ZooKeys 378: 1–15 (2014)
doi: 10.3897/zookeys.378.6695
www.zookeys.org

RESEARCH ARTICLE

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

A new subspecies of *Nitokra affinis* Gurney, 1927 (Copepoda, Harpacticoida) from the Caribbean coast of Colombia

Juan M. Fuentes-Reinés[1,†], Eduardo Suárez-Morales[2,‡]

1 *Universidad del Magdalena, Grupo de Investigación en Limnología. A.A 731 Santa Marta, Magdalena, Colombia* **2** *El Colegio de la Frontera Sur (ECOSUR), A.P. 424, 77014 Chetumal, Quintana Roo, Mexico*

† *http://zoobank.org/60A6B9EE-3E67-4C8C-862F-C57F221C649A*
‡ *http://zoobank.org/BACE9404-8216-40DF-BD9F-77FEB948103E*

Corresponding author: *Juan M. Fuentes-Reines* (juanmanuelfuentesreines@yahoo.com)

Academic editor: *D. Defaye* | Received 27 November 2013 | Accepted 24 January 2014 | Published 6 February 2014

http://zoobank.org/55F1E622-59B2-4761-B58C-445498320C87

Citation: Fuentes-Reinés JM, Suárez-Morales E (2014) A new subspecies of *Nitokra affinis* Gurney, 1927 (Copepoda, Harpacticoida) from the Caribbean coast of Colombia. ZooKeys 378: 1–15. doi: 10.3897/zookeys.378.6695

Abstract

Plankton samples from Laguna Navio Quebrado, La Guajira, northern Colombia, yielded male and female specimens of an harpacticoid copepod that was first identified as the widely distributed species *Nitokra affinis* Gurney, 1927 for which at least four subspecies have been described from different geographic areas. A more detailed examination of the Colombian specimens revealed that it differs from the other morphs so far considered as subspecies. The Colombian specimens differ from the other four known subspecies in the following aspects: (1) rostrum with long projection, (2) relatively long exopod of P1, almost as long as first endopodal segment, (3) endopodal and exopodal rami of P2 equally long, (4) a reduced number of endopodal setal elements of the male P5. It also differs from *N. a. californica* Lang in details of the ornamentation of the urosomites. Descriptions and illustrations of this new subspecies, the first one described from the Neotropical region, are presented together with a key to the five known subspecies of *Nitokra affinis.* As in many other cases of presumedly widespread species of harpacticoids, it is possible that *N. affinis* represents a species complex with more restricted distributional patterns, a notion that certainly deserves further study.

Keywords

Harpacticoids, taxonomy, meiofauna, marine crustaceans, lagoon systems biota

Introduction

The family Ameiridae is one of the most diverse among the harpacticoids; the genus *Nitokra* Boeck, 1865 is contained in this group. Species of this genus occur in fresh, brackish and marine water habitats (Karanovic and Pesce 2002), as well as a wide range of sediment types (Boxshall and Halsey 2004). *Nitokra* is considered a diverse taxon which is currently known to contain over 45 valid species (Wells 2007; Gómez et al. 2012), some of them with a remarkable morphologic variability that has motivated the erection of subspecific taxa. Currently, eight species (*N. affinis* Gurney, 1927, *N. divaricata* Chappuis, 1923, *N. fallaciosa* Klie, 1937, *N. hibernica* (Brady, 1880), *N. lacustris* (Shmankevich, 1875), *N. mediterranea* Brian, 1928, *N. minor* Willey, 1930, *N. platypus* Daday, 1906) are known to contain 22 subspecies (Wells 2007). *Nitokra affinis* is a widespread species containing four subspecies: *N. a. affinis* Gurney, 1927, *N. a. rijekana* Petkovski, 1954, *N. a. californica* Lang, 1965, and *N. a. stygia* Por, 1968 (Wells 2007).

In Colombia only three species and subspecies of *Nitokra*: the first record, involving the description of the subspecies *N. lacustris pacifica* Reid, 1987 was published by Reid (1987). More recently *N. lacustris sinoi* Por & Marcus, 1976 and *N. taylori* Gómez, Carrasco & Morales-Serna, 2012 (Fuentes-Reinés and Suárez-Morales,in press) were added to the national records of the genus.

From a biological survey of a coastal lagoon system in the Caribbean coast of Colombia, specimens of a species tentatively identified as *Nitokra affinis* Gurney, 1927 were obtained; a further analysis of these specimens revealed that they show consistent differences with respect to the other four subspecific forms currently known. In this contribution we describe and illustrate this taxon and provide a key to the identification of the five subspecies of *N. affinis*.

Materials and methods

Samples of near-shore and open water plankton were taken from the Laguna Navío Quebrado, Colombia (11°25'N and 73°5'W) from April to December 2012. Samples were mainly in the littoral areas with vegetation (macrophytes and mangrove) but also from limnetic areas close to oyster banks. Water salinity ranged from 0 to 28‰. Water samples were collected using a bucket of 25 L at both littoral vegetation areas and open water. Samples were filtered with a standard zooplankton net with a 45 μm mesh and fixed and preserved in 70% ethanol. Dissected specimens and appendages were mounted in glycerine and sealed with Canada balsam. Drawings of the mounted appendages were prepared with a camera lucida and also photographed using a Kodak Easy Share C140 digital camera adapted to a compound microscope. The specimens were measured in lateral position, from the tip of rostrum to the posterior margin of the caudal rami. Morphological nomenclature follows the terminology proposed by Huys and Boxshall (1991). The following abbreviations are used in the text and tables:

P1–P6, first to sixth swimming legs; EXP, exopod; ENP, endopod. The type specimens examined were deposited in the collection held at the Museo de Colecciones Biológicas de la Universidad del Atlántico (UARC), Barranquilla, Colombia. Additional specimens were deposited in the collection of zooplankton held at El Colegio de la Frontera Sur, Chetumal, Mexico (ECO-CHZ).

Results

Family Ameiridae Boeck, 1865
Subfamily Ameirinae Boeck, 1865
Genus *Nitokra* Boeck, 1865

***Nitokra affinis colombiensis* ssp. n.**
http://zoobank.org/B6610CBE-C007-4B2A-A2B6-3EE5ADF4BDD6
http://species-id.net/wiki/Nitokra_affinis_colombiensis

Material examined. One female holotype (UARC133M) and one male allotype (UARC134M), ethanol-preserved. Paratypes: one female (UARC142M-147M) and one male (UARC136M-141M), plus two females and two males (UARC135M). Additional material: Six adult females, four adult males in authors' (JF-R) personal collection. Two adult females, two adult males from same locality and date (ECO-CHZ-09088).

Type locality. Laguna Navío Quebrado, La Guajira, Colombia (11°25'N and 73°5'W).

Female. Habitus in lateral view as in Figure 1A. Body subcylindrical, tapering posteriorly, total body length measured from tip of rostrum to posterior margin of caudal rami ranging from 588 to 714 μm (average 660 μm, *n*= 6; holotype: 700 μm). Rostrum subtriangular with 2 sensilla and apical rostral projection which is about half the length of rostrum (Fig. 3H). Genital double-somite distinct dorsally and laterally, with partial ventral suture (Fig. 2A, B). Anterior ventral surface of genital somite with incomplete rows of spinules on medial outer surface, distal row of spinules and pair of sensilla. Succeeding urosomite with dorsal incomplete row of spinules on medial surface and distal row of spinules covering lateral margin and only part of ventral margin (Fig. 2A, B); same somite with ventral curved row of minute spinules on central surface, incomplete row on medial outer margin and 2 sensilla on posterior margin. Preanal somite with similar ornamentation pattern except for spinules encircling posterior margin of somite, absence of curved row on ventral surface and additional row of minute spinules. Anal somite with ventral and dorsal rows of spinules along posterior margin bordering insertion of caudal rami; anal operculum semicircular, ornamented with 14–20 large spinules, flanked by 2 sensilla and rows of minute spinules (Figs 1C, 2B). Caudal ramus short, subquadrate, with rounded margins, armed with 6 setae, seta I small, seta II as long as seta I, seta III on distal outer position, about 1.5 times

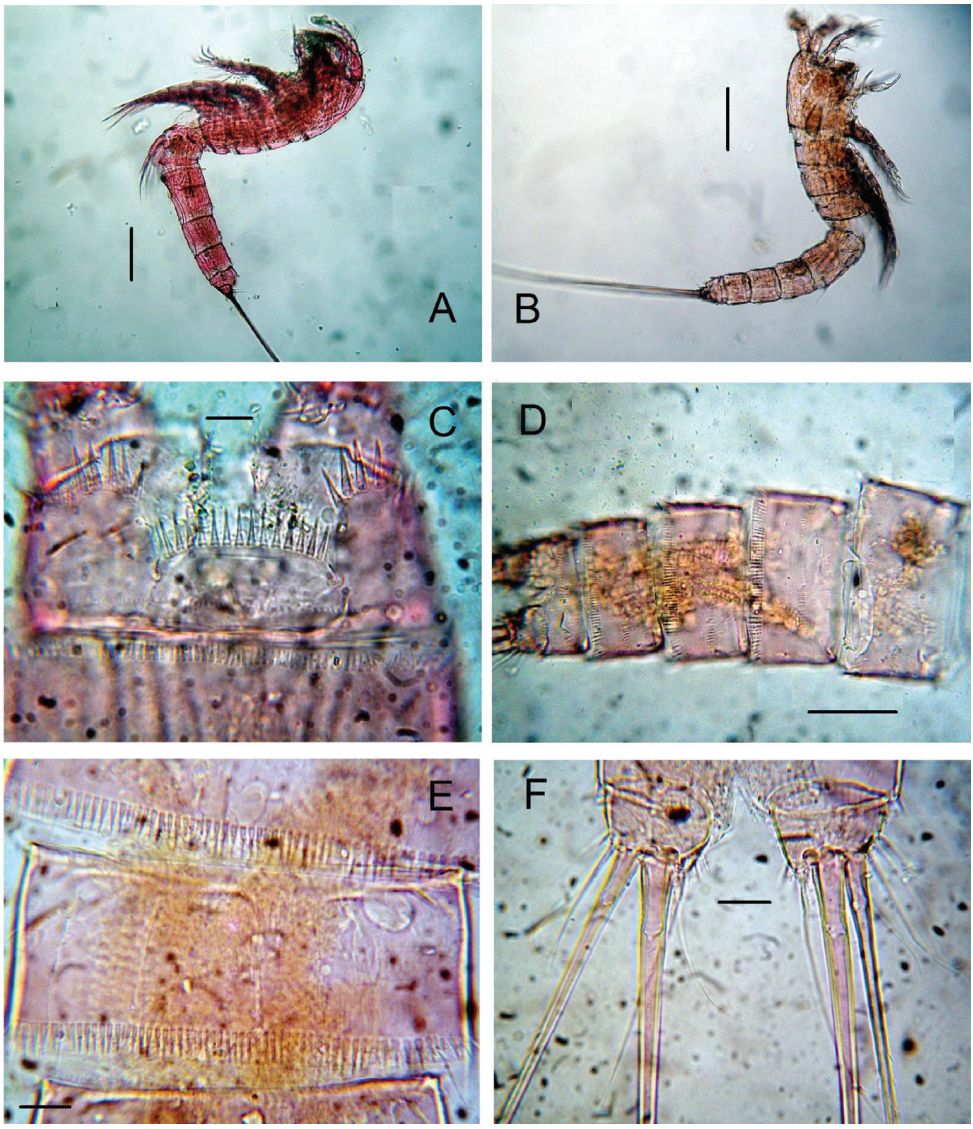


Figure 1. *Nitokra affinis colombiensis* ssp. n., from northern Colombia. **A** adult female, habitus, lateral view **B** adult male, habitus, lateral view **C** female, anal somite showing ornamentation of anal operculum **D** male, urosome, ventral view **E** male, third urosomite, ventral view **F** male, caudal rami, ventral view. Scale bars: **A, B**= 100 μm, **C, E, F**=10 μm, **D**=50 μm.

as long as setae I and II. Setae IV and V thick, long, the former being longest; seta VI slightly longer than seta III. Dorsal seta VII uniarticulate at base. Ramus ornamented with spinules at insertion of setae (Figs 1F, 2A, B).

Antennule. 8-segmented, second segment about 1.5 longer than first and third segments, aesthetasc on fourth segment reaching well beyond distal end of terminal

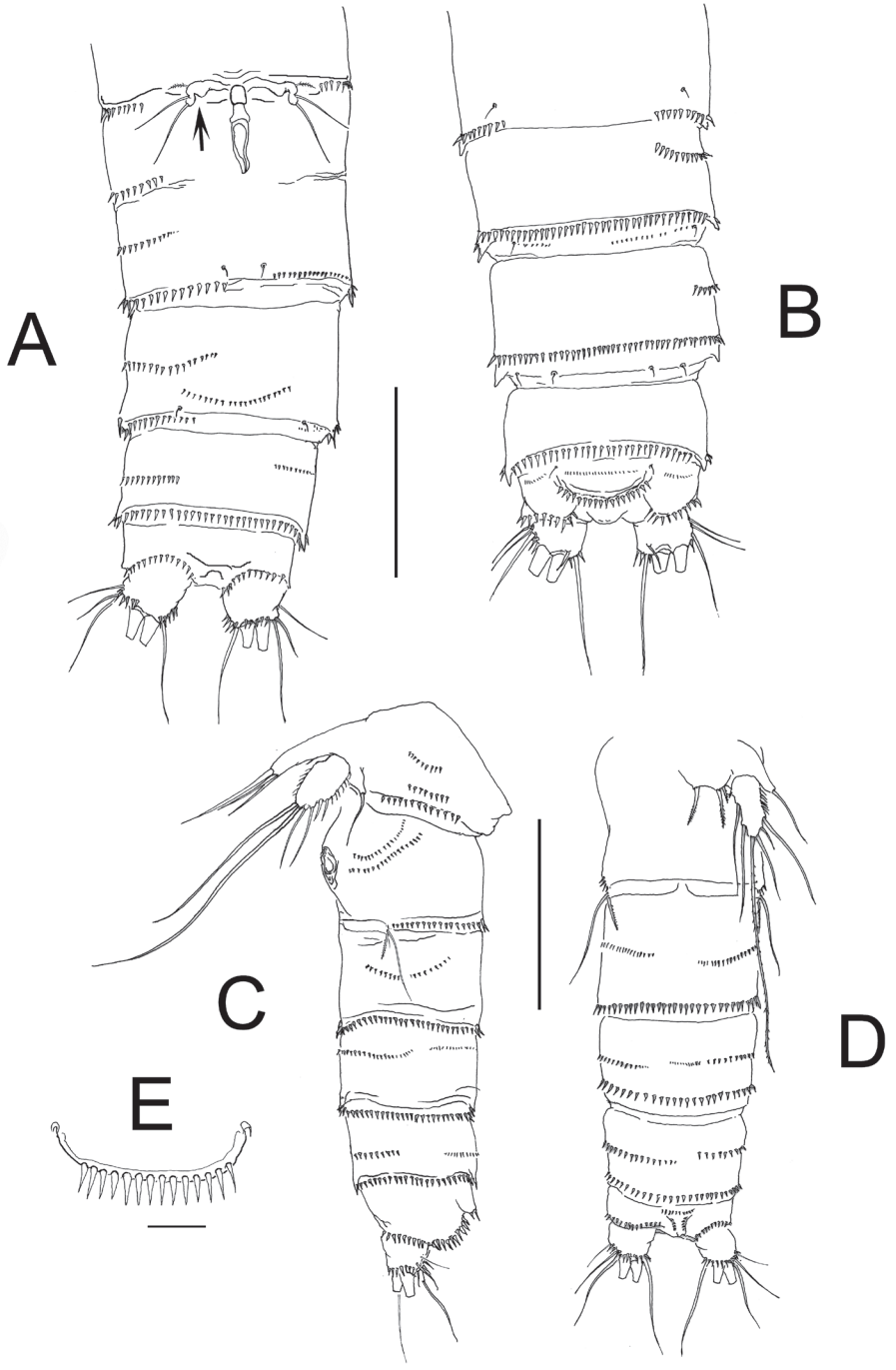


Figure 2. *Nitokra affinis colombiensis* ssp. n., from northern Colombia. **A** female, urosome, ventral view showing genital field and P6 **B** same, dorsal view, showing genital field and sixth leg plate, arrowed **C** male, urosome, lateral view showing P5 and P6 plate **D** same, ventral view **E** male, detail of ornamentation of anal operculum. Scale bars: **A–D** =100 μm, **E** = 10 μm.

