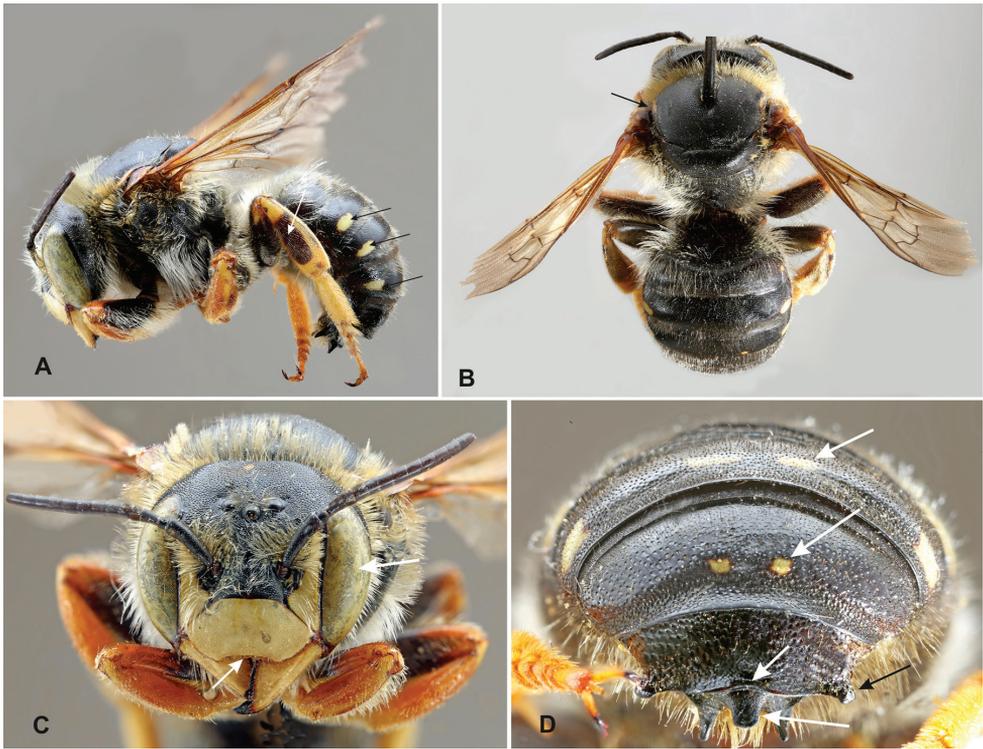


Figure 13. *Trachusa balcanica* sp. n., semi-melanistic individual from Greece.

Other material: **ARMENIA:** 6♂, Khosrov State Reserve, 10.06.2017, M. Kasperek leg. (at *Phlomis*) (cMK). **IRAN:** 1♂, prov. Esfahan (50 km SW of Daran, pass betw. Aragol and Cohrud vill., 2800 m) 32.49.47N, 50.14.89E, 11.07.2001, M. Kalabza leg. (cMS). **TURKEY:** 1♂, Pisidian Taurus (“Pisidischer Taurus”), July 1928 (“*Archianthidium pubescens maximus* Fr. det. Mavromoustakis / lectoparatype *Anthidium maximum* Friese 1931 (nec 1921) det. v. d. Zanden 1994 / *Trachusa maximum* (Friese) det. v. d. Zanden 1994”) (cMAV); 2♂, Adiyaman, Kuyucak env., 10.06.2001, M. Snizek leg. (cMS); 1♂, Maraş-Afsin, 30.06.1984, K. Warncke leg. (OLL); 1♂, Sille near Konya, 9.–17.6.1975, J. Heinrich leg., J. Heinrich det. 1977 (SMF); 1♂, Ankara, 09.06.1934, H. Noack leg. (“*Anthidium laticeps* Alfken det. 1934 / *Archianthidium maximum* Friese J. Pasteels det. 1969”) (SMF).

Differential diagnosis. The largest species of the *Trachusa pubescens* complex (17–20 mm versus 13–18 mm). It is clearly characterised by large mandibles, larger than in any other species in the complex. The median projection of T6 is widely rounded convexly, without apical emargination, and projects beyond the lateral projections (not projecting in *T. hakkariensis* sp. n. with which it may occur in the same region). T7 is parallel-sided or slightly broadened at apex and with a truncated apex (tapered with truncated apex in *T. hakkariensis* sp. n.).

The relative width of the mandible in relation to the clypeus length (index clypeus length / mandible width) is significantly higher in *T. maxima* (mean: 0.92 ± 0.059 mm)

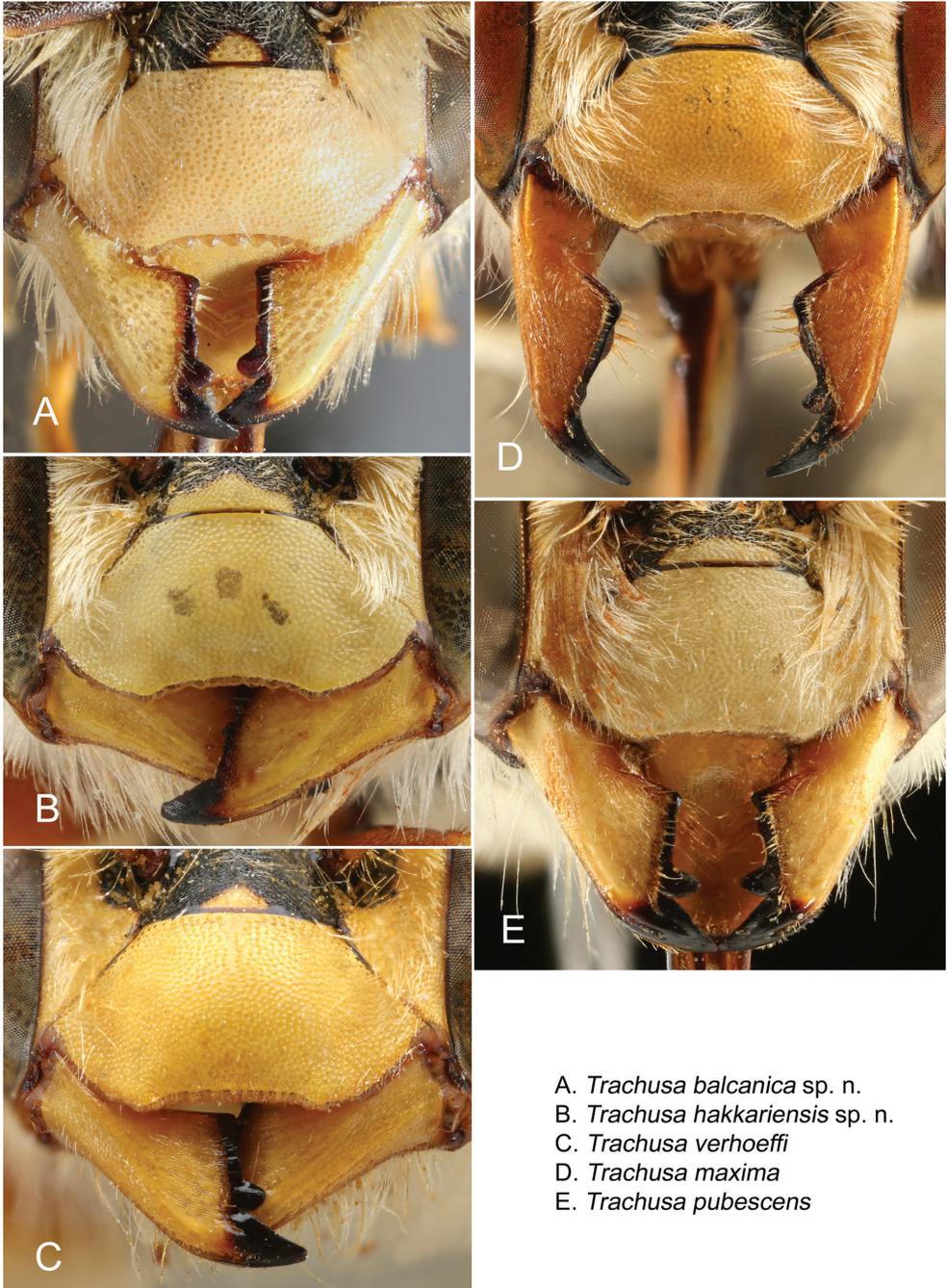


Figure 14. Clypeus and mandibles of the males of the five species of the *Trachusa pubescens* complex.

than in the other species of the complex. It overlaps to some degree with *T. balcanica* sp. n. (mean: 1.03 ± 0.052 mm), which is, however, the smallest species of the group (and *T. maxima* the largest), so that the combination of both characters allows an

unambiguous species distinction. The clypeus of *T. maxima* is emarginate, and the apical margin crenulated with 8–11 rounded tubercles, and it shares this character with *T. balcanica* sp. n., *T. hakkariensis* sp. n., and *T. verhoeffi*. The emargination is usually shallower in the latter two species.

The genal area has a large yellow maculation which is broad at the upper end and narrow at the lower end and extends from the top of the eye to its lower end.