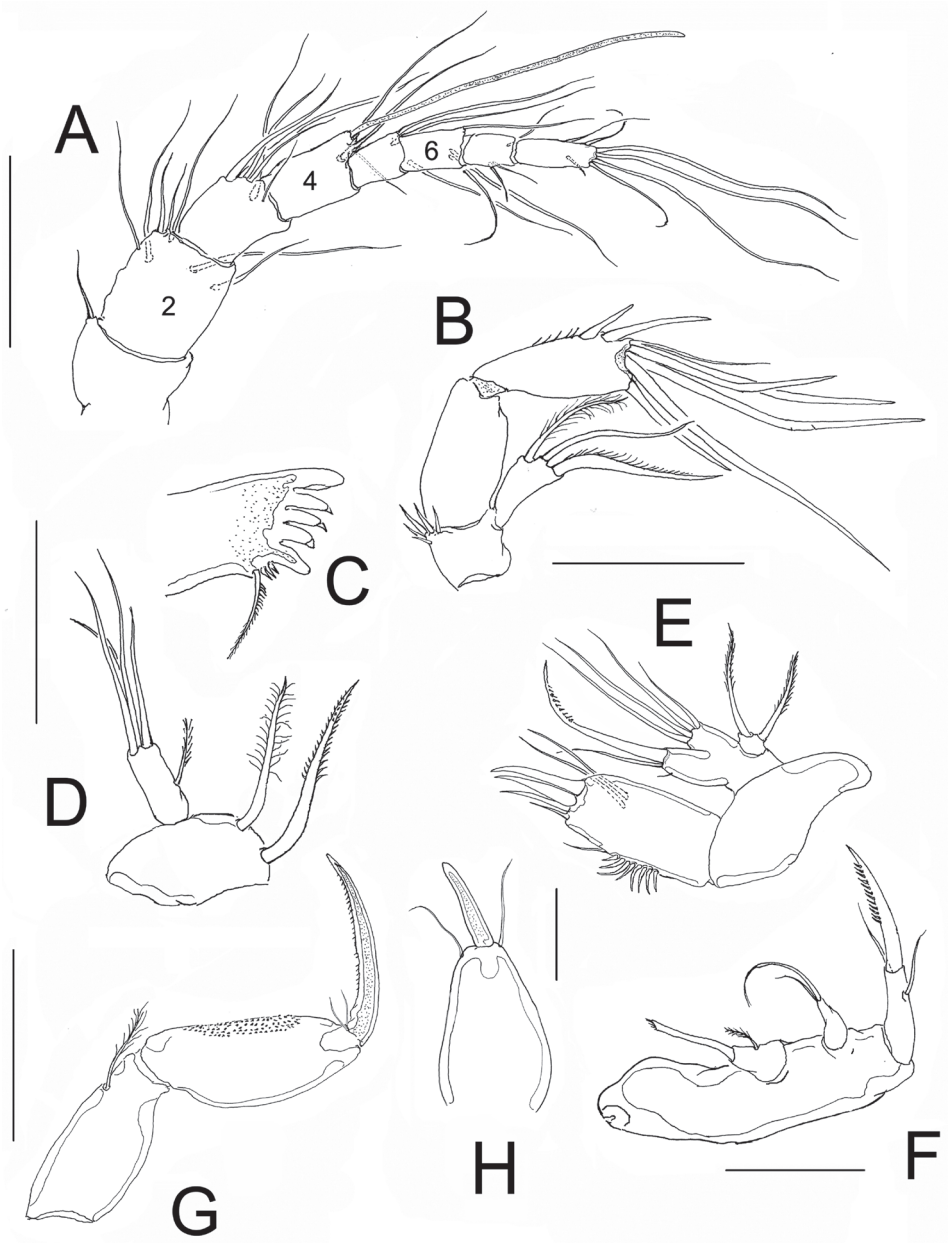


Figure 3. *Nitokra affinis colombiensis* ssp. n., adult female from northern Colombia. **A** antennule **B** antenna **C** mandible blade **D** mandibular palp **E** maxillule **F** maxilla **G** maxilliped **H** rostrum with rostral process. Scale bars: **A–G** = 50 μm, H = 10 μm.

segment (Fig. 3A). Second segment longest, about 1.5 times as long as third segment and 2.1 times longer than preceding first segment. Fourth segment about as long as third segment. Armature as follows: 1(1), 2(7), 3(7), 4(3+aes), 5(2), 6(3), 7(3), 8(7).

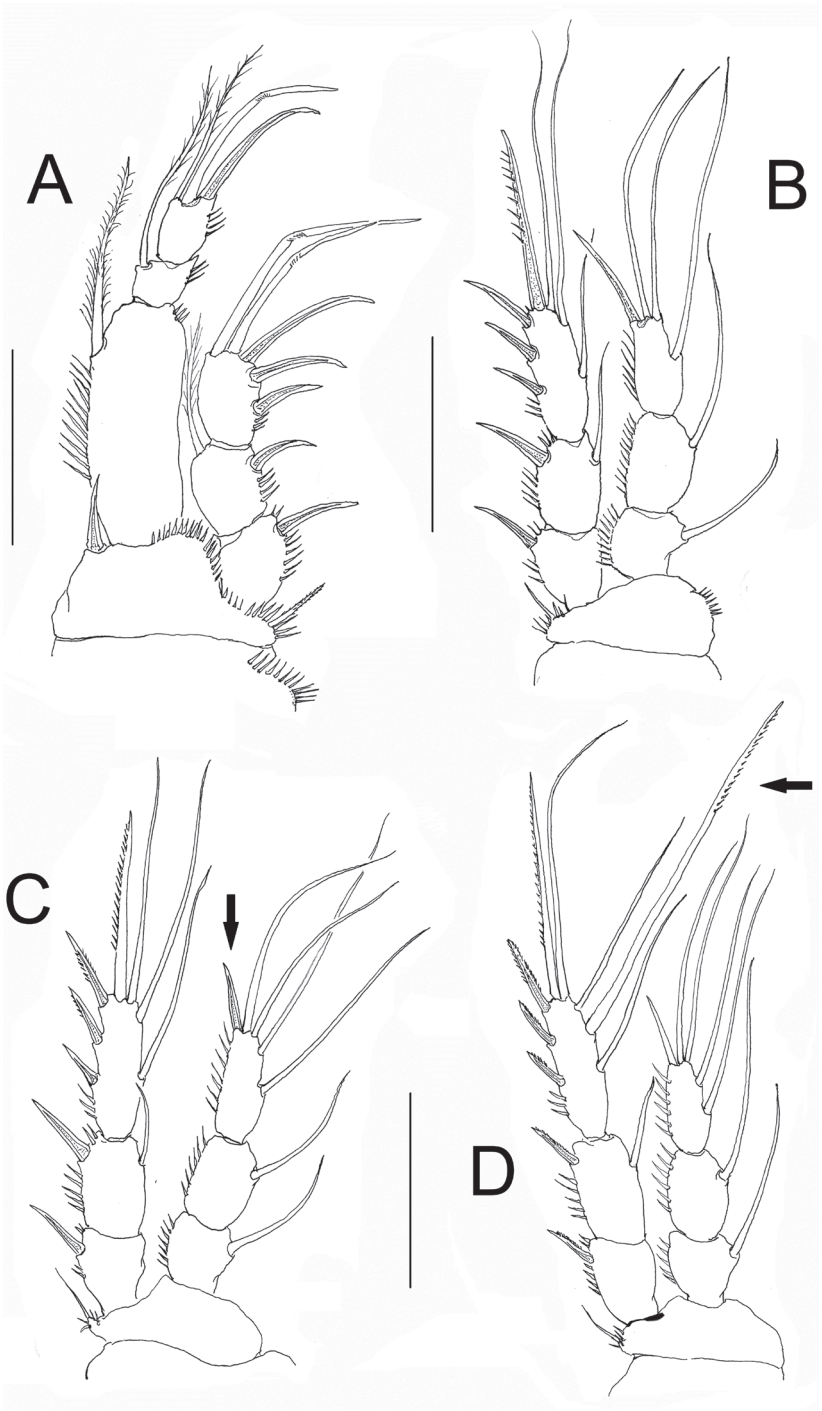


Figure 4. *Nitokra affinis colombiensis* ssp. n., adult female from northern Colombia. **A** first swimming leg (P1) **B** second swimming leg (P2) **C** third swimming leg (P3) **D** fourth swimming leg (P4) showing modified pectinate element (arrowed). Scale bars: **A–D**= 50 µm.

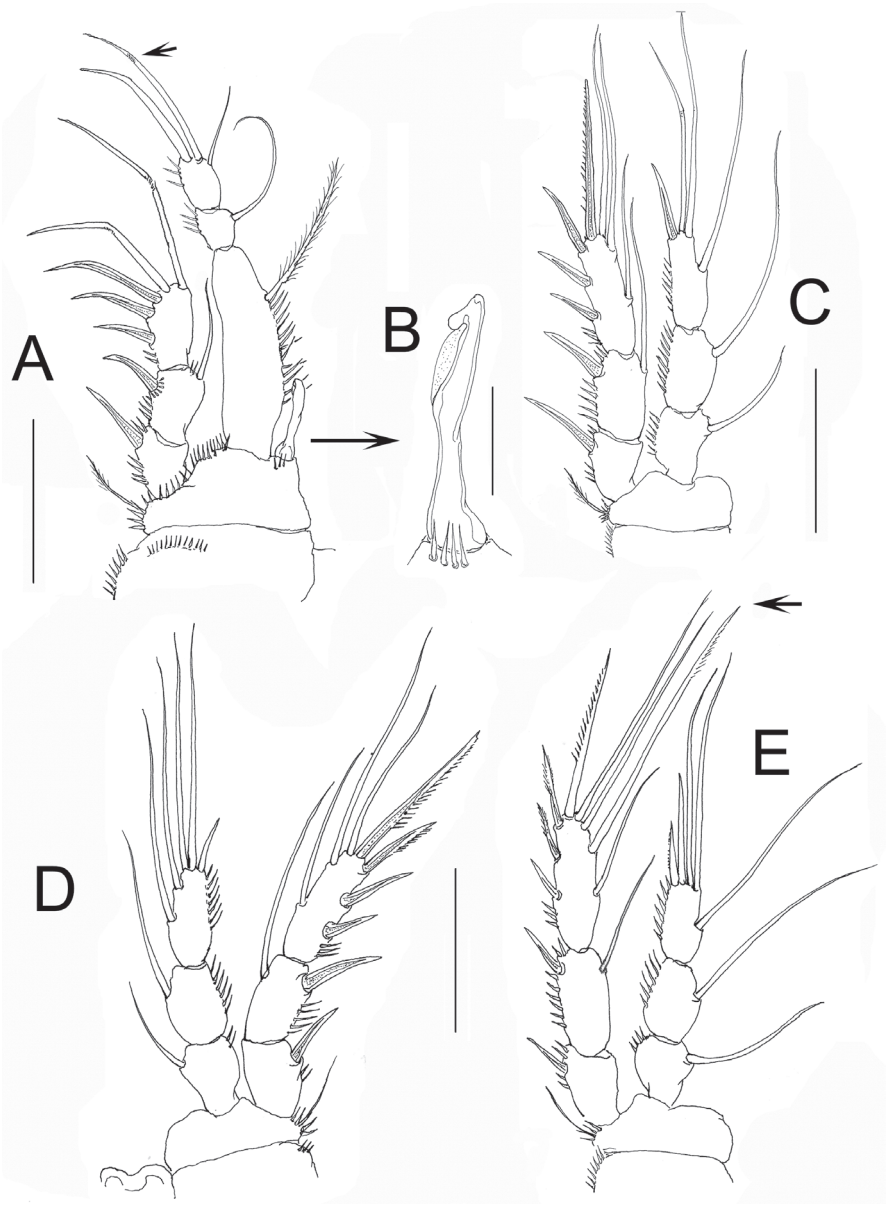


Figure 5. *Nitokra affinis colombiensis* ssp. n., adult male from northern Colombia. **A** first swimming leg (P1) **B** modified inner basipodal spine of P1 **C** second swimming leg (P2) **D** third swimming leg (P3) **E** fourth swimming leg (P4). Scale bars: **A,C–E**= 50 μm, **B**= 10 μm.

Antenna. Basis with group of 5 unequal spiniform setae, first endopodal segment subrectangular, smooth, second endopodal segment with subdistal row of spinules on inner margin, with 2 lateral inner spines and 6 distal elements, outermost two of them basally fused at insertion. Exopod one-segmented with 3 setae, 2 pinnate and 1 smooth seta (Fig. 3B).

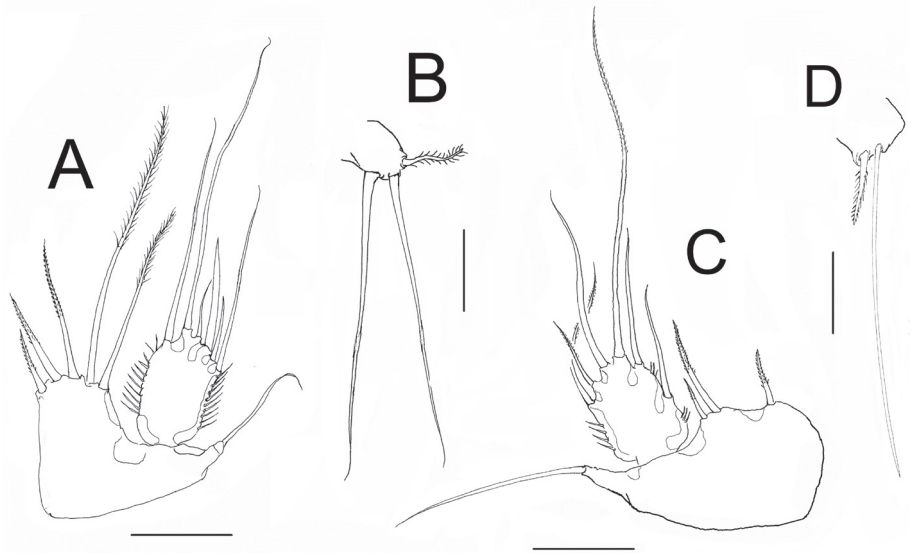


Figure 6. *Nitokra affinis colombiensis* ssp. n. from northern Colombia. Adult female: **A** fifth leg **B** sixth leg. Male: **C** fifth leg **D** sixth leg. Scale bars: **A, C** = 50 μm; **B, D**= 10μm.

Mandible. Gnathobase with 5 large teeth, and long dorsal seta ornamented with short spinules (Fig. 3C). Mandibular palp 2-segmented, first segment (basis) with 2 setae. Endopodal segment with 1 short lateral and 4 long apical setae (Fig. 3D).

Maxillule. Arthrite of praecoxa ornamented with group of subequal spinules, arthrite armed with 2 subdistal setae and 4 distal elements. Coxal endite with 2 setae. Basis with 4 setae; exopod 1-segmented, with 2 setae, one slender, the other thicker, distally serrate (Fig. 3E).

Maxilla. Syncoxa naked, with 2 endites, proximalmost with single, slender modified element with distal tuft of setules and with short proximal seta; second endite with 2 unequal setae. Allobasis forming strong serrate claw with 2 accessory setae on proximal position (Fig. 3F).

Maxilliped. Subchelate. Syncoxa with single seta on inner distal corner, basis unarmed, with longitudinal patch of spinules. Endopod drawn into long and slender lightly serrate claw with 2 short accessory setae (Fig. 3G).

P1. Coxa with outer row of slender spinules. Basis with spinules bordering insertion of exopodal and endopodal rami, inner basipodal spine short, stout, reaching 1/3 of length of first endopodal segment. Outer basipodal spine short, stout, spinulated. EXP and ENP 3-segmented. Exopodal ramus shorter than first endopodal segment. Third exopodal segment with 2 apical geniculate setae. First endopodal segment about 2.9 longer than its width; third endopodal segment with terminal claw, the latter about 1.5 times as long as segment (Fig. 4A).

P2. Coxa with outer row of slender spinules. Basipod with 2 groups of spinules, as figured. Exopod and endopod 3-segmented. Exopod endopod equally long. First

exopodal segment without inner seta, second and third exopodal segments with inner seta. Exopod without modified setae, outer margin of exopodal segments spinulated. Endopod 3-segmented, outer margin of segments ornamented with spinules (Fig. 4B).

P3. Coxa with outer row of slender spinules. Basipod with spinules only at insertion of outer basipodal seta. Exopodal and endopodal rami as in P2 except for shorter apical spiniform element (arrowed in Fig. 4C) and endopod slightly shorter than exopod (Fig. 4C).

P4. Coxa with outer row of slender spinules. Basipod as in P3. EXP longer than ENP (Fig. 4D). Middle inner seta of EXP3 thicker and longer than adjacent setae (arrowed in Fig. 4D).

P5. EXP subrectangular, about 1.66 longer than it is width, with 6 setae. Relative length of exopodal setae from inner to outer element as follows: 0.81, 1.00, 0.18, 0.38, 0.18, 0.56. Endopodal lobe quadrate, reaching almost halflength of EXP, with 5 spinulose setae, outermost being longest; relative length of setae from inner to outer elements as follows: 0.32, 0.37; 0.43, 1, 0.46 (Fig. 6A).

Armature formula of female P1-P5 as follows:

	P1	P2	P3	P4	P5
EXP	I-0; I-1;III,2,0	I-0;I-1;III,I,1,2	I-0;I-1;III,I,1,2	I-0;I-1;III,I,1,3	6
ENP	0-1; 0-1;I,2,0	0-1;0-1; I,2,1	0-1;0-1; I,2,2	0-1;0-1; I,2,2	5

P6. Represented by narrow plate with subdistal lobe-like process marked by a notch (arrowed in Fig. 2A); plate bearing 3 elements, 2 equal slender setae and outer small spinulated seta (Fig. 6B).

Male. Smaller than female, habitus in lateral view as in figure 1B. Total body length ranging from 518 to 574 μm (mean, 546 μm; *n*= 4; allotype: 518 μm). Ornamentation of urosomites resembling that of female except for position of rows of minute spinules on ventral surface of genital and preanal somites (Fig. 2C, D). Anal somite with row of small spinules on posterior margin at insertion of caudal rami. (Figs 1D, E, 2C, D). Rostrum, antennae and mouthparts as in female.

P1. As in female except for an additional row of spinules on the coxa, presence of small slender seta and 1 geniculate apical seta (arrowed in Fig. 5A), instead of 2 on ENP3, slenderer ENP1, and dimorphic modified inner basipodal spine (Fig. 5A, B).

P2-P4. As in female (Fig. 5C-E), including thickened middle inner seta of EXP3 (arrowed in Fig. 5E) which is relatively shorter than in female.

P5. EXP subquadrate, armed with 6 setae, distal innermost being longest, reaching midlength of fourth urosomite (Fig. 2 C,D). Baseoendopod with 3 unequally long setae, middle one longest, about twice as long as the other two (Fig. 6C).

P6. With 2 unequal seta, inner one three times longer than outer seta (Figure 6D). Caudal rami as in female (Fig. 2C, D).

Variability. One male with 2 elements (instead of3) on ENP3 of P1.

Etymology. The new subspecies is named after Colombia, the country from which it was first discovered.

Habitat. The estuary Laguna Navío Quebrado has a surface area of 10.7 km^2; it is characterized by the presence of an oyster bank in the limnetic area and vegetation (mangrove and beds of macrophytes) in the littoral zone. Water temperature ranged between 28 and 31 °C, salinity between 0-28 psu, and pH values were 7.8–8.3.

Discussion

Based on the combination of the armature formula of the P1EXP2-3, three species groups can be recognized within the genus *Nitokra* (Gómez et al., 2012). The first group exhibits one inner seta and four elements on P1EXP2 and EXP3, respectively, the second group lacks an inner seta on P1EXP2 but bears five setae on P1EXP3. The third group exhibits one inner seta, and five setal elements on P1EXP2 and EXP3, respectively. *Nitokra affinis* Gurney is part of this third group. This is a very widespread species, recorded from different geographic regions, including the Atlantic and Pacific Oceans, the Mediterranean, the Black Sea, the Red Sea, the Caribbean, and Brazil (Gurney 1927; Vervoort 1962, 1964; Lang 1965; Por et al. 1984; Suárez-Morales et al. 2006). According to Vervoort (1964) most records of *N. a. affinis* are related to sandy sediments including interstitial water of beaches but at least two subspecies have been collected from cave-related environments (Por 1968). Our specimens from Colombia were collected in open water and mangrove areas.

Despite the fact that Lang (1965) expressly used the term "forma" in his description of *N. a. californica* and thus caused the nomen to be infrasubspecific according to the ICZN (art. 45.6); the subspecies rank is reinstated when Por (1968) proposed this rank for the other formae described in the group, thus meeting the requirements stated by the ICZN (art. 45.6.4.1). Hence, these forms should be recognized as subspecies.

The four known subspecific forms of *Nitokra affinis* are known from different geographic areas: *N. a. affinis* from the Suez Canal, European and Mediterranean waters, and Bermuda (Gurney 1927; Willey 1930; Chappuis 1938; Roe 1958; Vervoort 1962); *N. a. stygia* Por, 1962 from the Red Sea; *N. a. californica* from Monterey Bay, California, and *N. a. rijekana* from Yugoslavia and Tenerife (Petkovski 1954; Noodt 1958). There are two additional records of *N. a. californica*, one from South Africa (Kunz 1975) and the other one from Bulgaria (Apostolov 1980). It is likely that the Bulgarian and the South African specimens might represent different subspecies but the available morphological data are insufficient to advance a conclusive statement. This notion is supported by the presence of a clearly shorter P1 exopod in both the Bulgarian and South African material, the exopodal ramus reaches only about ¾ of the length of the first endopodal segment, clearly diverging from the equally long exopod and first endopod segment condition that is diagnostic of *N. a. californica* (Lang, 1965). In addition, the relative lengths of the setae of the male fifth leg and the length/width proportions of the female exopodal segment show some differences with respect to Lang's (1965) *N. a. californica* (see Kunz 1975, table I; Apostolov 1980, Figs 1e,f). The number of subspecies of *N. affinis* could be underestimated.

The Colombian specimen shares most characters with *N. affinis* Gurney, and its subspecific forms, including the armature formula of P1-P4, the morphology of the mouthparts, the size proportions and armature of the caudal rami, and the number of setae on the female and male P5EXP. The new subspecies, *N. affinis colombiensis* ssp. n. differs from its congeners in the following aspects: (1) in the Colombian specimens the rostrum has a long rostral projection. This structure has not been hitherto described or depicted in any other subspecies of *N. affinis*; (2) the length of the EXP with respect to the enlarged P1ENP1 differs among these subspecies; in *N. a. affinis* and *N. a. rijekana* the exopod reaches about the point of insertion of the inner seta of the first endopodal segment (Gurney 1927; Lang 1965), whereas in *N. a. stygia* the exopod is clearly shorter and does not reach this level (Por 1968). In *N. a. californica* the exopod is longer, it reaches well beyond this point and it is about as long as the endopodal segment (Lang 1965). In the new subspecies the EXP reaches beyond the insertion of the inner endopodal seta but is shorter than the first endopodal segment; (3) in the new subspecies *N. a. colombiensis* the endopodal ramus of P2 reaches the distal margin of the exopod. In the other known subspecies the endopod does not reach beyond half the length of the third exopodal segment (Lang 1965), (4) the new subspecies can be readily distinguished by the number of elements of the male P5 baseoendopod, it has three setae vs. 5 in *N. a. rijekana*, 4-5 in *N. a. affinis*, and 4 in *N. a*. *californica* and *N. a. stygia* (Petkovski 1954; Lang 1965; Por 1968) and (5) in *N. a. colombiensis* the ornamentation of the posterior margin of the postgenital somite is similar to the strict form of *N. affinis*, with spinules absent on the ventral margin, but differs from the pattern described in both *N. a. rijekana* and *N. californica* in which the somite is encircled by spinules (Lang 1965). It also diverges from *N. a. stygia*, with a naked dorsal margin (Por 1968, pl. 5, fig. 28).

Overall, the new subspecies most closely resembles *N. a. californica*, but some additional characters can be useful to separate these two species; the number of spines on the posterior margin of the female anal operculum is only 14-20 in the new subspecies (Fig. 2H) vs. +25 in *N. a. californica* (Lang, 1965, fig. 196b). The second antennular segment of *N. a. californica* is relatively longer (1.7 times as long as third segment) than in *N. a. colombiensis* (1.3). Also, the fourth segment is elongate in *N. a. californica* (3.3 times as long as wide) and clearly shorter (1.4) in the new subspecies. The ornamentation of the maxillipedal basis is represented by row of short hair-like elements in *N. a. californica* (Lang, 1965, fig. 197c) whereas this segment has a patch of spinules in the Colombian specimens. The shape and armature of the female sixth leg plate differs between these taxa, the two inner setae are unequally long in *N. a. californica* but these elements have the same length in the Colombian specimens (Figs 2A, 6B). Also, in the new subspecies the distal section of the plate has a subterminal notch (arrowed in Fig. 2A) which is absent in *N. a. californica* (Lang, 1965, fig. 196d). The shape of the male fifth leg exopod is clearly subrectangular in the new subspecies *vs.* subtriangular in *N. a. californica* (Lang, 1965, fig. 197 h). In addition, the middle apical seta of the male fifth leg exopod is distinctively long in the Colombian specimens, it reaches

midlength of the fourth urosomite (Fig. 2 C, D) whereas this seta is clearly shorter in the Californian subspecies, barely reaching beyond the second urosomite (Lang 1965, fig. 197f). The ornamentation of the male urosome is different in these two forms; *N. a. californica* has a more complex ornamentation pattern on the lateral surface of the second and third urosomites, with 5 and 7 transverse rows of spinules, respectively (Lang 1965, fig. 197f) *vs*. a clearly lighter ornamentation in the Colombian form (1 and 2 rows, respectively).

As in many other cases of presumedly widespread species of harpacticoids, it is possible that *N. affinis* represents a species complex with more restricted distributional patterns, a notion already advanced by Vervoort (1964). The status of subspecific taxa in the genus *Nitokra* has been modified to recognize independent species on the basis of consistent morphological differences (Gómez et al. 2012). The comparative morphological data provided by Lang (1965) about *N. affinis* and the additional characters explored in this work appear to be a sound frame to define species boundaries for use in taxonomic discrimination in this species complex. The lack of detail in the original description of most of these subspecific taxa prevents a full comparative examination of characters leading to advance further in this direction. In addition, it has to be considered that the known morphological variability of the group together with the morphological stasis and convergent evolution of character states could hinder this task (Easton et al. 2010). Gene-sequencing studies have been proved to be a useful tool for species delimitation among harpacticoids (Rocha-Olivares et al. 2001); hence, if morphological differences are deemed uninformative, these techniques are the next step to take in testing the validity of these five subspecific taxa of *N. affinis* at the species rank. The use of the generic name *Nitokra* instead of *Nitocra* follows Bowman (1988) and Walter and Huys (2013). The former nomen is the original spelling and despite its widespread use, *Nitocra* has not been officially validated.

Key to the subspecies of *Nitokra affinis* Gurney, 1927

1A Female P1ENP1 less than 3.8 times as long as wide; EXP of P1 reaching the point insertion of inner seta of ENP1 (Figs 3A, 4A); male P5ENP with 3 setae; rostrum with rostral projection..... ***N. a. colombiensis* ssp. n.**

1B Female P1ENP1 more than 3.8 times as long as wide; EXP of P1 with a different length; male P5ENP with 4 or 5 setae; rostrum without rostral projection..... **2**

2A Middle inner seta of P4EXP3 (arrow in Fig. 3D) not longer and stronger than distal inner seta; male P5ENP with 5 setae ....***N. a. rijekana* Petkovski, 1954**

2B Middle inner seta of P4EXP3 longer and stronger than the distal inner seta3

3A Posterior edge of antepenultimate somite with incomplete spinules ring, dorsal to ventro-lateral only, ventral margin smooth.....***N. a. affinis* Gurney, 1927**

3B Posterior margin of antepenultimate somite spinulose as a continuous ring..... **4**

4A P1EXP short, not reaching insertion of inner seta of P1 ENP1; female P5EXP not elongated at distal half, about 1.3 as long as wide, innermost distal seta about as long as adjacent distal seta.....***N. a. stygia*** **Por, 1962**

4B P1EXP long, reaching well beyond insertion of inner seta of P1ENP1, both rami equal in length; P5EXP elongated at distal half, about 1.5–1.8 as long as wide; innermost distal seta about 1.5 times as long as adjacent distal seta..... .....***N. a. californica*** **Lang, 1965**

References

Apostolov A (1980) Deux formes nouvelles du genre *Nitocra* Boeck (Copepoda, Harpacticoida) de la mer Noire (côte bulgare). Acta Zoologica Bulgarica 15: 36–42.

Boxshall GA, Halsey SH (2004) *An Introduction to Copepod Diversity*. Ray Society, London, Publication 166, 2 vols., xv+966 pp.

Bowman TE (1988) *Nitokra sphaeromata*, a new harpacticoid copepod crustacean associated with the wood boring isopod, *Sphaeroma peruvianum*, in Costa Rica. Proceedings of the Biological Society of Washington 101: 171–175.

Chappuis PA (1938) Subterrane Harpacticoiden aus Sud- Italien. Buletinul Societatii de Stiinte din Cluj 9: 153–181.

Easton EE, Thistle D, Spears T (2010) Species boundaries in *Zausodes*-complex species (Copepoda: Harpacticoida: Harpacticidae) from the north-eastern Gulf of Mexico. Invertebrate Systematics 24: 258–270. doi: 10.1071/IS09038

Fuentes-Reinés JM, Suárez-Morales E (in press) Annotated checklist and new records of Harpacticoida (Copepoda) from a coastal system of northern Colombia, South America. Crustaceana.

Gómez S, Carrasco NK, Morales-Serna FN (2012) A new species of *Nitocra* Boeck, 1865 (Harpacticoida, Ameiridae, Ameirinae) from South Africa, with notes on its ecology and remarks on the status of *Nitocra sewelli husmanni,* Kunz 1976. ZooKeys 244: 33–58. doi: 10.3897/zookeys.244.2633

Gurney R (1927) Zoological Results of the Cambridge Expedition to the Suez Canal, 1924. XXXIII. Report on the Crustacea. Copepoda (littoral and semi–parasitic). Transactions of the Zoological Society of London 22: 451–577.

Huys R, Boxshall GA (1991) Copepod Evolution. The Ray Society, London, 468 pp.

Lang K (1965) Copepoda Harpacticoidea from the California Pacific coast. Kungliga Svenska Vetenskapsakademiens Handlingar 10: 1–566.

Karanovic T, Pesce G (2002) Copepods from ground waters of Western Australia, VII. *Nitokra humphreysi* sp. nov. (Crustacea: Copepoda: Harpacticoida). Hydrobiologia 470: 5–12. doi: 10.1023/A:1015694015451

Kunz H (1975) Copepoda Harpacticoidea aus dem litoral des sudlichen Afrika. 1 Teil. Kieler Meeresforschungen 31: 179–212.

Noodt W (1958) Die Copepoda Harpacticoidea des Brandungsstrandes von Teneriffa (Kanarische Inseln). Abhandlungen der Mathematisch-naturwissenschaftlichen Klasse. Akademie der Wissenschaften under der Literatur in Mainz 1958(2): 53–116.

Por FD (1968) Copepods of some land-locked basins on the islands of Entedebir and Nocra (Dahlak Archipelago, Red Sea). Israel South Red Sea Expedition Report 31. Sea Fish. Research Station of Haifa Bulletin 49: 32–50.

Por FD, Almeida Prado Por MS, Oliveira EC (1984) The mangal of the estuary and lagoon system of Cananeia (Brazil). In: Por FD, Dor I (Eds) Hydrobiology of the Mangal, the Ecosystem of the Mangrove Forests. Dr. W. JUNK Publishers, The Hague, 211–228.

Petkovski TK (1954) Harpacticiden des Grundwassers unserer Meeresküste. Acta Musei Macedonici Scientiarum Naturalium, Skopje 2: 93-123.

Reid JW (1987) Some cyclopoid and harpacticoid copepods from Colombia, including descriptions of three new species. Proceedings of the Biological Society of Washington 100: 262–271.

Rocha-Olivares A, Fleeger JW, Foltz DW (2001) Decoupling of molecular and morphological evolution in deep lineages of a meiobenthic harpacticoid copepod. Molecular Biology and Evolution 18: 1088–1102. doi: 10.1093/oxfordjournals.molbev.a003880

Roe KM (1958) The littoral harpacticoids of the Dalkay (Co. Dublin) area, with descriptions of six new species. Proceedings of the Royal Irish Academy 59B: 221–255.

Sarmento VC, Parreira PJ (2012) Species of Harpacticoida (Crustacea, Copepoda) from the phytal of Porto de Galinhas coral reefs, northeastern Brazil. Check List 8(5): 936–939.

Suárez-Morales E, De Troch M, Fiers F (2006) A checklist of the marine Harpacticoida (Copepoda) of the Caribbean Sea. Zootaxa 1285: 1–19.

Vervoort W (1962) Report on some Copepoda collected during the Melanesia Expedition of the Ôsaka Museum of Natural History. Publications of the Seto Marine Biological Laboratory 10: 393–470.

Vervoort W (1964) Free-living Copepoda from Ifaluk Atoll in the Caroline Islands with notes on related species. Bulletin of the United States National Museum 236: 1–431. doi: 10.5479/si.03629236.236.1

Walter TC, Huys R (2013) *Nitokra* Boeck, 1865. In: Walter TC, Boxshall G (Eds) World of Copepods database. Accessed through: World Register of Marine Species at http://www.marinespecies.org/aphia.php?p=taxdetails&id=115198

Wells JBJ (2007) An annotated checklist and keys to the species of Copepoda Harpacticoida (Crustacea). Zootaxa 1568: 1–872.

ZooKeys 378: 17–39 (2014)
doi: 10.3897/zookeys.378.6753
www.zookeys.org

RESEARCH ARTICLE

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

Nannodromus reveilleti (Acari, Anystida, Saxidromidae) a new genus and species from South Africa

Nestor Fernandez[1,†], Yves Coineau[2,‡], Pieter Theron[3,§], Louwrens Tiedt[4,|]

1 *National Council of Scientific and Technological Research (C.O.N.I.C.E.T). La Rioja University Campus. Research and Technology City. Av. Luis Mansueto de la Fuente S/N. (5300) La Rioja, Argentina* **2** *Professor Emeritus in Muséum National d'Histoire Naturelle, Paris France* **3** *Research Unit for Environmental Sciences and Management, North-West University, Potchefstroom Campus, 2520, South Africa* **4** *Laboratory for Electron Microscopy, North-West University, Potchefstroom Campus, Private Bag X6001, Potchefstroom, 2520 South Africa*

† *http://zoobank.org/32F81CCB-5D14-4A4E-950C-C3CD94D78AA9*
‡ *http://zoobank.org/F9277F63-59CB-4B51-9F82-CFC8E3530AC0*
§ *http://zoobank.org/2C8D7CCB-3013-459D-A606-F60CD0CE13E0*
| *http://zoobank.org/9BF84478-50EE-4AA2-8D5F-CB8A1003C5F1*

Corresponding author: *Nestor Fernandez* (nestorfernand51@yahoo.fr)

Academic editor: *V. Pesic* | Received 5 December 2013 | Accepted 24 January 2014 | Published 6 February 2014

http://zoobank.org/4429E4E0-0B55-4020-AFE9-ADAC21828A1F

Citation: Fernandez N, Coineau Y, Theron P, Tiedt L (2014) *Nannodromus reveilleti* (Acari, Anystida, Saxidromidae) a new genus and species from South Africa. ZooKeys 378: 17–39. doi: 10.3897/zookeys.378.6753

Abstract

The description of a new genus *Nannodromus* and a new species *Nannodromus reveilleti* (Acari: Anystides: Saxidromidae) from South Africa, based on adult males and females.

Keywords

Acari, Anystides, Saxidromidae, *Nannodromus* gen. n., *Nannodromus reveilleti* sp. n., South Africa, males–females

Introduction

Since 1974 studies of behavioural patterns, spermatophore types and characteristics, as well as mating and secondary characteristics of males have led to several publications (Coineau 1974, 1976; Alberti et al. 2000; Coineau et al. 2006, Alberti et al. 2010), as well as a short documentary film (Coineau and Kovoor 1982).