The median projection of T6 reaches beyond the lateral projections (Figs 7, 15) (in *T. hakkariensis* sp. n. this projection extends at most to the level of the lateral projections, and in *T. pubescens* the median projection has at its apex a small emargination or is at least truncated). The surface of T6 is shining, with fine punctures widely scattered especially in the centre of both sides; the punctures are often separated by a few puncture diameter. *Trachusa balcanica* sp. n. and *T. hakkariensis* sp. n. are similar with an on average only slightly denser punctation, while the punctation in *T. pubescens* and *T. verhoeffi* is noticeably coarser and denser. The punctures in these two species are usually subcontiguous.

Variability. Seven males examined from Turkey (including the type specimen) have a relatively narrow transverse yellow band on the vertex, broken in the middle and clearly separated from the yellow maculation on the genal area. In just one of these specimens, the yellow band is merged with the yellow maculation on the genal area. One specimen (from Konya in Turkey) has two small yellow spots between the lateral yellow bands on T2, a character which is often also present in *T. pubescens* (see Fig. 11D). The mesepisternum is black in all specimens. The Armenian population is distinguished from the Turkish population by the unified yellow colouration on gena and vertex. Three of the six males examined have a yellow mesepisternal spot, while it is black in the others. Only one specimen is available from the central Iranian population, and this is the largest specimen of all the *T. pubescens* s. l. examined. Already in the initial PCA, this specimen proved to be different from all other individuals of the complex (Fig. 2, see above). It has a large yellow spot on mesepisternum and the vertex has scattered, short hairs (longer and denser in the other populations). While the PCA places the specimens of these three populations (Armenia, Iran, Turkey) in different clusters (Fig. 5), this difference does not become evident in the Discriminant Analysis (DA) (Fig. 6).

Distribution. The distribution of *T. maxima* extends in the west from the northern slopes of the Taurus Mountains in Turkey to Ankara in Inner Anatolia in the north. It was also found in the Turkish south-eastern provinces of Kahraman Maraş and Adiyaman. Separated, possibly isolated populations are present in Armenia and central Iran (Isfahan). While some morphometric and colouration differences exist between the Turkish, Armenian and Iranian populations, the material is not comprehensive enough to justify the assignment to different taxa, for example to subspecies.

Flower preference. In Armenia, the species was found visiting the large yellow flowers of *Phlomis* sp. (M.K.).

Remark. The type locality is the Pisidian Taurus, where it was collected in 1928 (ZMB). Another male and a female were collected there at the same time (cMAV, ZMB). According to Friese (1931) the collector was the speleologist P. Weirather (not

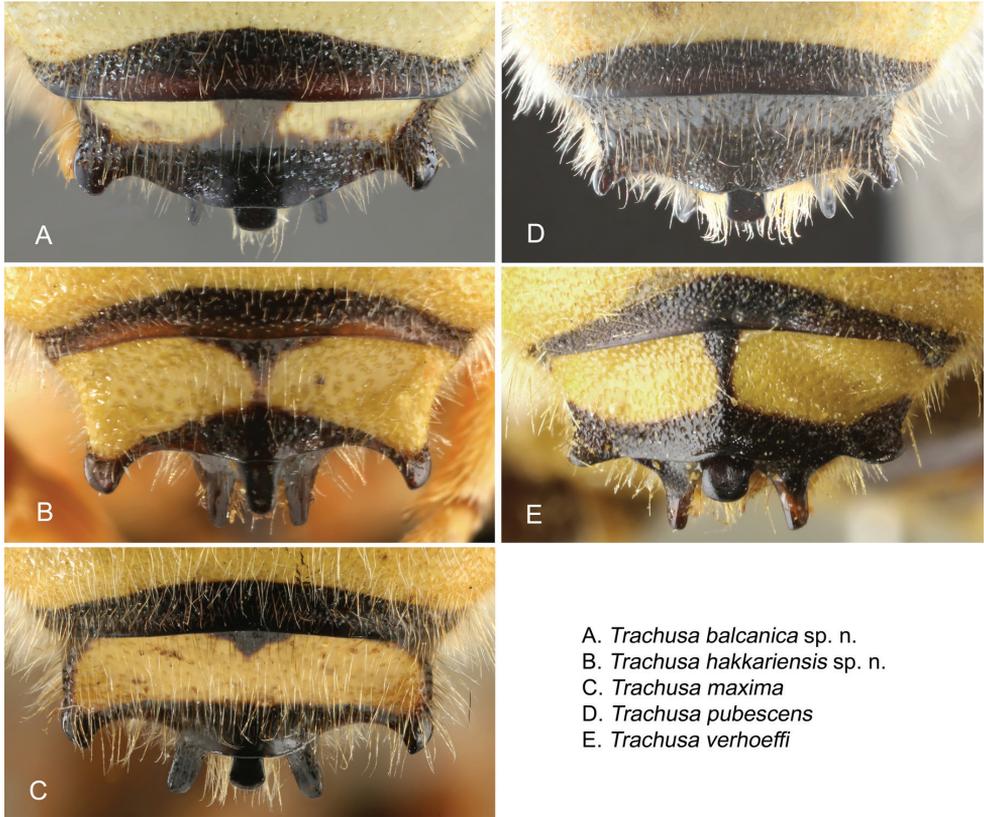


Figure 15. The two apical terga (T6–T7) of males of the five species of the *Trachusa pubescens* complex.

noted on specimen labels), and his collection activities and travel itineraries (Pretner 2011) point to the year 1929. The exact type locality could not be identified but it is likely that it is situated in the area around Isparta.

***Trachusa pubescens* (Morawitz, 1872)**

Figs 11, 12, 14, 15

Anthidium pubescens Morawitz 1872: 59–60 [Note: While the date of publication is given in many publications as 1873, it has now been accepted as 27.vi.1872. See Pesenko and Astafurova (2003)].

Anthidium pubescens Morawitz (1874).

Lectotype. Male, Derbent, Dagestan, Russia (ZISP). Photographs provided by Yu. Astafurova.

The species was described on the basis of two males collected in “Hab. in Caucaso, Derbent” (photographs of original labels in Proshchalykin et al. 2017). There are two

males in ZISP from this locality, which corresponds to the original description of Morawitz (1872, 1874). One of these males was designated as lectotype by Proshchalykin and Astafurova in 2016 (Proshchalykin et al. 2017).

Material examined. Females have been assigned to *T. pubescens* on the basis of the location of the collection area (as long as no other species of the species group are known to occur in this region: Crimea, southern Greece, northern Iran) or because they were collected together with males which were positively identified as *T. pubescens* (Turkey). **GREECE:** 2♀, 6♂, Alt-Korinth (ancient Corinth), Peloponnes, 03.06.1964, M. Schwarz leg. (6ex. cMS, 2ex. cMAV); 1♀, same location, 21.05.1964, 1♀, same location, 23.05.1962, M. Schwarz leg. (cMS); 1♀, same location, 01.06.1974, M. Schwarz leg. (cMAV); 1♂, Alt-Korinth (ancient Corinth), Solomos, Peloponnes, 24.05.1964, M. Schwarz leg. (cMS); 1♂, Athens, 02.06.1962, H. Hunder leg. (cMS); 2♀, Corinth, Peloponnes, 24.05.1962, M. Schwarz leg. (1 ex. cMAV, 1 ex. cMS); 1♀, Chelmos, Kalavrita, Peloponnes, 31.05.1962, H. Hamann leg. (cMS); 2♂, Chalkis (Euboea), V.1926, Holtz leg. (ZMB); 1♂, Hellas Alt-Korinth, 21.06.1996, W. Arens leg. (cWA); 1♂, *ibid.*, 07.06.1997, W. Arens leg. (cWA). **IRAN:** 2♂, Elburs, Polour 22 km N Ab Ali, 13.-14.7.1965, A. G. Soika & G. A. Mavromoustakis leg. (OLL); 3♀, *ibid.*, 11.07.1965, A. G. Soika & G. A. Mavromoustakis leg. (OLL); 1♀, Tehran, 5.-8.5.1972, H. Bytinski-Salz leg. (OLL); 3♂, Elburs, Ilekah road 4 km above Pol-e Zanguleh, 2450 m, 14.7.1967, Baker leg. (SEMC, Baker collection); 1♀, 1♂, Kakan, Yasouj, 9.07.2009 (cAM). **MACEDONIA** (Former Yugoslav Republic): 1♀, 1♂, Prilep, 01.06.1965, K. Warncke leg. (OLL). **RUSSIA:** 1♂ (paralectotype), Derbent, Dagestan (ZISP). Photographs provided by Yu. Astafurova. **TURKEY:** 1♀, 3♂, Turkey („Asia Minor“), 1890 (OLL, ZMB); 1♀, 1♂, Ankara, 16.06.1934, A. Seitz leg., „*Anthidium laticeps* F. Mor. det. J. D. Alfken 1934“ (ZMB); 1♂, *ibid.*, 21.06.1934, A. Seitz leg., „*Archianthidium maximum* Friese Pasteels det. 1967“ (SMF); 1♂, *ibid.*, 24.06.1934, A. Seitz leg., „*A. pubescens* Pasteels det. 1976“ (SMF); 1♂, *ibid.*, 25.06.1934, A. Seitz leg., „*A. laticeps* / *Archianthidium pubescens* J. Pasteels det. 1976“ (SMF); 3♂, Ankara: 40 km W of Ayas, 26.06.1998, J. Halada leg. (cMS); 5♂, Isparta: Karakuş Dağı Centr. (38°15'N, 30°39'E), 1460 m, 11.07.2006, J. Halada leg. (cMS); 2♂, Denizli: 35 km SSE Denizli (37°37'N, 29°17'E) 970 m, 05.07.2006, J. Halada leg.; 1♀, 2♂, 28 km SSE Kütahya (39°13'N, 30°08'E) 1110 m, 12.07.2006, J. Halada leg. (cMS); 3♀, 4♂, Tatvan, Van Gölü, 01.07.2000, M. Halada leg. (cMS); 2♀, 3♂, Bitlis, Nemrut Dağı (2000 m); 28.07.1986, I. Blank leg. (OLL); 2♀, 1♂, Siirt: 10 km S, 23.-24.6.1985, M. Schwarz leg. (cMS); 2♀, 1♂, Adiyaman: Gölbaşı, 21.06.1985, M. Schwarz leg. (cMS); 1♂, Hakkâri: 16 km SE Yüksekova (1700 m), 28.06.1985, M. Schwarz leg. (cMS); 1♂, Hakkâri: Sat Mountain S Vargös (2000 m), 06.08.1982, K. Warncke leg. (OLL). **TURKMENISTAN:** 1♂, West Kopet Dagh [Köpëtdag], Syunt Mts., 21.06.1953, O. Kryzhanovskiy leg. (ZISP). Photographs provided by Yu. Astafurova. **UKRAINE:** 1♂, Crimea, 03.08.1937 (SIZK); 1♂, Crimea (exact location illegible), before 1908 (SIZK); 1♂, Crimea („Tauria“; exact location illegible), 22.06.1914, V. Pliginski leg., (cMAV); 2♂, Crimea (exact location illegible), without date (cMAV); 1♂, Crimea („Tauria“), Sevastopol, 26.06.1911, V.