Intensive sampling around South Africa and neighboring countries over a period of many years, (by Y. Coineau and P.D. Theron) has led to the acquisition of many specimens. Coineau and colleagues described two new genera, namely *Bovidromus* Coineau et al. 2006 and *Rhinodromus* Coineau et al. 2006.

Obtaining large amounts of material made it possible to study some of this material of both sexes with Light Microscopy (LM) and Scanning Electron Microscopy (SEM). This and future publications aim to facilitate understanding of morphological variations, presence or absence of males, and geographical distribution of species of this very unique mite family.

According to the present study the new genus *Nannodromus* displays well definable differences as well as shared characteristics with the other three known genera of the family.

Materials and methods

Specimens studied by means of light microscopy (LM) were macerated in lactic acid, and observed in the same medium using the open-mount technique (cavity slide and cover slip) as described by Grandjean (1949) and Krantz and Walter (2009). Drawings were made using a Zeiss-Axioscope compound microscope equipped with a drawing tube.

Measurements taken: total length (tip of rostrum to posterior edge of notogaster); width (widest part of notogaster) in micrometers (μm).

Leg chaetotaxy studies done by use of standard, polarized and phase contrast microscopes.

Some specimens were studied by means of a Scanning Electron Microscope (SEM). For this purpose, specimens preserved in ethanol were carefully rinsed by sucking them several times into a Pasteur pipette, and then transferring them to buffered glutaraldehyde (2.5%) in Sörensen phosphate buffer: pH 7.4; 0.1 m for 2 hours. After post-fixation for 2 hours in buffered 2% OsO4 solution and rinsing in buffer solution, all specimens were dehydrated in a series of graded ethanols and dried in a critical point apparatus. Specimens were mounted on Al-stubs with double-sided sticky tape and then gold coated in a sputter apparatus (Alberti and Fernandez 1988; Alberti and Fernandez 1990a, 1990b; Alberti et al. 1991; Fernandez et al. 1991; Alberti et al. 1997; Alberti et al. 2007). For some studies, specimens were dissected and monitored during the lactic acid maceration process (in warm 70% lactic acid) before being stained with chlorazol black E (Coineau 1974). Measurements taken: total length (tip of rostrum to posterior edge of notogaster) and width (widest part of notogaster) in micrometres (μm). Leg chaetotaxy studies done using standard, polarized and phase contrast microscopes.

Morphological terminology

Morphological terms and abbreviations used are those developed by Coineau 1974, 1976; Coineau and Naudo 1986 and Coineau et al. 2006.

New taxa description

***Nannodromus* gen. n.**
http://zoobank.org/96115256-59DE-4C08-A075-D67C0A06BF4C
http://species-id.net/wiki/Nannodromus

Etymology. The generic prefix "*nanno*" derives from "*nannos*" (Greek = dwarf English = nain French) on account of the small size of this species.

Diagnosis. Adult. Male. Small animal of around 600 µm; male with two clearly discernible dorsal sclerites (***D*** and ***P***). Transversal furrow separating sclerites, situated at level of leg pair IV. ***D*** with naso globular shape and reticulate surface; trichobothrium simple. Dorsal paired processes. In dorsal view: digitiform; in lateral view: sabot-like (= like a wooden shoe or clog), apical zone rounded, arching upwards; in frontal view: cylindric with a blunt hornlike structure, directed paraxially, apical part curving upwards. Small setae *pa* situated antiaxially of dorsal paired processes, provided with very small asperities. Towards anterior, behind dorsal digitiform paired processes, in saggital position, conspicuous U-shaped depression. Anterior and posterior eye, *po*, a_1, a_2, b_1 and b_2 setae; six depressed areas, one unpaired situated in U shaped depression and five others, paired, in depressed area; lyrifissures *ly*, *ia*.

Sclerite ***P*** complete, with three pairs of depressed areas; setae c_1, c_2, d_1, d_2, e_1, e_2, e_3; lyrifissure *im* and *ip.* Chelicera exhibiting neotrichy (16–20 setae).

Type species. *Nannodromus reveilleti* gen. n., sp. n.

***Nannodromus reveilleti* gen. n., sp. n.**
http://zoobank.org/4582C9B7-96EF-4D55-8D78-9EEA69C15A45
http://species-id.net/wiki/Nannodromus_reveilleti

Etymology. The species is dedicated in homage to the late Pierre Reveillet, Pharmacist, Biologist and Entomologist from Valence, France; an intimate friend and assiduous and tireless contributor to many missions in Africa.

Type material. Holotype male and two female paratypes**,** N'Wanetsi, Kruger National Park, South Africa: S24°27'30.56", E31°58'35.30" altitude 171m. This area is bordered by the South African provinces Limpopo and Mpumalanga, and it also shares a border with Mozambique.

Basic volcanic rocks (tholeiites, picrite basalts and nephelinites), vegetation type Lowveld Savanna.

Material was collected by Y. Coineau, R. Cléva, P. Reveillet coll. 02 February 1996; Y. Coineau and P. Theron coll. 12 February 2001 (N'Wanetsi) and P.Theron 2010 and 12 February 2012 (N'Wanetsi) deposited in the Collection of the Muséum National d'Histoire Naturelle, Paris, France, preserved in 70% ethanol; two **paratypes** (1 male/ 1female) deposited in Museum d'Histoire Naturelle, Geneva, Switzerland, preserved in 70% ethanol.

Type locality: Kruger National Park, N'Wanetsi: S24°27'30.56", E31°58'35.30" altitude 171m.

Diagnosis. Males. shape: Elongate oval; colour yellowish-light brown.

Dorsal region. Sclerite ***D***: polygon network microsculpture, from sagittal zone towards posterior; *bp*, *oc*, a_1, a_2, b_1, b_2 setae. Lyrifissure *ly* situated near *op* and *ia* behind a_2; cuticular stria surrounding lyrifissures on ovoid sclerite.

Basal zone of U-shaped depression harboring depressed area numbered 1. Depressed area 2 behind the bothridium. Antiaxially and behind *po*, paired anterior eyes, with convex cornea and ovoid, slightly concave posterior eye. Angle between *oa* and *op* 90 degrees. Zone of very complex microstructure surrounding *oa* and *op*. Depressed area 3 behind 2; depressed area 4 between a_1, a_2 setae. Depressed area 5 behind this zone, with lyrifissure *ia*. Near posterior limit of aspidosoma, setae b_1, b_2 with depressed area 6 between them. Cheliceral setae: *cha*, simple; *chb* bifid. Other setae neotrichous. Sclerite ***P*** complete, polyhedral network microsculpture; depressed area 7 situated anteriorly near transversal furrow; depressed area 8 behind c_2 setae; 9 behind d_2 at level of e_3 setae.

Ventral region. Epimeric formula (2, 2, 3, 3); three pairs of aggenital setae; progenital lips, five pairs of setae. Along paraxial edge a line of short setae. Four pairs of anal setae; four pairs of adanal setae; five pairs of *ps* setae; lyrifissure *ih* clearly visible. All legs with apoteles, three heteromorphic claws, one pair isomorphic, another small unpaired medial hook. Paired claws with two different types of barbs one triangular with tooth-like appearance; another thin curved barb. Hypertrophic setae on leg I, tibia and tarsi; tibial claw I present.

Females. Shape: elongate oval, color: light yellow

Dorsal region. Three sclerites: anterior (***A***), middle (***M),*** posterior (***P***). Striated transversal furrrow separating sclerites. ***A*** unmpaired, triangular, anterior part rectangularly shaped. Bothridium, trichobothria, anterior eye, posterior eye, setae *po*, a_1, a_2; depressed areas 1, 2, 3, 4 present. ***M*** paired, rectangular to ovoid, b_1, b_2, setae; depressed areas 5, 6 present. ***P*** variable; several possibilities from one unique unpaired sclerite or divided into series of microsclerites. First case: sclerite ***P*** unique, unpaired, with c_1, c_2, d_1, d_2, e_1, e_2, e_3 and depressed areas 7, 8, 9; lyrifissures *im*, *ip*. Second case: sclerite ***P*** divided into five paired microsclerites and one unpaired microsclerite. Paired microsclerites: one rounded, with c_1, c_2, setae and depressed areas 7, 8; one small ovoid microsclerite with only d_1 setae; one small ovoid with d_2 setae. Lyrifissures (*im*, *ip*) are isolated and surrounded by microsclerites. Unpaired crescent-shaped microsclerite with e_1, e_2, e_3 setae and depressed area 9. Epimeric formulae (3-3-2-3). Aggenital sclerite triangular, three pairs of setae. Progenital lips 5-7 pairs of setae; paraxial edge

numerous aligned setae. Setae *ad*, *an*, and *ps* as in male. Only leg IV presenting sexual modifications with large number of hypertrophic setae and isomorphic apotele claws. Legs I, II, III, heteromorphic apotele.

Description. ***Measurements:*** *Males* SEM: 618 µm (615–646) × 215 (213–227) µm (material used for SEM studies not deposited).

LM: 628 µm (622–645) × 315 µm (297–322) (measurements of specimens deposited in Museum National d'Histoire Naturelle, France, and Geneva Natural History Museum, Switzerland.

Females SEM: 658 µm (656-664) × 301µm (296–306) (material used for SEM studies not deposited).

LM: 651 µm (643–657) × 325 µm (322–335) (measurements of specimens deposited in Museum National d'Histoire Naturelle, France, and Geneva Natural History Museum, Switzerland).

Shape: elongate oval; **Male**: Figures 1A, B; 2A; **Female**: Figures 8A, B; 9A

Color: specimens without cerotegument yellowish-light brown, slightly shiny when observed in reflected light. Males vaguely yellowish.

Integument. SEM-studies assisted greatly in complementing LM observations, particularly in studies of cuticular microsculpture and gender differences.

Males (LM and SEM observations).

Dorsal region: two clearly discernible sclerites (***D***, dorsal and ***P***, posterior). Conspicuous transversal furrow, separating sclerites, situated at level of legs IV. Transversal furrow constituted by a series of fine parallel cuticular striae (Figures 1A; 2A).

Sclerite ***D*** presenting a series of well-defined depressed areas, the first (Figures 1A, 2A, 3A) indicated by number 1, is unpaired, situated in U-shaped depression (indicated by white arrow) (Figures 2B; 3A), placed at level of the trichobothria and slightly behind dorsal paired processes (*PDP)* (Figures 1A, 2A; 3A); microsculpture of depressed area constituted by fine cuticular striae (Figures 3A; 8C) (in both sexes and in all cases the depressed areas display similar microsculpture). All other depressed areas on this sclerite paired: second depression (smaller than first) (Figure1A indicated by 2 and simple arrow) between anterior eye (*oa*) and trichobothria (*bp*). Third depression (indicated by 3) situated posterior and paraxially to posterior eye (*op*). Series of three aligned depressions (4-6) of similar type between setae a_1 and a_2 to b_1 and b_2 (Figure 1A).

Conspicuous area with irregular polygon network (Figure 1A) situated in sagittal zone behind *PDP*, between both *bp*, and zone delimited by *oc* and setae a_1, a_2, b_1, b_2 towards the transversal furrow.

Chelicerae (Figures 2B, 3A, 3B, 3C, 3D, 4B) and zone adjacent to *bp* at base of *PDP*, surrounding naso (*na*) and near peritremal zone (*per*) presenting very fine striated cuticular surface (Figures 2 B, C, D; 3A, 4A).

Several tendon attachment areas (*at*) clearly distinguishable (LM) between depressed zones 2-3 and 5-6 (Figure 1A).

Two lyrifissures: *ly* situated near and behind *op*, between them and 3rd depressed area (Fig 1A), *ia* situated behind a_2 setae. Finely striated cuticular striae surrounding both lyrifissures, situated on ovoid sclerite of similar type to Figures 10C, D.

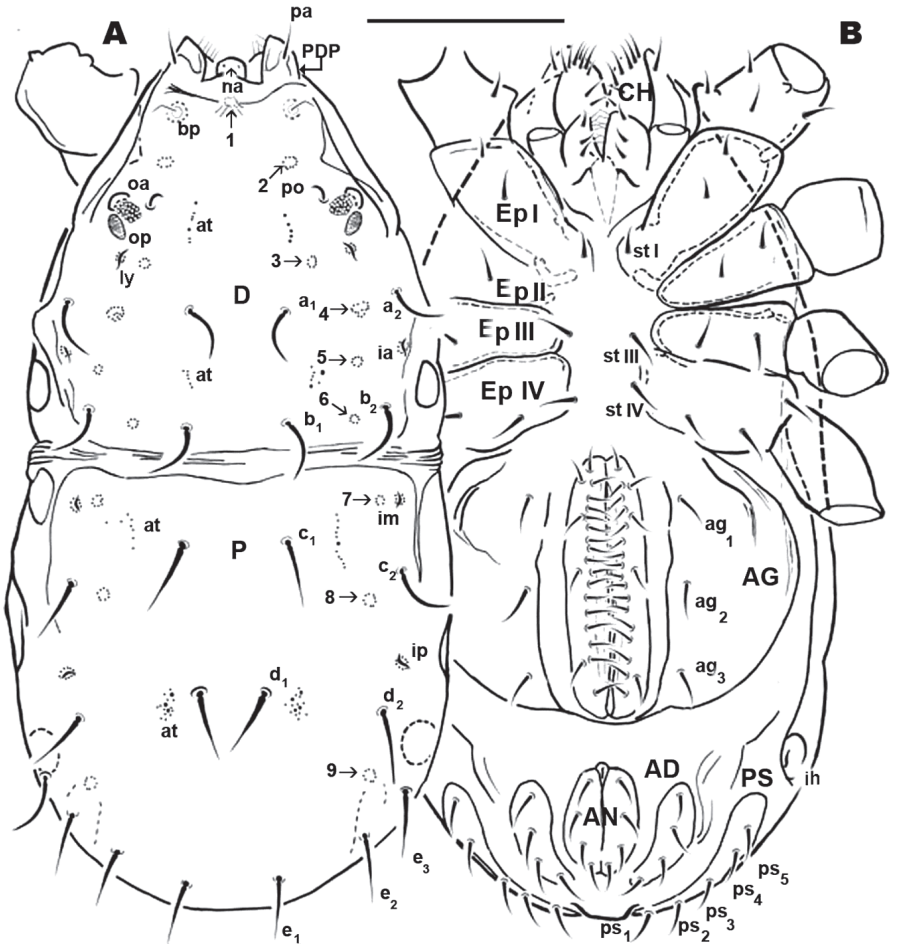


Figure 1. *Nannodromus reveilleti* gen. n., sp. n. Male. **A** dorsal view **B** ventral view. Scale bar: **A**, **B** = 130 μm.

Posterior sclerite ***P*** presenting conspicuous polygon network, extending to neighboring transversal furrow adjacent to posterior zone including setae e_1, e_2, e_3.

Three conspicuous depressed zones observed on sclerite: one antiaxially situated near transversal furrow (indicated by 7), two others between c_2 and d_2 setae (indicated by 8), with third in front of d_2 and at level of e_3 seta (indicated by 9). A line of several *at* situated antiaxially to c_1 setae and another group of *at* situated antaxially to d_1 setae (Figure 1A).

Legs appear smooth but in SEM, series of very fine aligned striae and polygon network visible (Figures 6C, D, E, F).

Females. LM observations (Figure 7). Three sclerites present: ***A***, ***M***, ***P***. ***A*** with four depressed areas (1-4), one unpaired (1) situated at sagittal plane in depressed U–zone. Three pairs; the second (2) situated close to and in front of *po*; third (3) paraxial pair situated near *ly,* the last pair (4) situated between a_2 and a_1 setae (Figure 7A).

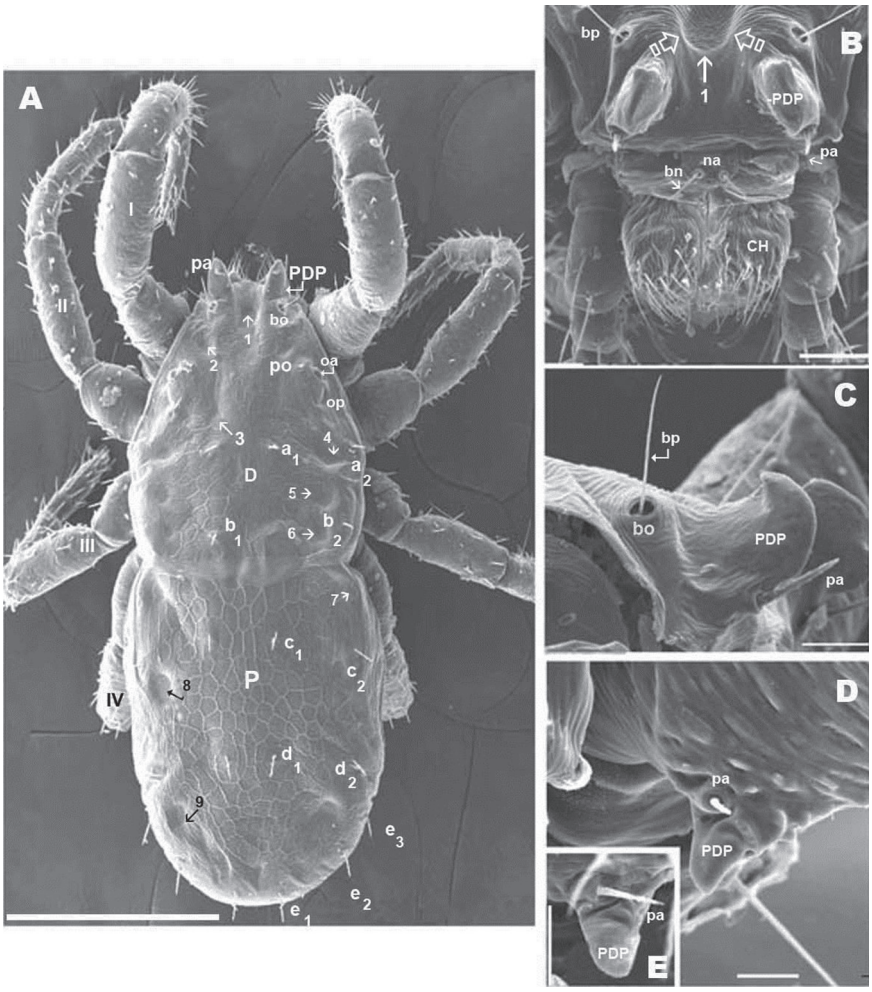


Figure 2. *Nannodromus reveilleti* gen. n., sp. n. Male. **A** dorsal view **B** frontal view **C** lateral view aspidosoma, anterior part **D–E** Prodorsal paired processes, details. Scale bar: **A** = 200 μm; **B** = 50 μm; **C** = 20 μm; **D** = 10 μm; **E** = 10 μm.