Pliginski leg. (cMAV); 1♂, Crimea ("Tauria"), 21.06.1909, V. Pliginski leg. (cMAV); 1♂, Crimea, Savastopol, 26.06.1986 (SIZK); 1♂, *ibid.*, 08.07.1912, V. Pliginski leg. (cMAV); 1♂, Karadag, Crimea, 01.07.1919 (OLL); 1♀, *ibid.*, 17.06.1923 (OLL); 1♂, *ibid.*, 23.06.1925, Kistjakovsky leg. (SIZK); 1♂, *ibid.*, 22.06.1929, J. Paramonum leg. (SIZK); 1♀, 1♂, Crimea, Feodossija, 17.06.1995, C. Ivanov leg. (SIZK).

Other material. TURKEY: The following females from Turkey are attributed to this species as "*Trachusa aff. pubescens*": 1♀, Ankara, 22.06.1973, K. Warncke leg. (OLL); 1♀, Ankara: Kızılcahamam; 18.06.1985, M. Schwarz leg. (cMS); 1♀, Ankara: 10 km S Ankara, 05.06.1988, K. Warncke leg. (OLL); 1♀, Konya: 10 km S Karaman, 19.06.1985, M. Schwarz leg. (cMS); 1♀, Konya: Sille; 08.06.1972, J. Heinrich leg. (SMF); 1♀, Akşehir, 07.1934, (OLL), "*A. interruptum* Pasteels det. 1967 / *A. pubescens* det. Warncke"; 2♀, Akşehir ("Ak-Chehir"), 1900, Korb leg. (OLL); 3♀, Hakkâri: 19 km S Beyütüşşebap (1200 m), 26.06.1985, M. Schwarz leg. (cMS); 1♀, Malatya: Erkenek 60 km SW Malatya (1300 m), 26.06.2000, M. Halada leg. (cMS); 1♀, Hakkâri: 16 km SE Yüksekova (1700 m), 28.06.1985, M. Schwarz leg. (cMS); 1♀, Hakkâri, Suvari-Halil-Paß östl. Beyütüşşebap (2300 m), 03.08.1982, K. Warncke leg. (OLL).

Differential diagnosis. The male is characterised by the following morphological features: Apical margin of clypeus straight or only slightly curved inwards and shallowly crenulated, usually without individually discernible tubercles; lateral projections of T6 subacute, apex of median projection emarginate (variable between a shallowly emarginate and a narrow V-shaped incision); punctation of T6 dense and coarse; median projection of T7 broadened toward apex. In some specimens in which the median emargination of T6 is inconspicuous or absent, the median projection of T7 is widened. For identification at least one of these two characters should hold true. Margins of yellow maculations on abdominal terga normally irregularly ragged.

Variability. Four OUs were distinguished: Greece (including one from FYR of Macedonia), Crimea, Anatolia, and northern Iran. Members of the Greek and Crimean OUs are characterised by yellow maculation in the genal area and a dark vertex. The genal maculation usually extends from the top of the eye to the lower end of the eye but is sometimes irregular (margins ragged or maculations broken). Only one specimen from the Crimea has yellow on the vertex. In the Anatolian OU, however, the yellow maculation of the genal area usually extends up to the middle of the vertex and merges, or at least the lateral bands are contiguous. There is, however, some variation within populations and, for example, specimens with merged maculation and with widely separated maculations can be found together. The colour pattern of northern Iranian specimens is in general close to the Greek and Crimean OUs but one specimen with subcontiguous bands is available.

The yellow colouration on T2 in the Crimean, Greek and northern Iranian OUs is confined to lateral bands far apart from each other, whereas in the Anatolian OU the gap between the lateral bands is narrower and two small yellow spots are normally situated between them.

Specimens of the northern Iranian OU are smaller than those in the other populations. Despite a small sample size (N = 5), the Iranian specimens proved to be signifi-

cantly smaller than Anatolian specimens in 22 of 27 morphological features (at least $p < 0.05$; t-test). Anatolian specimens in turn do not differ in size from Crimean and Greek specimens.

A Discriminant Analysis (DA) was carried out to find out whether the OUs attributed to *T. pubescens* s. str. are different from each other in morphometric characters. Fig. 4 shows that the specimens from Greece, Crimea, and Anatolia form three distinctive clusters. In their morphometric characters northern Iranian specimens are between the Greek and Anatolian specimens but their separation is less clear. Nevertheless, in a confusion matrix, which summarises the reclassification of the observations and enables us to see quickly the percentage of well-classified observations, all specimens (100%) of all four groups were correctly classified.

Altogether, the populations of *T. pubescens* s. str. from Greece, the Crimea, Anatolia, and northern Iran can be separated based on a set of morphological features. Northern Iranian specimens are smaller than all others. The colouration pattern of the vertex and gena enables most Anatolian specimens to be distinguished from the others, but due to variation within populations this feature is not regarded here as being of taxonomic significance. The pattern of the yellow colouration on the first three terga is on average different in the Anatolian population from the other OUs. All these features could justify giving the OUs subspecies rank. However, the holotype of *T. pubescens* could not be examined and, although the description is detailed enough to allow unambiguous species attribution within the *T. pubescens* species group, it is not detailed enough to decide whether the colouration and/or morphometric features agree with one of the OUs described here.

Flower preference. No information available.

Distribution. The distribution area extends from Crimea and southern Greece over Anatolia and the Caucasus to the Kopet Dagh Mountain in Turkmenistan. In the south, the distribution area extends into the Zagross Mountains of Iran. Possible hybridisation with *T. balcanica* sp. n. takes place in the F.Y.R. Macedonia.

Mocsáry (1879, 1884) describes material from Hungary with an emarginate T6. While this character alone does not allow unambiguous species identification, it may be interpreted as an indication that the distribution of *T. pubescens* may extend further north than indicated by the records presented in this paper.

***Trachusa verhoeffi* (Mavromoustakis, 1955), stat. n.**

Figures 11, 12, 14, 15

Archianthidium pubescens (F. Mor.), subsp. *verhoeffi*. – Mavromoustakis (1955: 921–922).

Anthidium pubescens ssp. *verhoeffi* Morawitz, 1872. – Warncke (1980).

Trachusa (*Archianthidium*) *pubescens verhoeffi* (Mavromoustakis, 1955). – stat. n.

Material. Holotype: Male. **ISRAEL:** 12-14.05.1951, P. M. F. Verhoeff leg. (cMAV). – Paratypes: 1♀ “allotype”, 1♀, 1♂ paratype, same data as holotype (cMAV).

Other material examined: **ISRAEL**: 1♂, Israel, 12–14.05.1951, P. M. F. Verhoeff leg. (cMAV); 2♀, 1♂, Jerusalem, 12-14.05.1951, P. M. F. Verhoeff leg. (cMAV); 1♂, Kirjat Anawim, 07.05.1930, Bodenheimer leg. (ZMB). **JORDAN**: 2♂, Jordan valley: Dayr Alla, 27.04.1996, Mi. Halada leg. (cMS). **LEBANON**: 2♂, Donieh: Sfiri (34°25'N, 36°03'E) 808 m, 27.05.2012, M. Kasperek leg. (cMK). **PAL-ESTINE** (State of): 1♂, Har Gilo, 5 km SW Jerusalem, 850 m, 23.04.1989, R. Kasher leg., *Phlomis viscosa* Labiatae (SEMC). **TURKEY**: 1♂, Akyaka: Korucak (Muğla prov.), 07.05.2013, (cMK); 1♀, 2♂, Akyaka: Kıran (700 m) (Muğla prov.), 15.05.2013, (cMK); 2♂, Akyaka: Çardak (700 m) (Muğla prov.), 15.05.2013, (cMK); 1♂, Akyaka: Çardak (700 m) (Muğla prov.), 19.05.2015, (cMK); 1♂, Akyaka: Gökçe (Muğla prov.), 13.05.2010, (cMK); 1♂, Akyaka: Korucak (Muğla prov.), 07.05.2013, (cMK); 1♂, Köyceğiz (Muğla prov.), 15.06.2016, (cMK); 1♀, Antalya: Termessos 700-1000 m (37°00'N, 30°28'E), 23.-24.5.83, Aspöck, Rausch & Ressler leg. (cMS); 1♀, Termessos, 07.05.1989, W. Perraudin leg. (OLL); 1♂, Antakya, 01.06.1965, M. Schwarz leg. (cMS); 1♂, Antakya, 04.06.1965, M. Schwarz leg. (cMS); 1♀, Antakya, 06.06.1965, M. Schwarz leg. (cMS); 1♂, Antakya env., 30.04.1994, Mi. Halada leg. (cMS); 1♂, 10 km N Saimbeyli, 120 km N Adana, 12.06.1998, Ma. Halada leg. (cMS). 1♀, 1.5 km SW Yeşilova (Ula, Muğla prov.) (75 m), 18.04.2018, H. Koç, O. Özgül & M. Kasperek leg. (cMK). – **SYRIA**: 1♀, Syria, 1886, Gödl leg. (OLL) [Note: Gödl gave only “Syria” as the location for this and for other collected insect material, without further specifications. It cannot be ruled out that the specimen was collected in an area which is nowadays in Turkey or Lebanon].

Differential diagnosis. Males are characterised by a widely rounded median projection on T6 (apical emargination absent) combined with a short, obtuse and rounded process on each side (acute or subacute in all other species) (Figs 16, 17). Punctuation on T6 slightly finer than in *T. pubescens*, but clearly coarser than in *T. hakkariensis* sp. n., *T. maxima* and *T. balcanica* sp. n. Median projection of T7 relatively broad, more or less parallel-sided (no significant apical thickening as in *T. pubescens* s. str. or apical tapering as in *T. hakkariensis* sp. n.). The apex of the clypeus is shallowly emarginate (on average slightly shallower than in *T. balcanica* sp. n., *T. maxima* and *T. hakkariensis* sp. n.) and crenulated with approximately 8-11 denticles. The abdominal T1 and T2 have a very broad transverse yellow stripe on each side not reaching the middle; T3 similar, but often extending almost to the middle (subcontiguous); T4 and T5 with broad yellow bands, broken in the middle or with a basal notch.

Variability. Males from the Levantine coastal area (from the Turkish provinces of Hatay over Lebanon to Israel, Palestine, and Jordan) are much richer in yellow than those from SW Turkey. The yellow maculation extends from the lower end of one eye over the vertex to the lower end of the other eye, only narrowly broken on vertex in some specimens. In the specimens from SW Turkey, this yellow colouration is reduced to some remnants on genae and vertex. While there is great individual variation in the extent of the yellow, the yellow on the genae and vertex are never merged. Also the extent of the yellow on the scutum is much reduced in SW Turkish specimens: Levantine specimens

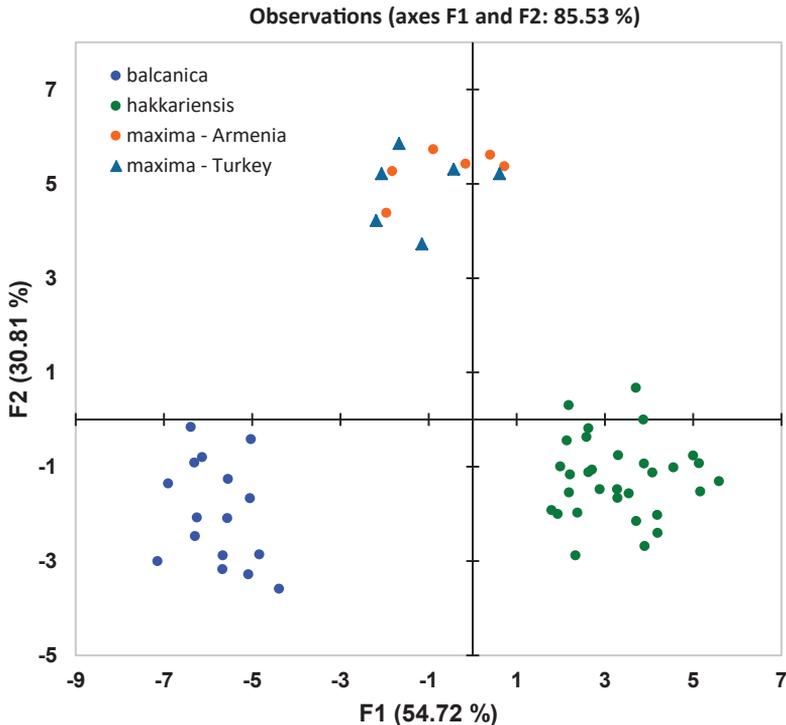


Figure 16. Discriminant Analysis (DA) of the 26 morphometric characters of males of *Trichusa balcanica* sp. n., *T. hakkariensis* sp. n., and *T. maxima*. Members of these OUs are characterised by an emarginate clypeus and subacute lateral projections of T6. *Trichusa maxima* is subdivided into the Armenian OU (including one specimen from central Iran) and the Anatolian OU.

have a broad yellow L-shaped anterolateral band on scutum and sometimes also some inconspicuous yellow spots on axillae. This yellow maculation is much reduced in SW Turkish specimens and often entirely absent. Although not apparent to the naked eye, specimens of the Levantine OU proved to be larger than those of the SW Turkish OU. From 26 morphometric measurements examined, the Levantine OU is on average larger in 24 of them. In nine of them, the size differences are significant (at least $p < 0.05$, t-test).

The colouration pattern of a male from the central Taurus Mountains (Saimbeyli, Turkey) coincides with the pattern of the SW Turkish OU including the absence of yellow colouration on the scutum. On T6, the lateral projections are shallow and rounded as is typical for *T. verhoeffi*, but the apex of the median projection has a shallow emargination as is typical for *T. pubescens*. This is the only specimen with such an emargination among the 20 males examined of this taxon. Additionally, the punctuation of T6 is coarser than in the other specimens and in this character also resembles *T. pubescens*.

Distribution. Mavromoustakis (1955) thought that the distribution of this taxon was confined to the Levantine coastal area (Israel, Palestine, Lebanon). Warncke (1980) supposed that it extends to the Amanus Mountains in southern Turkey. The new re-

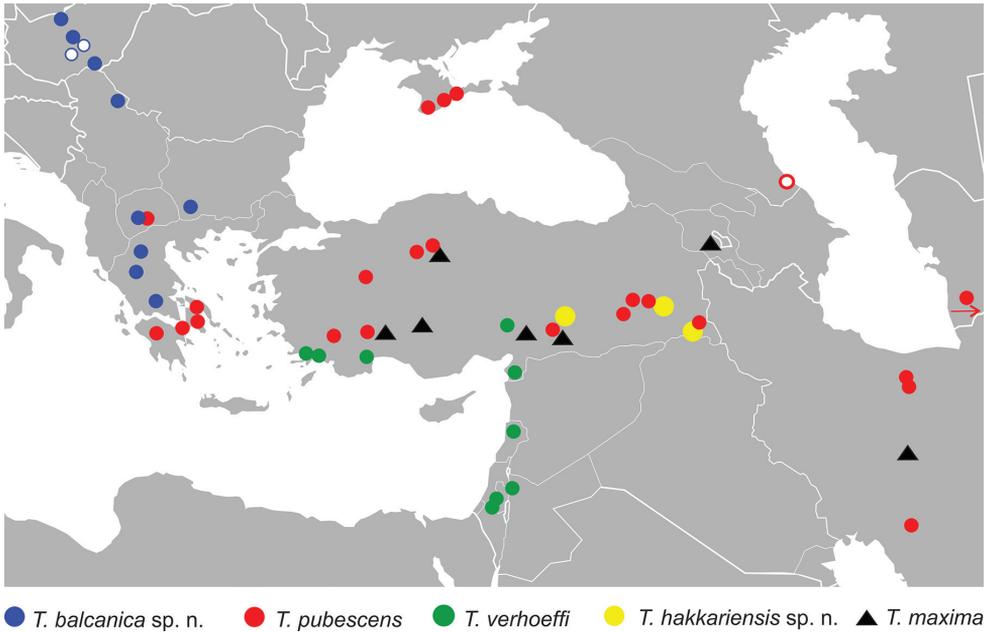


Figure 17. Distribution of the species of the *Trachusa pubescens* complex. The red circle shows the locus typicus of *T. pubescens* s. str. A locality of *T. pubescens* s. str. in Turkmenistan is not shown as it is beyond the limits of the map.

cords show that the distribution actually extends along the entire Mediterranean coastal area of Turkey and in Muğla province reaches the border with the Aegean region.