Paired microsclerite ***M*** presenting lyrifissure *ia*, with two well defined paired depressed areas (5, 6), situated paraxially in front of and behind b_2 setal level.

Transversal furrow exhibiting finely striated cuticular microsculpture, between sclerites ***M*** and ***P***.

Three depressed areas (7, 8, 9) on sclerite ***P***; one (7) situated anteriorly, near anterior border and close to lyrifissure *im*; second depressed area (8) paraxially close to seta c_2. The third (9) situated behind d_2 and at level of e_3 setae. Lyrifissure *ip* situated between c_2 and d_2 setae. Several *at* in semi-circular line situated between setae d_2 and e_3.

SEM observations (Figures 8, 10). Very complex microsculpture of sclerite ***A***: striated with small polygonate pattern (Figure 8B) in zone near *bp*. Area surrounding *oa* and

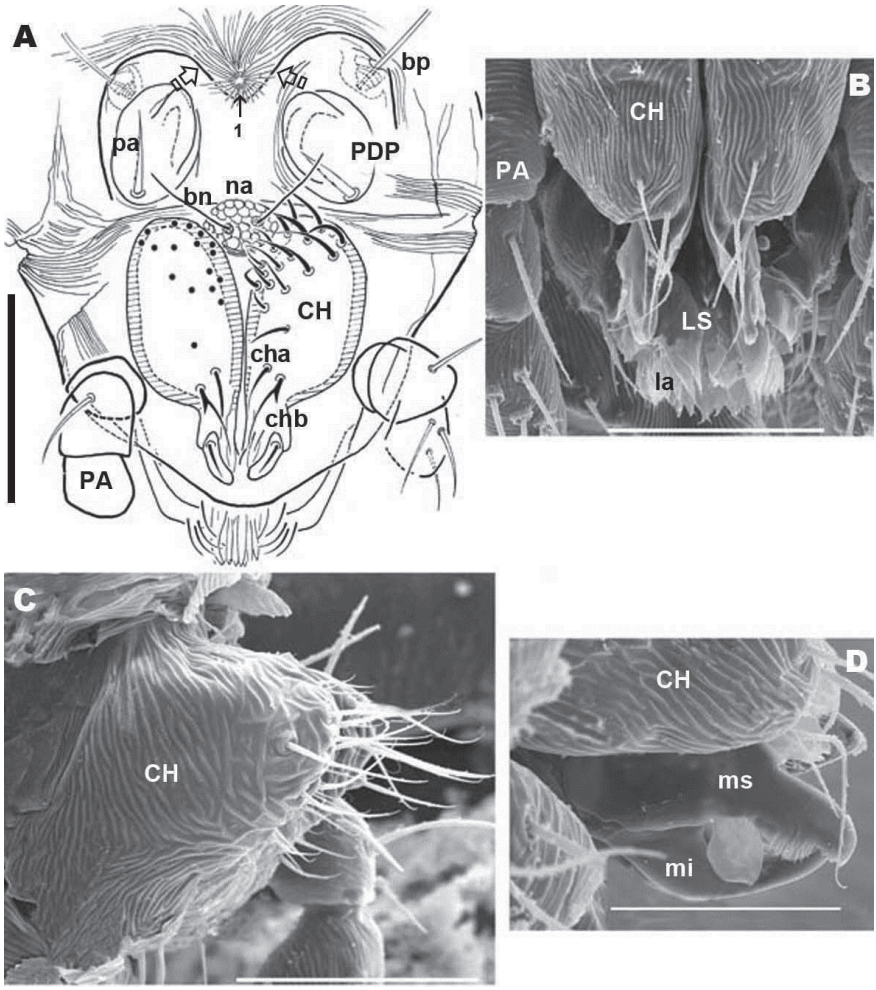


Figure 3. *Nannodromus reveilleti* gen. n., sp. n. **A+C** male **B+D** female **A** frontal view (LM observation) **B** frontal view (SEM observation) **C** chelicerae left (SEM observation), paraxial view **D** chelicerae (SEM observation), inferior and superior digits. Scale bar: **A**, **B**, **C** = 50 μm; **D** = 10 μm.

op, and near *po* setae, polygonate (general view Fig 8D), but with variable network type and cell shape (Figures 9B, E, F). Sclerite ***M*** with two depressed areas (numbered 5, 6) slightly visible; lyrifissure *ia* situated outside sclerite. Large transversal furrow with finely striated cuticular ornamentations completely separating sclerites ***A*** and ***P***.

Sclerite ***P*** in this specimen divided into several sclerites; one anterior with lyrifissure *im* and two depressed zones (numbered 7, 8) (Figure 8A). Behind this anterior sclerite; two small ovoid-circular sclerites, at base of setae d_1 and d_2 respectively, striated cuticular ornamentations surrounding each sclerite.

Each lyrifisure *ly*, *ia*, *im* and *ip* (Figure 8A), with a small rounded sclerite, surrounded by striated cuticular pattern (Figures 9C, D).

Final sclerite, in posterior position, presenting a paired depression (numbered 9) (Figures 8A; 10A).

Remarks. Variation observed in the female dorsal region with LM and SEM (Figure 6, 7) caused interpretive difficulties, as the number of sclerites visible under SEM differed from LM observations.

Only sclerite ***P*** (Figure 8A) was visible in our initial LM observation and a divided sclerite in SEM observation (Figure 9B). Further observations were deemed necessary, and though a number of specimens were available for study, it was considered insufficient to address the problem. P.D. Theron re-sampled in the type locality, on the same rock, and several security measures were taken to ensure we studied the same species, that we collected adult females, and that we worked with a series of specimens of the same species. We identically reproduced previous studies in LM and SEM. Males obtained in each sample did not present deviations to characteristics as pointed out.

We considered several possibilities: 1) the existence of large intraspecific variability in the number of sclerites in zone ***P***: sclerites may be more or less visible in animals of different ages, for this reason when using light microsocopy with recently hatched specimens, and when working with lactic acid, these structures appear faintly visible or are invisible. These slightly visible sclerites are most often observed in SEM microscopy. 2) It is possible that populations with different numbers of sclerites exist. 3) Due to the succession of generations over several months, it is possible that populations exist in which the coalescence of elementary sclerites to make up a large scutum is more or less progressed.

Figures 7A and 8A illustrate the the two extremes: one with only one sclerite ***P*** (Figure 7A), and one with several sclerites (Figure 8A), but it is necessary to indicate that we observed a comprehensive range between these two.

These issues prove the importance of using both complementary technologies (LM and SEM) as well as a large number of specimens as a unique solution to resolve this type of problem.

Dorsal region. Males. General body aspects differ greatly between *Bovidromus roussouwi*, *Rhinodromus lootsi* and *Nannodromus reveilleti*; the last is more stylized and gives the impression of more compactly built animals.

Anteriorly the aspidosoma presents the naso (*na*), globular shaped with reticulate surface; the trichobothrium (*bn*) is simple (Figures 1A, 2B, 3A, 4A). Males exhibit important particularities in the anterior zone relating to accentuated sexual dimorphism (Figures 1A, 2A, 3A, 4A). An expanded paired process (Figure 2A) plays an important role in sexual behaviour and spermatophore transfer (Alberti et al. 2007, 2010; Coineau 1974, 1976; Coineau and Kovoor 1982; Coineau et al. 2006). Digitiform dorsal paired processes (*PDP*) (in dorsal view) (Figure 2A) appear "sabot-shaped" with rounded, upwards arching apical zone (Figure 2C), cylindrical in frontal view with a paraxially directed blunt horn (Figure 2B), apical part curving upwards (Figures 2A, C; 3A). The *PDP,* presenting setae *pa* situated basally, lateral, antiaxial with length of 20 µm (22.4-19.3) (Figures 2C, D, 3A), coated by very small asperities. Both *PDP*, are parallel, slightly diverging (Figures 2B, 3A), conspicuous U-shaped depression behind

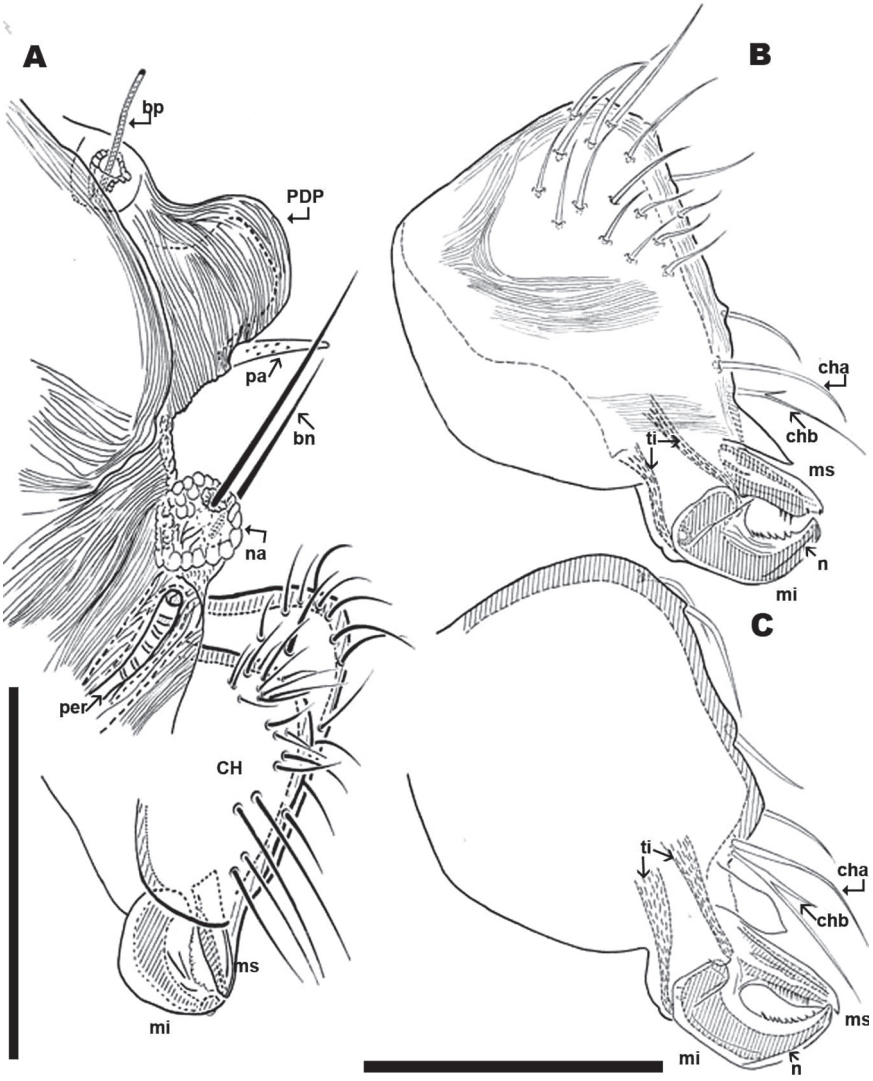


Figure 4. *Nannodromus reveilleti* gen. n., sp. n. **A, B** Male **C** Female **A** anterior region with antiaxial view of right chelicera **B** left chelicera, paraxial view **C** left chelicera, paraxial view. Scale bar: **A**, **B**, **C** = 100 μm.

them in saggital position, harboring numbered 1 depressed area in basal zone (Figures 1A, 2B, 3A). The paraxial extremities of U-depression extending in a rounded elevation which houses the trichobothrium *bp* (Figures 2B, 3A, 4A).

Simple bothridium and *bp* with asperities (Figure 8B). Depressed area 2 behind bothridium (Figure 1A); slightly antiaxially and behind depressed area, 2 small setae *po* (±10 μm length), covered with small asperities (Figure 9B) are present. Antiaxially and behind *po*, paired eyes *oa* (anterior eye) and *op* (posterior eye) (Figures 1A, 2A, 8D, 9A) present. Paired eyes show no observable differences between sexes. The *oa* is an ovoid structure of

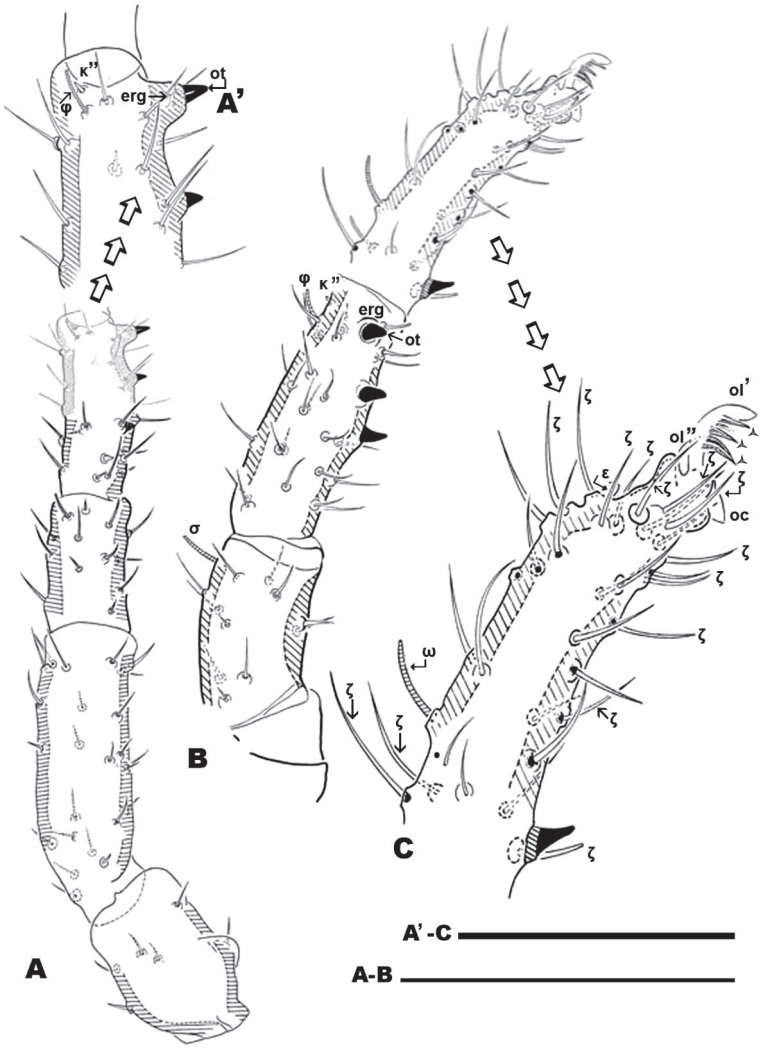


Figure 5. *Nannodromus reveilleti* gen. n., sp. n. Male. Leg I **A** dorsal view **B** lateral view, distal paraxial segments **C** lateral view tarsus I, paraxial. Scale bar: **A, B** = 100 μm; **A', C'** = 50 μm.

15 μm diameter. Small furrow (Figure 8D) surrounding convex cornea. Cornea situated in small depressed area, presenting a surface of vermiculate ornamentations (Figure 9A). Ventrally and posterior to *oa*, *op* observed as an ovoid structure, slightly concave, well delimited by a surrounding line. The *op* exhibiting a particular microsculpture (Figure 8D). The angle between *oa* and *op* is 90 degrees. The zone around *oa* and *op* exhibits very complex microsculpture (Figure 8D) as illustrated in Figure 9F. Microsculpture of zone surrounding *po* setae complex (Figure 9B, E): behind and around *op* as in Figure 9E; in this same Figure, on the anterior side, striated cuticular network extending laterally to setae *po* and in front of and behind bothridia, extending to *PDP* (Figs 2C, 4A).

Setae a_1, a_2, and depressed zone 4: close to the posterior limit of the aspidosoma, setae b_1, b_2 and depressed area 6 are observed. Relative lengths of setae *po*, *a,* and *b* are: $po < a_1, a_2 < b_1, b_2$.

Gnathosoma (Figures 2B; 3A, B; 4A): buccal structure comparable to that of *Saxidromus delamaraei* (Coineau & Naudo, 1986), *Bovidromus roussouwi* Coineau et al. 2006 and *Rhinodromus lootsi* Coineau et al. 2006 with four lips, with a particular disposition of the lateral lips with coaptation on ventral and paraxial zones and showing lamellar fringe expansions ("lacinulae") (*la*) (Figure 3B).

Chelicerae (male and female) (Figures 2B; 3A, B, C; 4A, B, C) show lineate to ruminate microsculpture (Figs 3B, C), cheliceral body a large, broad hump, very similar in both sexes (Figure 4B, C). Positions and number of setae are very specific with some similarities and in other respects large differences: in common they have simple *cha* setae and bifid *chb*. Numbers of other setae differ significantly with only four in females; and males presenting a very rare form of neotrichy. This secondary multiplication of setae is a significant phenomenon, resulting in 16 to 20 setae. This bristle assembly forms a veritable brush, paraxially situated.