Flower preference. Mavromoustakis (1955) records *Phlomis viscosa* (Lamiaceae) for Israel and Lebanon, and R. Kasher (as per collection label) found it in the West Bank (State of Palestine) on the same flowers. Kasperek (2017a) collected it in Lebanon at *Ph. chrysophylla*. Both *Phlomis* species are very similar. *Ph. viscosa* occurs along the Levantine coast up to southern Turkey (Hatay – Adana region), whereas *Ph. chrysophylla* is native to Lebanon, Syria and Israel/Palestine, i.e. not reaching so far north. In SW Turkey, Kasperek (unpubl.) collected it on *Phlomis* cf. *fruticosa*.

Conclusions and discussion

The examination of more than 200 specimens of *T. pubescens* s. l. showed that this is actually a complex of at least five species. This includes two species which had previously been assigned as “variants” or subspecies and are elevated here to the species level. All species are clearly defined by a combination of colouration and morphometric features. They maintain either phenotypic integrity in sympatry, or, in the case of geographic replacement species, their contact zone consists of an abrupt transition with little phenotypic intergradation. Below the species level, morphometric and/or colour

differences were also found between some OUs (populations), and it cannot be ruled out that some of them actually represent subspecies or even distinct species.

Species concept

An important criterion for the assignment to species level was whether males can be clearly distinguished from the males of all other taxa by the combination of two or three functionally independent characters (Helbig et al. 2002), for example colouration plus shape of T6 or shape of clypeus plus shape of T6. Actually or potentially covarying characters, such as the extent of yellow colouration on the genae and vertex are not regarded as independent. Size differences or differences in the extent of yellow colouration alone were not taken as a basis for species assignment. For this reason, the OUs of *T. verhoeffi* in SW Turkey and the Levant were not given different taxonomic status despite some distinctive characters. Additionally the OU Armenia and the OU Anatolia of *T. maxima* are not assigned to different taxa despite differences in body size and colouration. In these cases, the evolutionary distinctness of the OUs at the species-level is doubtful and their assignment to different species would put the future integrity of the taxonomic status at risk. In *T. pubescens*, the OUs in Greece, Crimea, Anatolia, and Iran are assigned to the same species although differences are found between them both in colouration and morphometrics. Here we are faced with the dilemma that all these OUs correspond with the description of the species, but a finer classification cannot be made as the type material was not examined, and we therefore do not know which (if any) of the OUs corresponds exactly with the original name-bearing material.

The characters used for classification were the shape and size of the clypeus, mandibles, terga T6 and T7, overall colouration pattern and morphometric features. With this taxonomic concept, it was only possible to distinguish males. The colour pattern of females often resembles that of males within a certain OU, but due to the absence of distinguishing structural characters, it was impossible to determine females unambiguously. Morphometric analyses were not carried out because of the much lower number of females available (60 females compared to 148 males).

Flower preferences

Trachusa verhoeffi and *T. maxima* are known to have strong preferences for visiting the large yellow flowers of various species of *Phlomis*. Species identified include *Ph. chrysophylla*, *Ph. grandiflora*, *Ph. nissolii*, *Phlomis* cf. *fruticosa*, and *Ph. viscosa* (Güler et al. 2014, Kasperek 2017a, Kasperek, unpubl.). Some of these plant species are very similar and difficult to distinguish and we cannot be sure whether the species has always been identified correctly. The flowers of *Phlomis* are arranged in whorls which encircle the stems. The flower consists of an upper and a lower lip (“Labiatae”) and the upper lip is hood-shaped and laterally compressed. *Trachusa balcanica* sp. n., the smallest species of the complex,

is the only species which was observed visiting other plants and these include *Genista* (yellow flowers) and *Stachys germanica* (pink or pinkish-purple) (Friese 1898; Mocsáry 1884). Also a record on *Scabiosa ochroleuca* (whitish yellow flowers) from Moldova probably refers to this species. While *Genista* has pea-shaped flowers, the five-lobed corolla of *Stachys* has a “hood” formed by the top lobe, and *Scabiosa* has clusters of flowers (inflorescences) in the form of heads, with each head containing many small florets.

Müller (1996) showed in a pollen analyses that more than 99% of the pollen sampled from in excess of 30 specimens of *Trachusa pubescens* s. l. comes from Labiatae. His specimens were sampled over a large portion of the range of the *T. pubescens* complex. Özbek and van der Zanden (1993) mention *T. pubescens* s. l. visiting *Onobrychis viciifolia* (purple pea-shaped flowers) in eastern Turkey. It is not clear to which taxon of the *T. pubescens* complex this observation can be attributed to. According to Grace (2010), *T. pubescens* s. l. is an oligolege of Labiatae and therefore flower visit records to the Asteraceae, including *Carduus* and *Centaurea*, will refer to nectar gathering by either sex.

In Anthidiini, the females of the species studied so far are polyandrous, and polyandry is combined with male territoriality (Paxton 2005). In the case of *Anthidium*, the defended territories are the females’ food flowers (Severinghaus et al. 1981). The data presented here suggest that the evolution of the *Trachusa pubescens* complex is closely related to their flower preferences. Flowers of the genus *Phlomis*, which may have played a key role, are native to Asia, southern Europe, and northern Africa and comprise approximately 113 species (IPNI 2012, Mathiesen 2006).

Distributional relationships

The distribution of all species of the complex is given in Fig. 17. *Trachusa balcanica* sp. n. and *T. verhoeffi* have distribution areas which do not overlap with any of the other species of the group and can thus be characterised as allospecies. In contrast, the distribution areas of the other three species, *T. pubescens*, *T. maxima*, and *T. hakkariensis* sp. n. overlap to some extent and these species co-exist at least to some degree in sympatry. While two or three of these species have been found together in the same region, they have so far never been found together at exactly the same location. It is suggested that species divergence went in parallel with ecological differentiation. Niche partitioning such as flower preference is a mechanism which may be invoked to explain this.

Trachusa pubescens has the widest distribution, extending from the Balkan Peninsula and the Crimea Peninsula over Anatolia and the northern slopes of the Greater Caucasus (Dagestan, Russia) to the Elburs Mountains in northern Iran and the Kopet Dag Mountain in Turkmenistan. In the Balkans, the border between the distribution of *T. pubescens* and *T. balcanica* sp. n. is sharp; both species can easily be distinguished, usually on the basis of their size and colouration alone without considering detailed morphological features. In the contact area, in the FYR of Macedonia, some specimens with intermediate characters were found. It is thought that a secondary contact zone exists there, with some hybridisation occurring there.

In Inner and Northern Anatolia, the distribution of *T. pubescens* overlaps with the distribution of *T. maxima*; both species were collected in Ankara province. However, according to the collection labels the species have never been collected together and it may well be that this is due to different ecological requirements.

Trachusa verhoeffi occurs along the Mediterranean coast from the southern Aegean region to the southern Levant. Its distribution area is clearly separated from those of *T. maxima* and *T. hakkariensis* sp. n. which occur north of the Taurus mountain ridge. One male collected in the central Taurus Mountains shows some characters which are close to *T. pubescens*. A final appraisal of the taxonomic status and possible hybridisation cannot be made on the basis of this single individual.

Trachusa maxima shows a disjunct distribution: it occurs in Inner Anatolia, south-eastern Anatolia, Armenia and central Iran. It is not known whether this scattered distribution pattern is merely the result of a lack of material. Differences between these three populations were found in terms of morphology, morphometry and colouration. They are, however, not strong enough to justify the assignment to different species. From central Iran, a single male is available, and this is by far the largest individual examined of the entire *T. pubescens* complex. More material is needed to show whether it is justified to give this OU a separate taxonomic status.

Trachusa hakkariensis sp. n. has a relatively narrow distribution area in eastern and south-eastern Turkey. It has been found in the same region as *T. pubescens* but never together at the same location. *Trachusa maxima* also lives in areas close to *T. hakkariensis* sp. n. but was never found together with it.

Mocsáry (1884) mentions material in the Hungarian Natural History Museum from Constantine in Algeria, which is far outside the known range of *T. pubescens* s. l. This material could not be traced (Zoltán Vas, pers. comm.) and it is suggested that it should be ignored.

Dentition

Trachusa pubescens s. l. has a large apical and a smaller subapical tooth, followed by two teeth which are often merged or reduced to an edentate tooth ridge (Figs 14A, C, E). As even fresh individuals often have straight tooth ridges, a straight tooth ridge is certainly not merely the result of abrasion. In approximately 45% of all males examined, the subapical tooth is completely or almost entirely absent (see e.g., Figs 14B, D). Such a high proportion of broken teeth is unusual and raises the question of its function. It may be speculated that this tooth has a special role, e.g. in opening the walls of the brood cells.

Colouration of tergum 6

The colouration of tergum 6 is highly variable in all species of the complex. While the median projection and the lateral teeth are always black, and also a small black v-shaped maculation is always present on the proximal side, the extent of the yellow

colouration shows high variation: yellow maculation may be completely absent (resulting in an entirely black T6), may be confined to a small median spot on the surface of T6 or to two spots (one on each side), or may cover most of T6. On average, there are more specimens with entirely black T6 or with only small yellow maculation in *T. pubescens* s. str. than in the other species of the complex. Within the species, specimens with black or almost black T6 are more frequent in material from Ukraine and Greece than from Anatolia and Iran. Despite interspecific differences in the frequency pattern, this character apparently does not have taxonomic relevance.