The denticulate, sickle-shaped inferior digit *mi*, situated opposite the superior digit *ms,* is an important primitive character indicated by Grandjean 1949, Coineau 1974 and Coineau et al. 2006. Blade *n* on paraxial surface of digit *im* situated on the distal zone of the inferior margin. Blade *n*, the *la* and the positions of *mi* and *ms*, may play an important role in feeding.

Transversal furrow establishing the posterior limit of sclerite ***D***. The posterior dorsal part is composed of one undivided sclerite ***P***.

Sclerite ***P*** (Figures 1A, 2A), presenting three pairs of depressed areas; seven pairs of setae (c_1, c_2, d_1, d_2, e_1, e_2, e_3), lyrifissures *im* and *ip* and two tendon attachments. Depressed area 9 clearly visible in SEM and hardly observable by LM.

Female. Dorsal region differs greatly from that of the male. The female displaying two well defined sclerites ***A*** and ***M*** (Fig 6A, 7A), separated by two transverse furrows. One at level of posterior zone of leg IV and another at the level of the space between epimeres III and IV. A third sclerite ***P*** (Fig 6A, 7A) situated behind the second transversal furrow; considerable variation was observed in this sclerite. Only two examples of the most extreme variations are illustrated: Figure 7A with only one undivided sclerite ***P*** with anterolateral incisions, and Figure 8A with sclerite ***P*** divided into four paired and one unpaired microsclerites. Several variations between the two extremes were observed, sclerites are more or less visible but asymmetric variations were never found.

Sclerite ***A***: unpaired structure, triangular to polyhedral; setae *pa* situated anteriorly to *bo*; depressed area 1 (unpaired) situated in sagittal plane, behind depressed area 2 (paired); this last area situated in front of and close to setae *po*. The *oc*, *op*, *ly*, the microsculpture and depressed area 3 (paired) is similar to male. In the posterior zone and near the first transversal furrow, we observed setae a_1, a_2, and the 4 paired depressed areas (Figure 8A).

Paired sclerite ***M***, ovoid to rectangularly shaped, situated between first and second transverse furrows: *ia* situated in anterior antiaxial angle of the sclerite; two depressed areas (5, 6) aligned longitudinally, and setae b_1 and b_2.

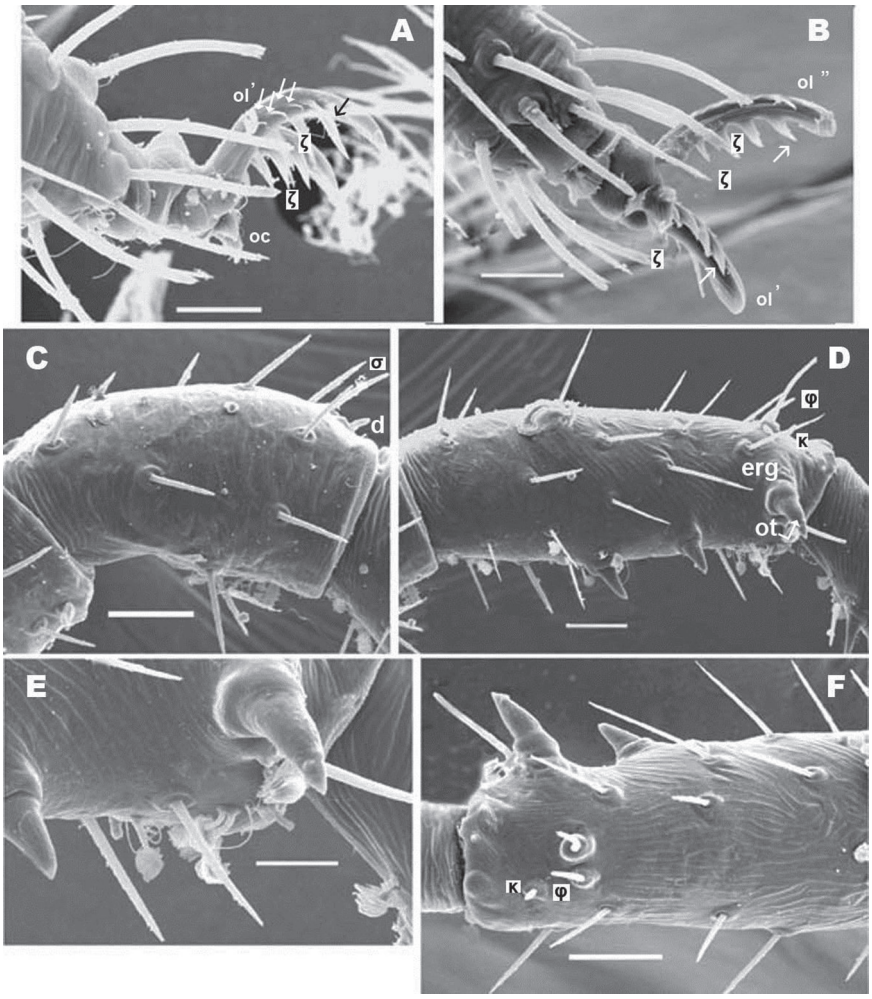


Figure 6. *Nannodromus reveilleti* gen. n., sp. n. Leg I. Male **A** tarsus I lateral left paraxial view **B** tarsus I dorsal view **C** genu, lateral view **D** tibia lateral left paraxial view **E** tibia, detail, paraxial left **F** tibia left dorsal view. Scale bar: **A**, **B** = 10 μm; **C** = 20 μm; **D** = 20 μm, **E** = 10 μm; **F** = 20 μm.

Sclerite *P* (Figures 7A; 8A) can be observed with either of two characteristics: 1) unique unpaired sclerite (Figure 6A) presenting shape, structure, setal disposition (c_1, c_2, d_1, d_2, e_1, e_2, e_3) and depressed areas (7, 8, 9) similar to male (Figure 1A). 2). Paired ovoid to polyhedral microsclerite presenting setae c_1, c_2, depressed areas 7 and 8, and lyrifissure *im*, surrounded by striate microsculpture (Figure 8A), and another paired microsclerite with setae d_1, d_2. Finally there is an unpaired, crescent-shaped sclerite (Figures 8A, 10A, B), clearly discernible in dorsal and posterior views with setae e_1, e_2, e_3 and depressed area 9.

The posterior view permits a clear comparison of the last dorsal sclerite of the two sexes. In the male (Figure 10B) the absence of the dorsal microsclerite containing e_1,

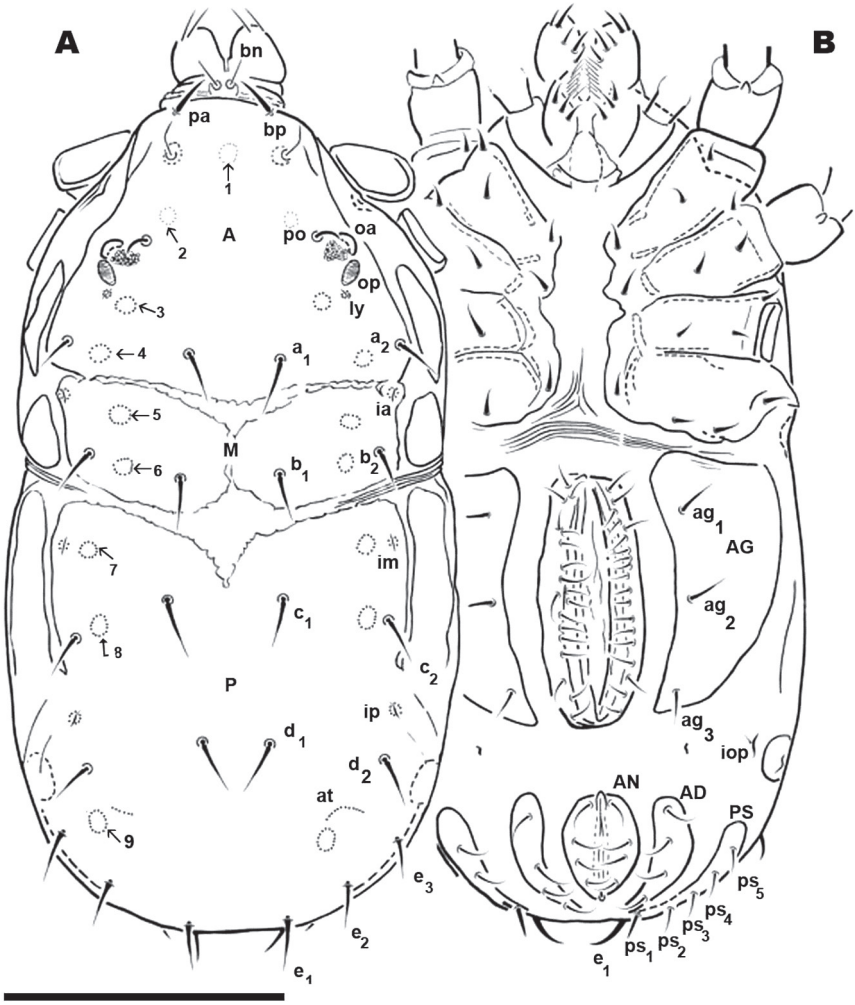


Figure 7. *Nannodromus reveilleti* gen. n., sp. n. Female. **A** dorsal view **B** ventral view**.** Scale bar: **A**, **B** = 200 μm.

e_2, e_3 setae is clearly visible; the opposite is found in the female (Figure 10A), where the crescent-shaped microsclerite is perfectly observable. Other ventral sclerites such as ***PS*** and ***AD*** and the anal opening are clearly visible in both cases.

Ventral region (Figure 1B). **Male.** Sternal region bearing setae (*st*) with epimeric formula (3-2-3-3). Aggenital region occupied on either side by a large aggenital sclerite (***AG***), semicircular, with 3 pairs of aggenital setae. Progenital lips surrounding large genital opening, with five pairs of setae. An aligned row of 16 pairs of short setae occurs along paraxial border.

Anal segment surrounding anal opening (***AN***), with four pairs of setae; adanal segment (***AD***) outwardly more or less bean-shaped with four pairs of adanal setae; more paraxially ***PS*** segment with five pairs of setae.

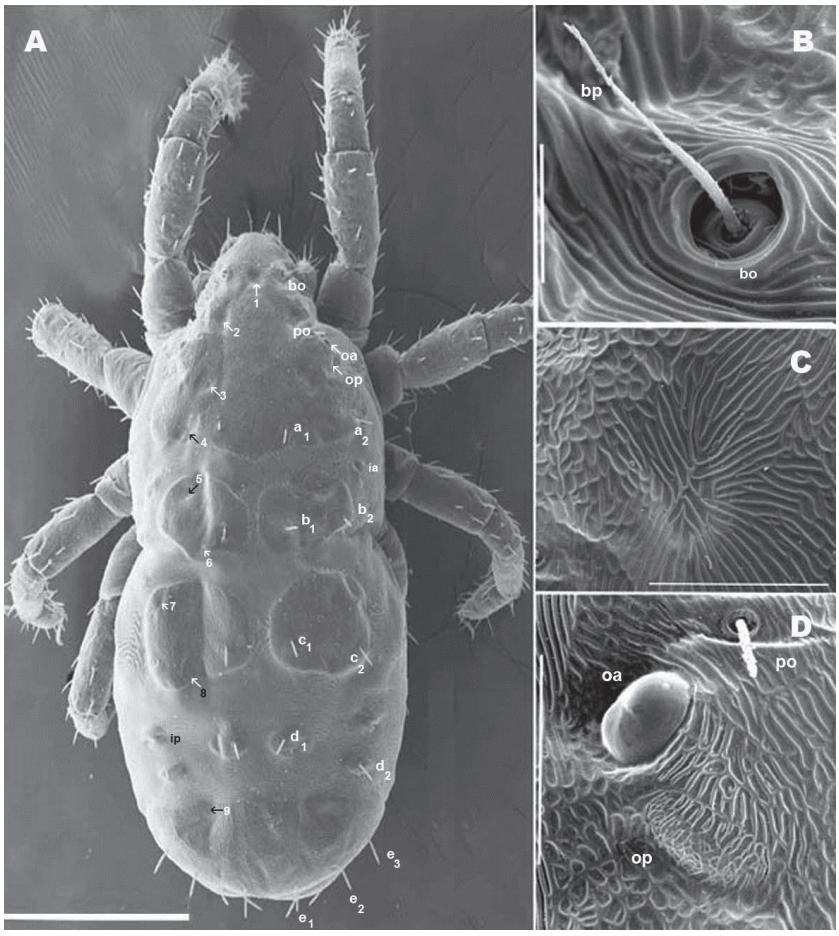


Figure 8. *Nannodromus reveilleti* gen. n., sp. n. Female. **A** dorsal view **B** trichobothrium **C** microsculpture depressed area **D** the two left eyes: the anterior normal with a convex cornea, the posterior regressed or modified and probably dedicated to another function . Scale bar: **A** = 200 μm; **B** = 10 μm; **C** = 20 μm; **D** = 30 μm.

Lyrifissure *ih* clearly visible, slightly closer to the anterior margin of *PS* sclerite

Female (Figure 7B; 10C). Shape of sternal region resembling that of male; epimeric formulae (3-3-2-3). Aggenital region occupied by large ***AG*** sclerite, more or less triangularly shaped, with three pairs of simple setae.

Progenital lips surrounding genital opening with 5-7 pairs of simple setae. Numerous simple setae aligned along paraxial edge. Due to the short distance between the progenital lips and the paraxial edge, and the almost equal lengths of setae, it is difficult to determine the exact number of both types of setae.

Other segments ***AN***, ***AD*** and ***PS,*** and the number and disposition of setae are similar to that of male.

Legs. Male. The legs present characteristics of other South African species (Coineau et al. 2006). Cuticular microsculpture on tibiae and tarsi in the form of linear striae

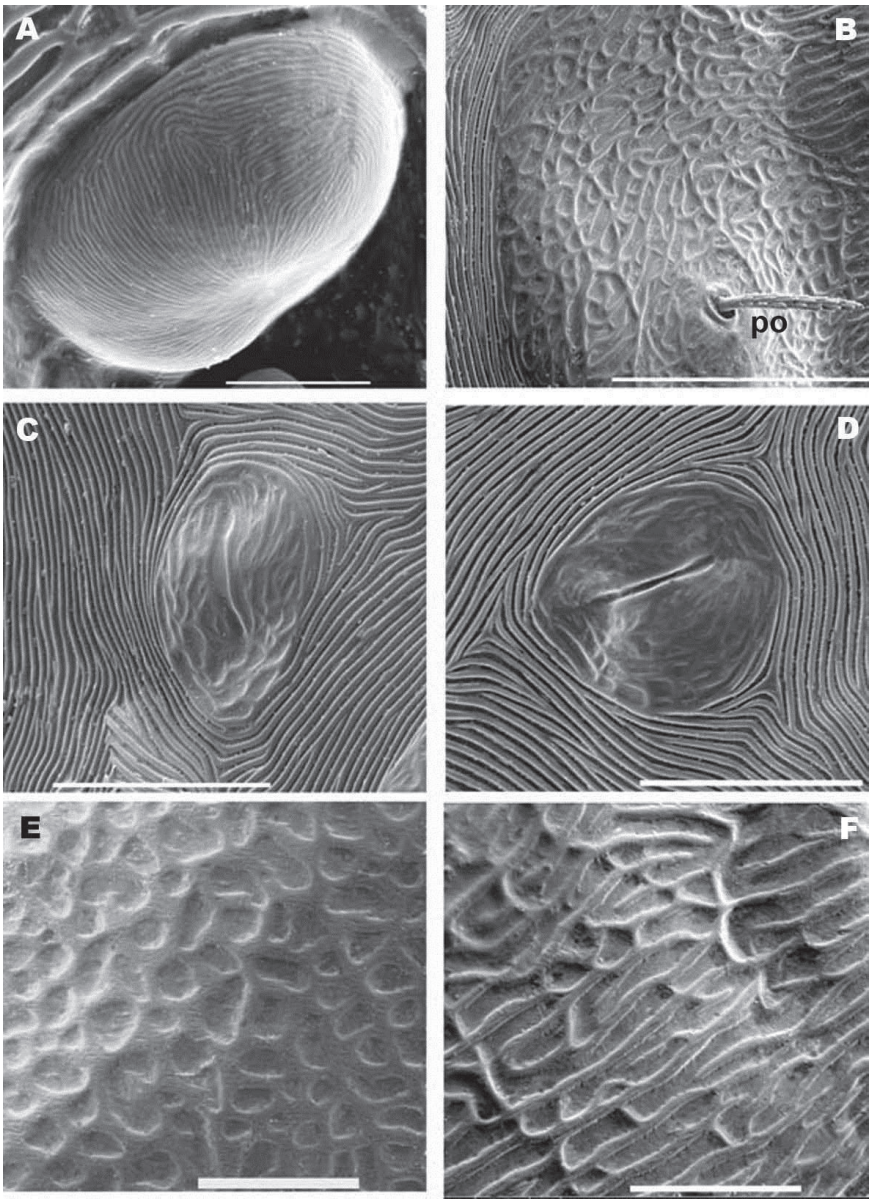


Figure 9. *Nannodromus reveilleti* gen. n., sp. n. Female. **A** anterior eye, cornea **B** microsculpture, zone surrounding *po* setae **C** lyrifissure, *ia* **D** lyrifissure *im* **E**, **F** microsculpture around ocular zone. Scale bar: **A** = 5 μm; **B**= 20 μm; **C**, **D** = 20 μm; **E** = 10 μm; **F** = 10 μm.

(Figs 6A, B, D), while for other segments (trochanter, femur, genu) microsculpture is principally a polygonnetwork (Figure 6C), but in the basal zone cuticular striae are always present. Apotele in all legs, with three heteromorphic claws with a pair isomorphics (*ol*), and a small unpaired medial hook (*oc*) (Figures 5B, C; 6A, B). Two differ-

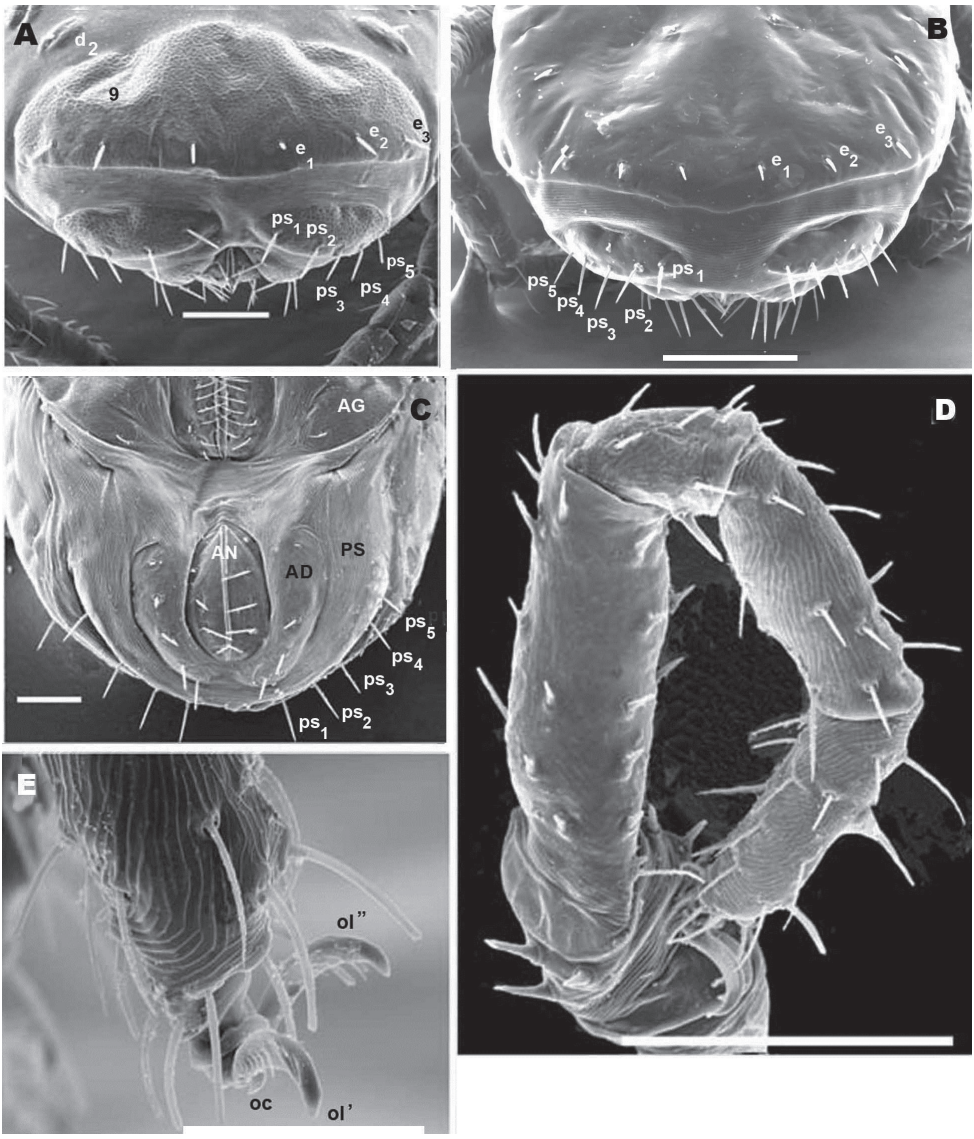


Figure 10. *Nannodromus reveilleti* gen. n., sp. n. Female/Male. **A** posterior view, female **B** posterior view, male **C** female, genito-anal zone **D** legs IV, female, view from above, several setae are lost **E** female, anterior zone tarsus I. Scale bar: **A** = 50 μm **B** = 70 μm; **C** = 50 μm; **D** = 100 μm; **E** = 40 μm, **F** = 10 μm.

ent types of barbs are presented by the paired claws (indicated in Figures 6A, B, with simple and double arrow): triangularly shaped barbs with a tooth-like appearance of relative length (length 5–7 μm, width in basal zone 1.5–2 μm) (Figure 6A, B, simple arrow); while the other type is a thin curved barbs (indicated Figure 6A, double arrow).

Leg I of Saxidromidae males show secondary sexual characters related to their role during the mating ritual, when lifting the female. They are generally more developed

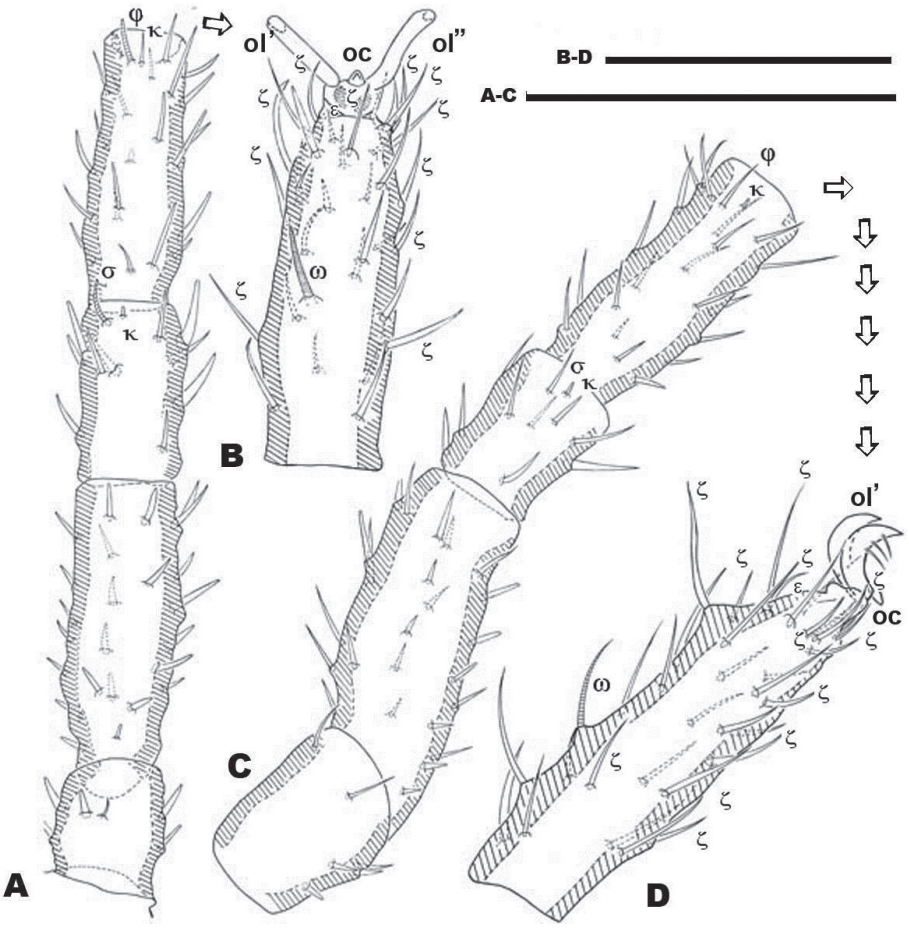


Figure 11. *Nannodromus reveilleti* gen. n., sp. n. Female. Legs I **A**, **B** dorsal view **C**, **D** lateral view. Scale bar: **A, B** = 100 μm; **C–D** = 50 μm.

than that of females. In all four genera tarsus and tibia I constitute a pincer-like structure with grabbing function.

In *Saxidromus* the conversion to a pincer affects relative movement of the setae, and a depressed soft integumental area allows tethering of legs II and IV of the female close to their base (Coineau 1976, Figure N, page 239). Amongst males of these three South-African genera the locking of female legs is enhanced by the existence of hypertrophied setae.

Nannodromus and *Bovidromus* show a hypertrophied seta on tarsus I, and as in the other genera *Nannodromus* shows a hypertrophied seta (*ot*) at the tip of a true spur (*erg*) (French: ergot) at the tip of the tibia.

Rhinodromus exhibits a curved integumental thickening at the level of the upper part of the tibia near the tibiotarsal articulation (Coineau et al. 2006, Fig 11 C).

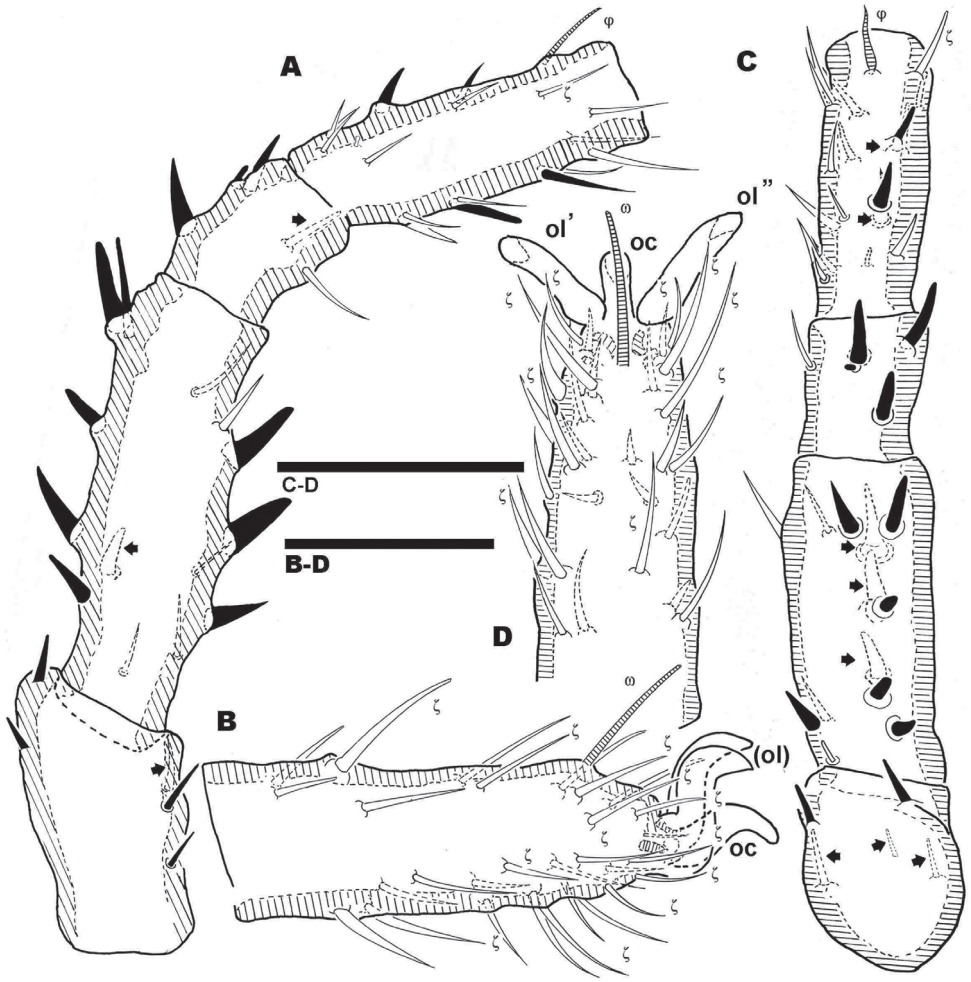


Figure 12. *Nannodromus reveilleti* gen. n. sp. n. Female Legs IV **A**, **B** dorsal view **C**, **D** lateral view. Scale bar: **A, B** = 70 μm; **C–D** = 40 μm.

Several differences in sexual dimorphisms are indicated (Coineau et al. 2006); of which one is the hypertrophied setae. In *Nannodromus reveilleti* these are found on the tibia and tarsi (in Figs indicated as black setae) of the first pairs of legs (Figures 5B, C). Tibia I presenting a tibial claw (*ot*) situated on a protuberance (*erg*) (Figs 6D, E, F).

Female. Characteristics of legs similar to those of male, but principal sexual modifications are found in legs IV, not on the first pair as in males.

Pairs I, II, III (only first pair illustrated, Figures 11A, B, C, D) presenting three heteromorphic claws as do males, also with the presence of two types of barbs (Figure 10E) (see above). Legs IV bearing three isomorphic claws.

Large number of hypertrophic setae (Figures 12A, C) (indicated as black setae or with black arrow depending on the side of the leg on which they are found) on leg pairs IV (Figures 12A–D).

Remarks. This present study of legs is provisional as we are at the moment conducting further detailed leg studies of the four known genera.

The large number of setae, and the presence among them of euphathidia, solenidia, *k* setae and hypertrophic setae necessitated meticulous study with large enough quantities of material, as well as highlighting the need for the study of immature stages. Figure 10D permits observation of the size and shape of the claw, but several setae as well as their positions are lost. Our intention with this figure is to show the real shape of the claws.

Discussion

This is divided into two parts, the first a comparison of the three South-African genera (*Bovidromus, Rhinodromus* and *Nannodromus*) and the second a comparison and discussion of feeding in *Saxidromus*.

Comparison of the three South-African genera

The three genera present a series of similarities and differences:

Size. Important differences in size: *Bovidromus* (±900×450 μm); *Rhinodromus* (±845×380 μm) and *Nannodromus* (±610×215 μm); thus *Bovidromus* > *Rhinodromus* > *Nannodromus.*

Dorsal structure. Both sexes of *Bovidromus* exhibit a unique transverse furrow delimiting two dorsal sclerites, ***D*** and ***P***. In *Rhinodromus*, the male and female exhibit two transverse furrows delimiting three dorsal sclerites (***A***, ***M***, ***P)***.

Nannodromus presents, in the male, a dorsal structure with only one transverse furrow and two dorsal sclerites (***D***, ***P***); while in females at least two transverse furrows delimit three sclerites ***A***, ***M***, ***P***; sclerite ***P*** in some instances divided into several microsclerites. Without considering the detail of the subdivision of sclerite ***P***, it can be stated that the genera *Bovidromus* and *Rhinodromus* display a similar dorsal structure for both sexes, while in *Nannodromus* the male displays one type of dorsal structure and the female another.

Setae e_2 and e_3. Present in all three genera.

Sexual dimorphism. Male. *Bovidromus* 1) Large paired dorsal process, horn-shaped, arching upwards, situated apically on the aspidosoma. 2) One pair of triangular ridges, with tips facing each other at level of trichobothria and situated in paraxial position. 3) One pair of outward directing lateral horns, situated at level of trichobothria in antiaxial position.

Legs. Apotele of all legs of similar type with three heteromorphic claws consisting of a pair of isomorphics and a small unpaired medial hook. Leg I: tibia presents a tibial

claw situated on a protuberance; hypertrophic setae found on femur, genu, tibia and tarsi; larger number on tibia and less on tarsi.

Rhinodromus 1) Large, unpaired cylindric process, curving slightly upwards, situated apically on aspidosoma. 2) One pair of horns, each directing outwards, situated in front and slightly paraxial to trichobothrium.

Legs. Apotele as in *Bovidromus*. Leg I: tibia with tibial claw situated on protuberance; hypertrophic setae on tibia in smaller numbers.

Nannodromus 1) Small, paired digitiform dorsal process, arching slightly upwards, situated apically on aspidosoma.

Legs. Apotele as in *Bovidromus*. Leg I: tibia with tibial claw situated on a protuberance; hypertrophic setae on tibia and tarsus.

Females. Legs. Apotele I-III, similar type in *Bovidromus*, *Rhinodromus* and *Nannodromus*, with three heteromorphic claws consisting of a pair of isomorphics and a small unpaired medial hook. Sexual dimorphism is found in leg IV, presenting three large claws and a series of hypertrophied setae along the leg.

Leg IV of *Nannodromus reveilleti* displaying hypertrophic setae on trochanter, femur, genu, tibia and tarsus. Hypertrophic setae absent from leg I.

Chelicerae. Characters in common: cheliceral body large, broad, and hump-shaped; setae *cha* simple; *chb* bifid; similar in both sexes.

Characters which differ: other setae: In all cases there is high neotrichy in males and low neotrichy in females: *Bovidromus* male ± 40 setae; female ± 12 setae; *Rhinodromus* male ± 16 setae; female ± 3 setae; *Nannodromus* male ± 20; female ± 4.

Feeding in *Saxidromus*. First observation of the chelicerae, with mobile falciform digit with teeth opposite fixed digit, and massive dentition may suggest the equipment of a predator (Lindquist 1979) such as *Labidostoma*; but more detailed study of the chelicerae (Coineau and Naudo 1986), supplemented with field observations (Coineau and Kovoor 1982; Coineau et al. 2006), several examinations of the digestive system (personal observation) and ultrastructural studies (Alberti 2012 – personal communication) all confirm that the Saxidromidae are microphytophages.

The chelicerae show a series of very important details such as: 1) the mobile digit exhibits an elevated blade throughout the middle distal zone of inferior edge; this structure probably contributing towards collection of particles from rock surface. 2) The system of lamellae (lacinulae) of lateral lips, which by brushing retain the charge of particles at the entrance of mouth, which have the chaelicerae. 3) The form in which the digits and body of chelicera are situated and connected (clearly observed in lateral view) shows significant suppleness, to maintain contact with substrate while absorbing the irregularities and retaining effectiveness for tiny particle collection.

The digestive system, in many dissections, shows the presence of particles, while ultrastructural studies show that the anterior pharynx extends deeply into the idiosoma and the esophagus presents a very wide lumen.

Field observation. In large numbers of field observations and during filming, mites often stopped and scraped vigorously on the rock surface possibly to obtain food.

Acknowledgement

This work is based on research supported in part by the National Research Foundation of South Africa (UID) 85288. Any opinion, findings and conclusions or recommendations expressed in the material are those of the authors and therefore the NRF does not accept any liability in regard thereto.