Melanism

A semi-melanistic individual of *T. balcanica* sp. n. was found. It had all the yellow colouration much reduced on the head, meso- and metasoma, and had black maculation also on the hind tibiae, which are normally completely yellow. As the habitus, general structure, and body measurements fall completely within the range of *T. balcanica* sp. n., it is thought that this individual belongs to this species and not to a hitherto undescribed taxon. Melanistic or partly melanistic bees have been found in several bee species and may form a certain component of a population. For example, Sheffield et al. (2011) regularly found both pale and melanistic forms in three species of *Megachile* in Canada and Alaska. In the Western Palaearctic, melanism is well known in several species of *Bombus* (e.g. Schmiedeknecht 1907, Pekkarinen and Teräs 1986) and the proportion of melanistic *Bombus* has increased recently in Finland (Södermann 1999). The phenomenon of melanism has been thought to be related to unfavourable environmental conditions in early spring (Södermann 1999). For *Andrena albihirta*, Landham (1974) found a melanism rate of up to 36 percent in twelve populations in the Rocky Mountains and suggested that black colouration functions to lengthen the active period of the species by absorption of solar heat even in reduced sunlight. Nemésio and Martins (2013) found specimens of the Neotropical orchid bee *Euglossa carolina* in which the metallic integument is replaced by black colouration, indicating a reversion in the evolution of the colouration of the integument.

Identification key (males)

- 1 Apical margin of clypeus straight or almost straight, shallowly crenulated with hardly distinguishable tubercles (Fig. 14E); apices of penis valves straight (Fig. 10) [SE Europe over Caucasus to Iran and Turkmenistan]..... ***T. pubescens* s. str.**
- Apical margin of clypeus impressed in the middle, forming a wide emargination; margin crenulated with 8-11 rounded tubercles (Fig. 14A–D); apices of penis valves hooked..... **2**
- 2 Lateral projections of T6 rounded (Fig. 7) [Mediterranean coast]..... ***T. verhoeffi* stat. n.**
- Lateral projections of T6 subacute or acute (Fig. 7)..... **3**

- 3 Median projection of T6 extending beyond lateral projections (Fig. 7); T7 parallel-sided or widened apically (Fig. 8) **4**
- Median projection of T6 not extending beyond lateral teeth (Fig. 7); T7 usually tapering towards apex (Fig. 8); small to medium-sized species [Eastern and south-eastern Turkey] ***T. hakkariensis* sp. n.**
- 4 Mandible large (Fig. 14D), mandibular width at base of teeth at least as long as clypeus length; large yellow maculation in genal area extending from upper to lower end of eye; large species [Anatolia and Iran] ***T. maxima* stat. n.**
- Mandible smaller (Figs 14A–C, E), mandibular width at base of teeth less than clypeus length; yellow maculation on genal area confined to its upper half or rarely slightly beyond; yellow stripe on vertex usually separated from yellow genal maculation; small species [Balkans] ***T. balcanica* sp. n.**

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A review of the *Delia interflua* group with descriptions of two new species (Diptera, Anthomyiidae)

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Abstract

The *Delia interflua* group is reviewed to include 16 species. Two new species are described, namely *Delia subnemostylata* Xue & Du, **sp. n.**, *Delia nigeriposticrus* Xue & Du, **sp. n.** A catalogue and amended key to new species of this group are also included.

Keywords

Anthomyiidae, *Delia*, key, new species

Introduction

The genus *Delia* Robineau-Desvoidy, 1830 belongs to the dipteran family Anthomyiidae. More than 310 species in this genus (excluding Neotropical species) are known from around the world (Hennig 1974, Ackland and Pont 1977, Fan et al. 1988, Pont 1989, Griffiths 1991, Dely-Draskovits 1993, Wei et al. 1996, Ackland 2008, Xue and Du 2008, Xue and Du 2009, Wang et al. 2014, Du and Xue 2017). The *Delia interflua* group is a small group and can be recognized by the following characters: the apices of the sternite V processes dilate and rounded, except for *D. subnemostylata* sp. n.; cercal

plate with long setae; surstyli elongated, except for *D. kullensis*; usually the acrophallus is supported by a sclerotized bridge between the bases of the free paraphallic processes; the sclerotized bridge is prolonged downwards, forming a membranous process (Griffiths 1991, Xue and Du 2008). In this work, two new species of this group are described, *Delia subnemostylata* Xue & Du, sp. n., *Delia nigeriposticrus* Xue & Du, sp. n. The key produced by Wei et al. (1996) is here modified to include three couplets leading to the identification of the new species.

Materials and methods

All specimens were collected from Yunnan province of China. Type specimens are deposited in the Diptera collection of the Institute of Entomology, Shenyang Normal University (IESNU). They were examined under an Olympus SZ-ST stereomicroscope. Morphological terminology is based mainly on that of McAlpine (1981). Abbreviations for terms used in this study are:

<i>a</i>	anterior setae;	<i>pd</i>	posterodorsal setae;
<i>acr</i>	acrostichal setae;	<i>post acr</i>	postsutural acrostichal setae;
<i>ad</i>	anterodorsal setae;	<i>post dc</i>	postsuturaldorsocentral setae;
<i>av</i>	anteroventral setae;	<i>pra</i>	prealar setae;
<i>d</i>	dorsal setae;	<i>prst acr</i>	presutural acrostichal setae;
<i>dc</i>	dorsocentral setae;	<i>prst dc</i>	presutural dorsocentral setae;
<i>ial</i>	intra-alar setae;	<i>pv</i>	posteroventral setae; and
<i>p</i>	posterior setae;	R_{4+5}	branch of radius.

Addendum to the key by Wei et al. (1996) for the new species of the *Delia interflua* group (males)

- 7a Hind tibia with 2 rows of *pv* *D. duplicipectina* Fan in Fan & Zheng, 1993
 – Hind tibia with no more than 1 row of *pv* 7b
 7b Mid tibia without *pv* *D. subnemostylata* Xue & Du, sp. n.
 – Mid tibia with 2 *pv* 7c
 7c Hind tibia with 2–3*av*, 5*ad*, 5–7*pd* and 5*pv*
 *D. nemostylata* Deng & Li, 1984
 – Hind tibia with a row of *av* (approx. 9–10), a row of *ad* (approx. 7–8), a row of *pd* (3 strong) and a complete row of *pv*
 *Delia nigeriposticrus* Xue & Du, sp. n.

Taxonomy

Delia subnemostylata Xue & Du, sp. n.

<http://zoobank.org/7B62520A-3712-4E81-83CE-A71C0897DFED>

Figure 1

Type material. *Holotype*. China, Yunnan Province, Baimang Snowberg, 3800–4200 m, 5 July 2006, Mingfu Wang Co., ♂ (IESNU). *Paratype*. China, same data as holotype, 3 ♂♂.

Diagnosis. Frontal setae 4–5 pairs, *pra* approx. 1.2 times as long as posterior notopleural seta; sternite I with dense long fringes, sternite III with dense long setae; postgonite without setae.

Description. *Holotype male*. Body length 5.5 mm.

Head. Eyes only with several short ciliae in lower margin; frontal vitta red brown in lower part, remaining black, 2.0 times as wide as fronto-orbital plate; frons 1.5–2.0 times as wide as anterior ocellus; frontal vitta with a pair of inter frontal setae; without orbital setae; frontal setae 4–5 pairs, situated on lower half; fronto-orbital plate, parafacial with dark gray tomentum, parafacial 1.3 times as wide as postpedicel; antenna black, postpedicel 2.0–2.3 times as long as broad; arista pubescent, the longest arisal hairs shorter than its basal diameter; lower facial margin not projecting, vibrissal angle and frontal angle in the same vertical plane in profile; gena sparsely with dark gray tomentum, genal height approx. 1/4 of eye height; anterior margin of gena with two rows of upcurved subvibrissal setulae; postocular setae extending to ventral surface, epicephalon haired; proboscis short, prementum with gray tomentum sparsely, 2.5 times as long as broad, palpus black, equal to the length of prementum.

Thorax. Ground color black with fuscous tomentum; scutum with three distinct black vittae; with two rows of hair-like *prstacr*, only one pair of *post acr* distinctly in front of scutoscutellar suture, *dc* 2+3, *ial* 0+2; without outer posthumeral seta; *pra* approx. 1.2 times as long as posterior notopleural seta; scutellum without spots, lower surface with some pale hairs apically; anterior anepisternal setae absent; notopleuron haired; basisternum of prosternum, anepimeron, meron and katepimeron all bare; both anterior and posterior spiracles small and fuscous; katepisternal seta 1+2.

Wing. Base brown and basicosta fuscous; costa setulose only basally on ventral surface, anterior surface with a row of pectinated spines; costal spine subequal to crossvein r-m; radial node bare, calypters yellowish, lower calypter approx. 2/5 length of upper one; halter yellow.

Legs. Entirely black; fore tibia with 1 submedial *ad* and 1 medial *p*; mid femur without distinct *av*, with 4–5 strong *pv* in basal half; mid tibia with 1 submedial *av*, 1 *pd* and 1 preapical *p*, without *pv*; mid tarsomere 1 without distinct setae; hind femur with 7–8 *av* in distal 2/3 (2 strong), only with distinct *pv* in distal part; hind tibia with 3 *av*, 2 *ad*, 3 *pd*, and 4–5 *pv*; all tarsi shorter than tibiae, claws and pulvilli shorter than tarsomere 5.

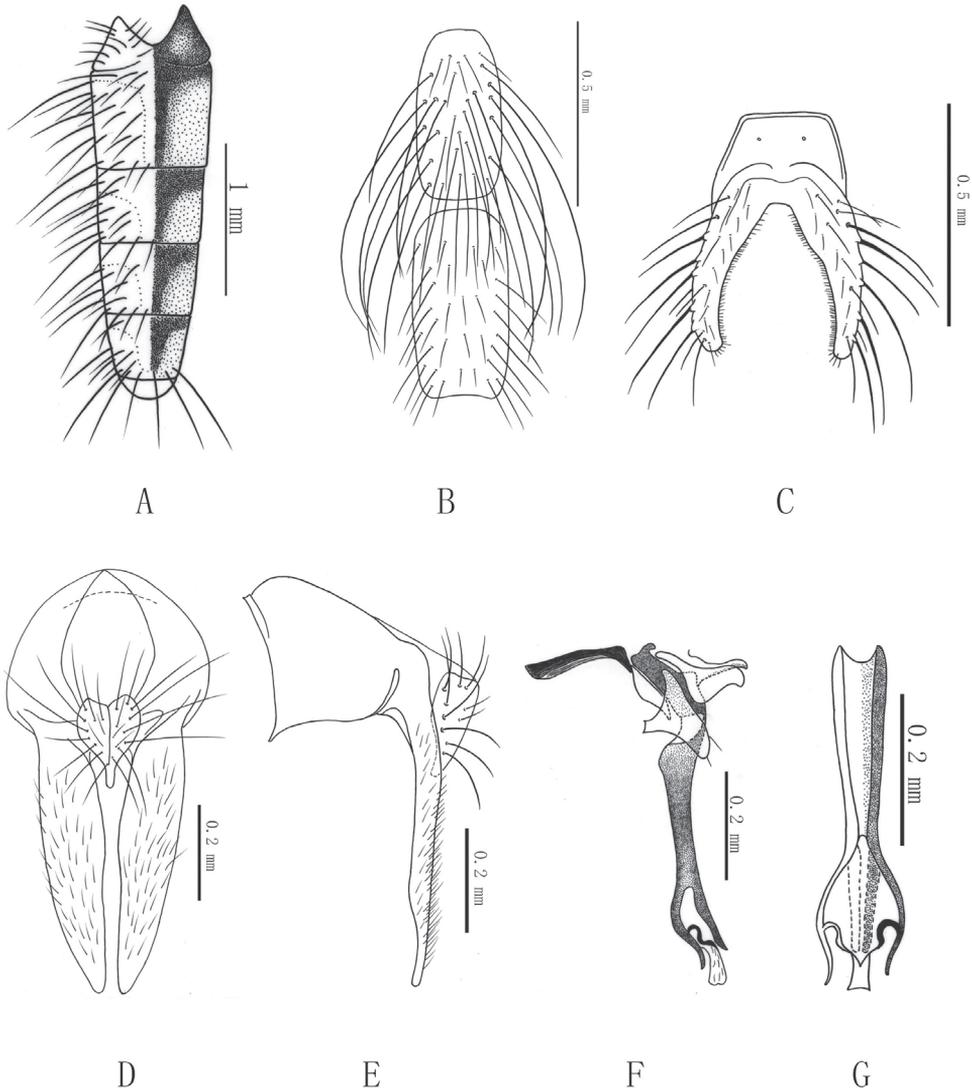


Figure 1. *Delia subnemostylata* Xue & Du, sp. n. (male). **A** Abdomen in dorsal view **B** Sternites III and IV in ventral view **C** Sternite V in ventral view **D** Epandrium, cerci, and surstyli in posterior view **E** Ditto, left lateral view **F** The hypandrial complex in left lateral view **G**. Distiphallus in anterior view.

Abdomen. Black, long flat-shaped (Fig. 1A); tergite 2 slightly longer; all tergites with T-shaped spots, lateral setae and posterior marginal setae developed, tergite VI bare; sternite I with dense and long fringes, sternite III with dense and long setae (Fig. 1B); sternite IV with short setae; sternite V processes (Fig. 1C) longer than base; cercal plate (Fig. 1D) 1.2 times longer than wide, heart-shaped, apex finger-shaped, bearing a few short setae; surstyli 3.0 times length of cercal plate, in lateral view (Fig. 1E) slender; pregonite with two setae, postgonite without setae. Aedeagus as illustrated in Figure 1F, G; acrophallus longitudinally directed, supported by a sclerotized bridge

between the bases of the free paraphallic processes, the sclerotized bridge is prolonged downwards, forming a membranous process.

Female. Unknown.

Remarks. This new species is similar to *D. nemostylata* Deng & Li, 1984 as it has very similar genitalia, but differs from it for its frontal setae 4–5 pairs, katepisternal seta 1+2; lower calypter approx. 2/5 length of upper one; fore tibia with one submedial *ad* and one medial *p*; mid tibia without *pv*; hind tibia with two *ad* and three *pd*.

Etymology. This new species is similar to *D. nemostylata* Deng & Li, 1984. Hence, its epithet is derived to reflect this relationship.

Distribution. China, Yunnan Province (Baimang Snowberg).

Delia nigeriposticrus Xue & Du, sp. n.

<http://zoobank.org/7EC8D21A-C593-4267-9FF6-2EE7691A547C>

Figure 2

Type material. Holotype. China, Yunnan Province, Yulong Snowberg, Big rope-way, 4571 m, 29 June 2006, Mingfu Wang Co., ♂ (IESNU). **Paratype.** China, same data as holotype, 2 ♂♂.

Diagnosis. Frontal vitta almost absent at the narrowest part; *pra* longer than posterior notopleural seta; both mid femur and hind femur with complete rows of *av* and *pv*; sternites V processes with expanded tips, without blunt apical setae; postgonite without setae.

Description. Holotype male. Body length 5.0–5.2 mm.

Head. Eye bare; frontal vitta black, line form at the narrowest part; frons as wide as anterior ocellus; frontal vitta with 2 pairs of interfrontal setae; without orbital setae; 7 pairs of frontal setae, situated on lower half of frons; fronto-orbital plate and parafacial with fuscous tomentum; parafacial 1.2 times wider than postpedicel; antenna black, postpedicel 1.5–2.0 times longer than broad; arista pubescent, the longest hair shorter than its basal diameter; vibrissal angle situated behind frontal angle in profile; genal height approx. 1/4 eye height; anterior margin of gena with 2 rows of upcurved subvibrissal setulae; postocular setae extending to ventral surface, epicephalon bare; prementum mostly with gray tomentum, 5.0 times longer than broad; palpus short and black, not more than half length of prementum.

Thorax. Black in ground color with brown-gray tomentum; scutum with 3 black vittae, extended to scutoscutellar suture; two rows of hair-like *prstacr*, only a single pair of *post acr* developed, *dc* 2+3, *ial* 0+2; one pair of weak outer posthumeral setae; *pra* longer than posterior notopleural seta; scutellum without spots, ventral margins with some pale setae apically; anterior anepisternal setae absent; notopleuron, basisternum of prosternum, anepimeron, meron, and katepimeron bare; both anterior and posterior spiracles small and fuscous; katepisternal seta 1+2.

Wing. Base fuscous, basicosta black; costa setulose only basally on ventral surface; costal spine short; radial node bare, calypters brown yellow; lower calypter approx. 1/3 length of upper one; halter yellow.

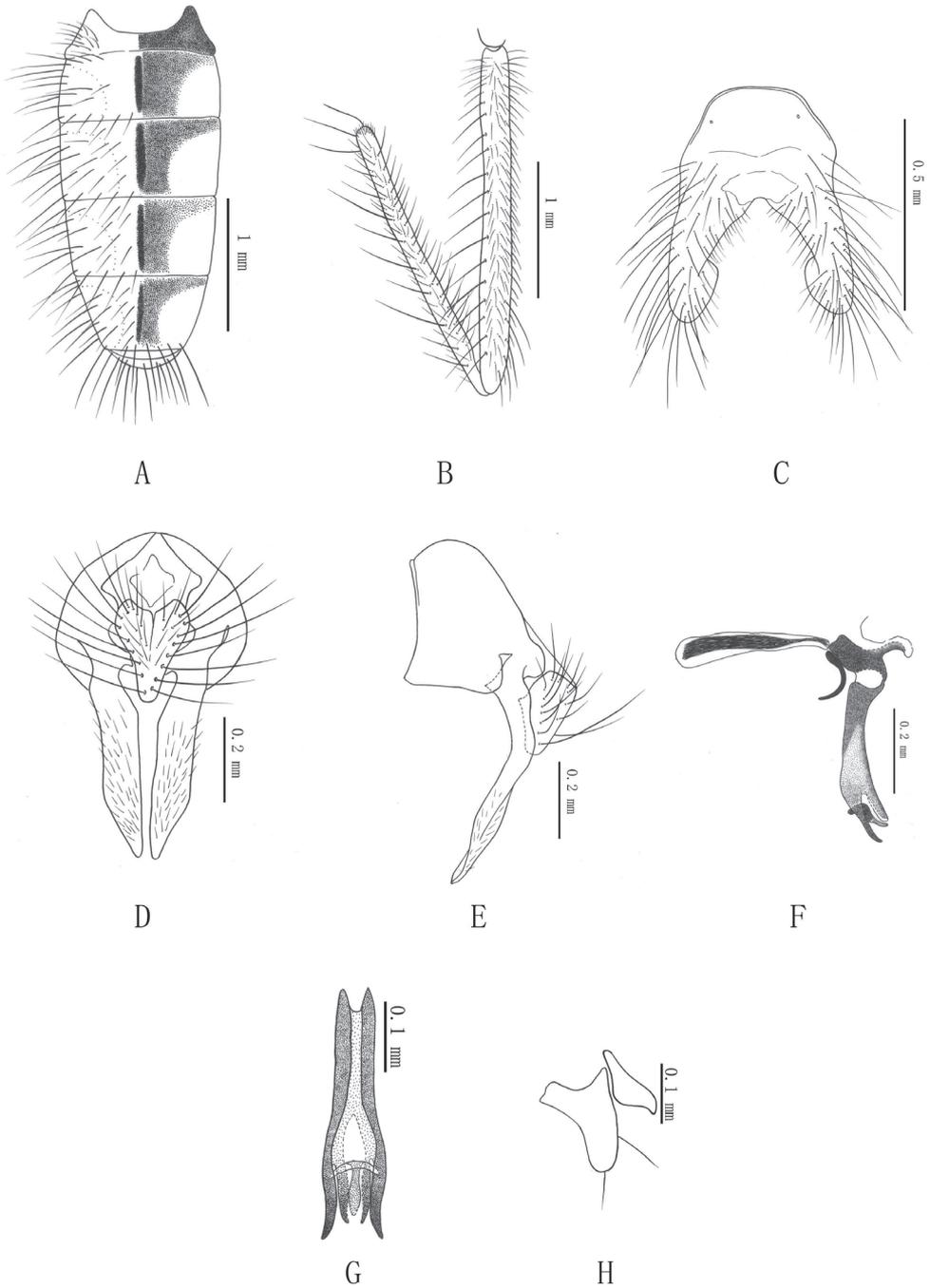


Figure 2. *Delia nigeriposticus* Xue & Du, sp. n. (male). **A** Abdomen in dorsal view **B** Hind femur and tibia in posterior view **C** Sternite V in ventral view **D** Epandrium, cerci, and surstyli in posterior view **E** Ditto, left lateral view **F** The hypandrial complex in left lateral view **G** Distiphallus in anterior view **H** Gonites.

Legs. Entirely black; fore tibia with single medial *p*; mid femur with a complete row of *av*, becoming shorter apically, a complete row of long and dense *pv*, becoming longer medially, 1.8 times as long as its diameter, 1–2 preapical *pd*; mid tibia with one super-medial *pd* and two *pv*; hind femur with complete rows of *av* and *pv*, becoming longer apically; hind tibia with a row of *av* (approx. 9–10), a row of *ad* (approx. 7–8), a row of *pd* (three strong) and a complete row of *pv*, becoming shorter apically; fore tarsus longer than tibia, all claws and pulvilli longer than tarsomere 5.

Abdomen. Black, long flat-shapes in dorsal view (Fig. 2A); all tergites with narrow black vittae in center, lateral surface with dark brown allochroic spot, outer lateral surface with gray tomentum; tergite VI bare; sternite I with dense hairs; sternites V processes with expanded tips. Cercal plate (Fig. 2D) 1.2 times longer than wide, heart-shaped, with narrowly rounded apex; surstyli 2.5 times length of cercal plate, in lateral view (Fig. 2E) strongly bent in basal half; pregonite (Fig. 2H) with 2 setae, postgonite without setae. Aedeagus as Fig. 2F–2G; acrophallus longitudinally directed, supported by a sclerotized bridge between the bases of the free paraphallic processes, the sclerotized bridge is prolonged downwards, forming a membranous process.

Female. Unknown.

Remarks. This new species is similar to *D. fulviposticrus* Li & Deng, 1981 as it has very similar genitalia, but differs from it for its male body length 5.0–5.2 mm; frontal vitta black; prementum 5.0 times longer than broad; legs black; mid femur with a complete row of *av*, becoming shorter apically, a complete row of long and dense *pv*, becoming longer medially, 1.8 times as long as its diameter, 1–2 preapical *pd*; hind femur with a complete row of *pv*, becoming longer apically.

Etymology. The specific name is from the Latin word *niger*, black, referring to its legs being entirely black which differs from those of *Delia fulviposticrus* Li & Deng, 1981 which are yellow legs.

Distribution. China, Yunnan Province (Yulong Snowberg).

Catalogue of the known species in the *Delia interflua* group

Delia absidata Xue & Du, 2008

Delia absidata Xue & Du, 2008. Type locality: China: Yunnan, Shangri-la.

Distribution. China: Yunnan Province, Shangri-la, Bitahai.

D. abstracta (Huckett, 1965)

Hylemya (Delia) abstracta Huckett, 1965. Type locality: Canada: North-West Territories.

Distribution. Canada; Mongolia.

Delia brevialpis Xue & Zhang, 1996

Delia brevialpis Xue & Zhang, 1996. Type locality: China: Qinghai, Hoh Xil.

Distribution. China: Qinghai, Hoh Xil.

Note. According to type species, both pregonite and postgonite without setae.

***Delia conjugata* Deng & Li, 1994**

Delia conjugata Deng & Li, 1994. Type locality: China: Sichuan, Emeishan.

Distribution. China: Sichuan, Emeishan.

Note. This species is very similar to *D. stenostyla*, but sternites V processes with narrowly rounded apices, without expanded tips; cercal plate more narrower, with a pair of long distal setae; surstyli in caudal view not expanded medially.

***Delia duplicipectina* Fan in Fan & Zheng, 1993**

Delia duplicipectina Fan, 1993. Type locality: China: Sichuan, Xiangcheng.

Distribution. China: Sichuan, Xiangcheng.

Note. According to type species description, the sternite V processes have broadly rounded apices, without expanded tips.

***Delia fulviposticrus* Li & Deng, 1981**

Delia fulviposticrus Li & Deng, 1981. Type locality: China: Sichuan, Emeishan.

Distribution. China: Sichuan, Emeishan.

***Delia interflua* (Pandellé, 1900)**

Chortophila interflua Pandellé, 1900. Type locality: France: Hautes-Pyrénées, Arrens.

Chortophila flavisquama Stein, 1916. Type localities: Germany: Treptow; Austria: Innsbruck; Sweden.

Chortophila setitibia Stein, 1916. Type localities: Yugoslavia: Istria; Austria: Schneeberg in Krain.

Hylemyia latifasciata Ringdahl, 1926. Type locality: Sweden: Jämtland.

Delia karasawana Suwa, 1974. Type locality: Japan: Honshû, Nagano-ken, Mt. Hodaka.

Distribution. China (Sichuan, Qinghai); Austria; Switzerland; The Czech Republic; Slovakia; Germany; France; Great Britain; Hungary; Italy; Poland; Sweden.

***D. kullensis* (Ringdahl, 1933)**

Hylemya (Delia) kullensis Ringdahl, 1933. Type locality: Sweden: “Kullaberg in Schonen”.

Distribution. Sweden; Czech Republic; Slovakia.

***D. kumatai* Suwa, 1977**

Delia kumatai Suwa, 1977. Type locality: Nepal: Bangel Kharka.

Distribution. Nepal.

***Delia nemostylata* Deng & Li, 1984**

Delia nemostylata Deng & Li, 1984. Type locality: China: Sichuan, Emeishan.

Distribution. China: Sichuan, Emeishan.

***Delia pansihirta* Jin & Fan in Jin et al. 1981**

Delia pansihirta Jin & Fan, 1981. Type locality: China: Gansu, Wenxian.

Distribution. China: Gansu, Wenxian.

Note. A body covered with more hair is a characteristic that distinguishes this species from other species of this species group.

***Delia spicularis* Fan in Fan et al. 1984**

Delia spicularis Fan, 1984. Type locality: China: Qinghai, Yushu.

Distribution. China: Qinghai, Yushu.

***Delia stenostyla* Deng & Li, 1994**

Delia stenostyla Deng & Li, 1994. Type localities: China: Sichuan, Emeishan; Songpan; Maowen.

Distribution. China: Sichuan, Emeishan; Songpan and Maowen.

***Delia subinterflua* Xue & Du, 2008**

Delia subinterflua Xue & Du, 2008. Type localities: China: Sichuan, Balangshan; Yunnan, Yulong Snowberg and Baimang Snowberg.

Distribution. China: Yunnan Province, Mt. Yulong, Big Ropeway; Sichuan, Mt. Balang.

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