References

Alberti G, Coineau Y, Fernandez N, Theron P (2010) Fine Structure of the male genital systems, spermatophores and unusual sperm cells of Saxidromidae (Acari, Actinotrichida). Acarologia 50(2): 243–256. doi: 10.1051/acarologia/20101954

Alberti G, Fernandez N (1988) Fine structure of a secondarily developed eye in the fresh water moss mite, *Hydrozetes lemnae* (Coggi 1899) (Acari: Oribatida). Protoplasma 146: 106–117. doi: 10.1007/BF01405919

Alberti G, Fernandez N (1990a) Aspects concerning the structure and function of the lenticulus and clear spot of certain oribatids (Acari: Oribatida). Acarologia 31: 65–72.

Alberti G, Fernandez N (1990b) Fine structure and function of the lenticulus and clear spot of Oribatids (Acari: Oribatida). In: Andre HM, Lions J-Cl (Eds) L'ontogénèse et le concept de stase chez les Arthropodes. Agar Publishers, Wavre, Belgium, 343–354.

Alberti G, Fernandez NA, Coineau Y (2007) Fine structure of spermiogenesis, spermatozoa and spermatophore of *Saxidromus delamarei*, Coineau 1974 (Saxidromidae, Actinotrichida, Acari). Arthropod Structure & Development 36(2): 221–231. doi: 10.1016/j.asd.2006.11.002

Alberti G, Fernandez N, Kümmel G (1991) Spermatophores and spermatozoa of oribatid mites (Acari: Oribatida). Part II. Functional and systematical considerations. Acarologia 32(4): 435–449.

Alberti G, Norton R, Adis J, Fernandez N, Franklin E, Kratzmann M, Moreno AI, Ribeiro E, Weigmann G, Woas S (1997) Porose integumental organs of oribatid mites (Acari:Oribatida). 2. Fine structure. Zoologica 48(146): 33–114.

Coineau Y (1974) Les Adamystidae, une étonnante famille d'Acariens prostigmates primitifs. Proc.4th International Congres of Acarology, Saalfelden, Austria, 12–19 August: 431–435.

Coineau Y (1976) Les parades sexuelles des Saxidrominae Coineau 1974 (Acariens, Prostigmates, Adamystidae). Acarologia 18(2): 234–240.

Coineau Y, Kovoor J (1982) *Saxidromus delamarei* (Acarines prostigmate primitif) - aspects biologiques évolutifs. Réalisateur A. R. Devez. CERIMES, Vanves, France; 21 min. French and English versions, 16mm and VHS Pal. www.cerimes.fr

Coineau Y, Naudo M (1986) Contribution à l'étude de la morphologie et du développement postprelarvaire de *Saxidromus delamarei*, Y. Coineau 1974. 1. Chaetotaxie du corps et région buccale**.** Acarologia 27: 303–309.

Coineau Y, Theron P, Fernandez N (2006) Parades et dimorphismes sexuels compares chez deux nouveaux genres de Saxidromidae (Acari, Alycina) d'Afrique du Sud. Acarologia 46 (1.2): 65–87.

Fernandez N, Alberti G, Kümmel G (1991) Spermatophores and spermatozoa of Oribatid mites (Acari: Oribatida). Part I: Fine structure and Histochemistry. Acarologia 32: 261–286.

Grandjean F (1949) Observation et conservation des très petits Arthropodes. Bulletin Museum Histoire Naturelles, Paris 21(2): 363–370.

Krantz GW, Walter DE (2009) A manual of Acarology. 3rd ed. Lubbock. Texas Tech, University Press, 807 pp.

Lindquist E (1979) Acari. In: Danks HV (Ed) Canada and its insect fauna. Memoires Entomological Society Canada 108: 252–290.

ZooKeys 378: 41–47 (2014)
doi: 10.3897/zookeys.378.6435
www.zookeys.org

RESEARCH ARTICLE

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

Description of *Oculogryphus shuensis* sp. n. (Coleoptera, Lampyridae), the first species of the genus in the Sino-Japanese realm, with a modified key to the subfamily Ototretinae

Ming-Luen Jeng[1,†], Michael S. Engel[2,‡]

1 *Department of Biology, National Museum of Natural Science, No. 1, Guanqian Rd., Taichung City 40453, Taiwan, R.O.C.* **2** *Division of Entomology, Natural History Museum, and Department of Ecology & Evolutionary Biology, University of Kansas, 1501 Crestline Drive – Suite 140, Lawrence, Kansas 66045, USA*

† *http://zoobank.org/79AB741C-67E4-4B38-A9D5-133CB1B938DD*
‡ *http://zoobank.org/3714A7FF-E19E-495A-AAF9-98D2F597B757*

Corresponding author: *Ming-Luen Jeng* (jengml@nmns.edu.tw)

Academic editor: *L. Penev* | Received 15 October 2013 | Accepted 19 December 2013 | Published 6 February 2014

http://zoobank.org/1B95ECE3-0DE6-4E97-B81E-622DF1C2423B

Citation: Jeng M-L, Engel MS (2014) Description of *Oculogryphus shuensis* sp. n. (Coleoptera, Lampyridae), the first species of the genus in the Sino-Japanese realm, with a modified key to the subfamily Ototretinae. ZooKeys 378: 41–47. doi: 10.3897/zookeys.378.6435

Abstract

A new species of the lampyrid genus *Oculogryphus* Jeng, Engel, and Yang, *O. shuensis* **sp. n.** from China (Sichuan Province) is described and figured. The genus previously was known only from Vietnam, and the new species is the first representative of the genus in the Sino-Japanese zoogeographic realm. Some morphological variations of *Oculogryphus* and the allied genus *Stenocladius* are discussed and a modification to the most recent key to ototretine genera is proposed to accommodate *Oculogryphus*.

Keywords

Oculogryphus, Lampyridae, Ototretinae, *Stenocladius*, China, key

Introduction

Oculogryphus is a small beetle genus currently composed of two species known only from northern Vietnam (Jeng et al. 2007, 2011). The genus is morphologically distinctive in having enlarged compound eyes which are closely approximate ventrally and deeply

emarginate on the posterior upper margin laterally. It was thought to be en enigmatic taxon with a mosaic of features intermingling those of Rhagophthalmidae, Luciolinae, Lampyrinae, and the ototretine-ototretadriline complex when established (Jeng et al. 2007). Subsequently the genus was revealed to be closely related to the ototretine genus *Stenocladius* Fairmaire s.str. based on a comprehensive phylogenetic study of Lampyridae based on male morphology (Jeng 2008, Jeng et al. 2011). In the most current revision of Ototretinae, Janisova and Bocakova (2013) synonymized the subfamily Ototretadrilinae and accordingly redefined the limits of the group. Eighteen ototretine genera were reviewed or revised, diagnostically characterized, and a key based on male characters, especially of aedeagal morphology, was given, but *Oculogryphus* was overlooked.

Here we describe a third species of the genus, recently collected in Sichuan Province, China. The new species is the first representative of the genus in the Sino-Japanese zoogeographic realm (*sensu* Holt et al. 2013). Some morphological variations of *Oculogryphus* and *Stenocladius* are discussed in detail and a modification to Janisova and Bocakova's (2013) key to ototretine genera is proposed so as to include *Oculogryphus*.

Material and methods

The methodology and morphological terminology used herein follows that of Jeng et al. (2007, 2011). The body length (BL) is the sum of the pronotal and elytral lengths (PL and EL, respectively) plus length of those exposed portions of the head from the pronotum. Body width is considered as twice the elytral width (BW = 2EW). Pronotal width is abbreviated as PW. The nomenclature of the hind wing venation follows that of Kukalová-Peck and Lawrence (2004). In reporting label data the symbol "/" indicates separate lines on a single label. The holotype will be deposited in the insect collection of the Chinese Academy of Sciences, Beijing (CAS) and the paratype in the National Museum of Natural Science (NMNS), Taichung, Taiwan.

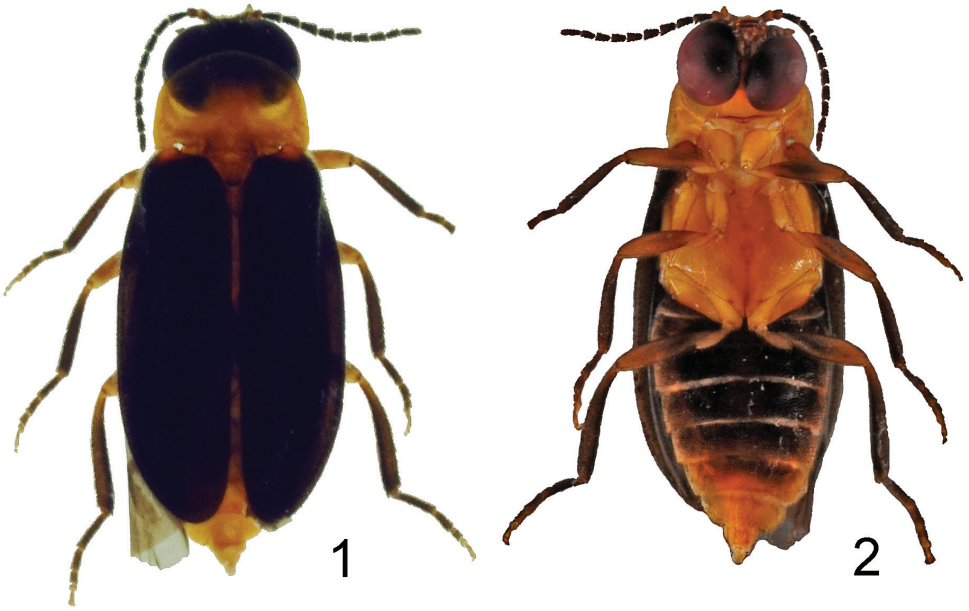
Results

***Oculogryphus shuensis* sp. n.**
http://zoobank.org/275FCCE6-4581-427C-9717-C2285D2AD8BD
http://species-id.net/wiki/Oculogryphus_shuensis
Figs 1–5

Holotype. ♂, "CHINA: Sichuan Province/ Chongqing City, Jijiang Distr./ Shuikousi, by net/ 24.VI.2013/ YT Wang leg.

Paratype. 1 ♂,"CHINA: Sichuan Province/ Chongqing City, Jiangjin Distr./ Dawopu, by FIT/, 22.VI.2013/ YT Wang leg.

Type-locality. China, Sichuan Province, Chongqing City, Jijiang Distr., Shuikousi, 18°22'N, 106°13'E.



Figures 1–2. Habitus of holotype of *Oculogryphus shuensis* sp. n. **1** dorsal aspect **2** ventral aspect.

Diagnosis. In comparison with the other two documented species, *O. shuensis* sp. n. more closely resembles *Oculogryphus bicolor* Jeng, Engel et Branham than it does *O. fulvus* Jeng. For example, the new species has a broader elytral epipleura, more slender metatibia, and more elongate parameres, much like *O. bicolor*. The new species can be differentiated easily from the others by its highly contrasting bicoloration on the dorsum (Fig. 1) and black abdominal ventrites 1–5 (Fig. 2). It additionally differs from *O. bicolor* by having a subparallel-sided median lobe of the aedeagus and a strongly sinuate basal margin to the parameres in lateral aspect (Fig. 5).

Description. ♂: BL: 6.7–7.1 mm; BW: 2.8–3.1 mm; PW/PL = 1.5–1.6; EL/EW = 3.4–3.7; EL/PL = 3.7–3.9; BW/PW = 1.3–1.4. The species is very similar to *O. bicolor* in general morphology and those characteristics need not be repeated here (*vide* Description of *O. bicolor* in Jeng et al. 2011). As described for *O. fulvus* and *O. bicolor* except: head capsule and antennae black; pronotum and mesoscutellum orange; elytra and epipleura opaquely black except humeri brown; thoracic sternites yellowish brown; all coxae, trochanters and subapices of femora yellowish brown, other parts of legs otherwise black; abdominal ventrites 1–5 and basal half of 6 opaquely black, apical half of 6 and 7–8 yellowish brown. Venation of hind wing (Fig. 3) similar to that of *O. fulvus*, with MP_4 absent or faint. Aedeagal sheath about 0.89 mm in length and 0.42 mm in width; abdominal tergites IX and X clearly recognizable individually; sternite IX with basal corners somewhat squared (Fig. 4). Aedeagus (Fig. 5) about 0.66 mm in length and 0.37 mm broad; median lobe slightly surpassing parameres apically, subparallel-sided dorso-ventrally, with apex significantly dilated in lateral aspect; parameres elongate dorso-ventrally, strongly sinuate

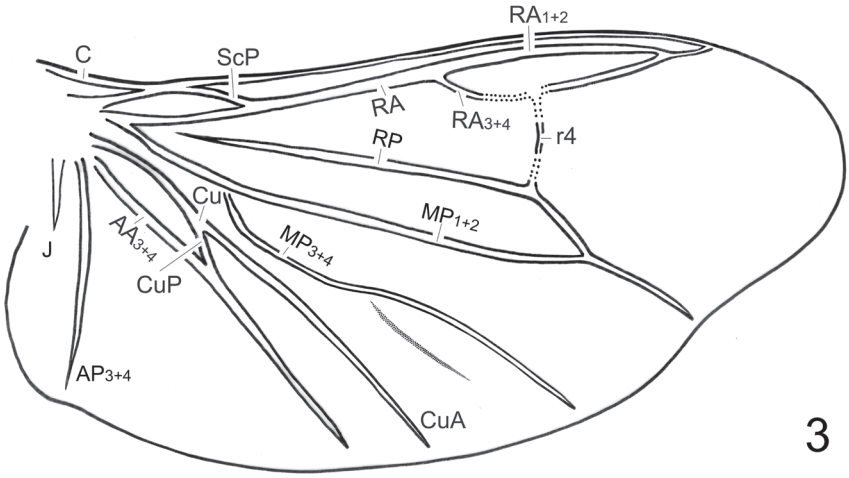
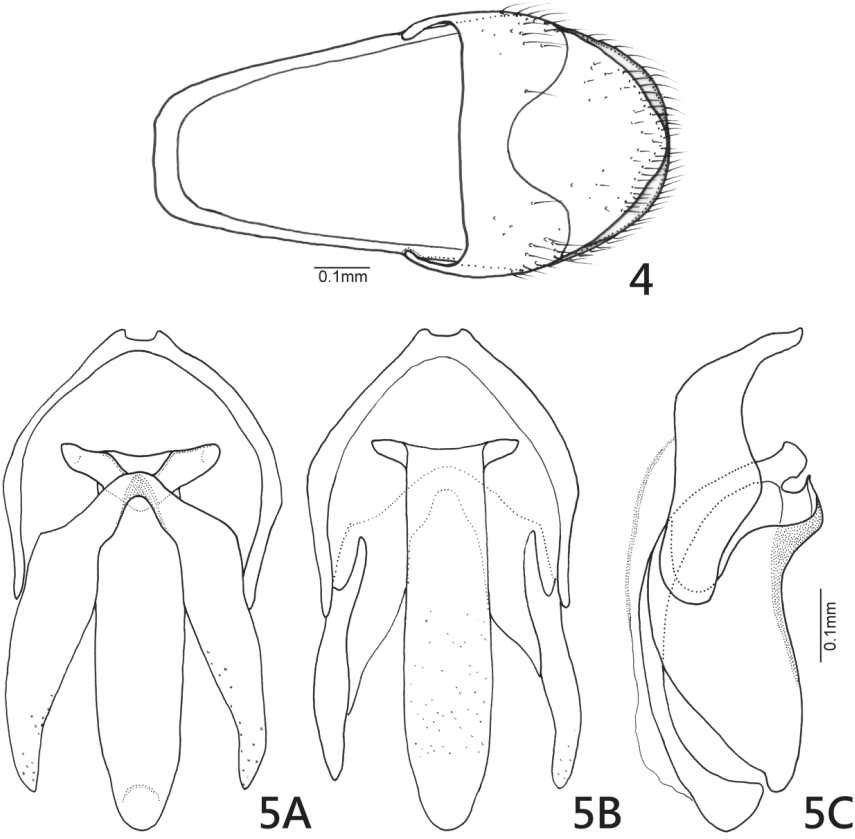


Figure 3. Sketch of right hind wing of *Oculogryphus shuensis* sp. n., male, modified from that of *O. bicolor* to show venation.



Figures 4–5. *Oculogryphus shuensis* sp. n., male. **4** aedeagal sheath, dorsal aspect **5** male genitalia, dorsal (**A**), ventral (**B**), and lateral (**C**) aspects.

on basal margin laterally; basal piece somewhat horseshoe-shaped, with a median notch in caudal margin.

♀: Unknown.

Etymology. The specific epithet is derived from the old name of Sichuan (Shu), where the new species was found.

Phenology. Males appear at least in June.

Key to species of *Oculogryphus*

1 Pronotum and elytra highly contrasting in ground coloration, elytra black and pronotum orange; abdominal ventrites 1–5 and basal half of 6 black, apical half of 6 and 7–8 yellowish brown (China: Sichuan) ..... ***O. shuensis* sp. n.**

– Pronotum and elytra sharing similar or identical ground coloration, mostly yellowish brown; abdominal ventrites exclusively yellowish brown **2**

2 Elytra with base, lateral margins, and sutures yellowish brown and disc smoky brown; body size larger (body length 6.2–8.2 mm); male genitalia with median lobe slightly surpassing apex of parameres (Vietnam) ....***O. bicolor* Jeng, Engel & Branham**

– Elytra more or less uniformly brown in coloration; body size smaller (body length 6.0 mm); male genitalia with median lobe far surpassing apex of parameres by about 1/3 length of median lobe (Vietnam) ..... ***O. fulvus* Jeng**

Discussion

We examined the type material of the type species and several other species of the ototretine genera deposited in the Muséum national d'Histoire naturelle, Paris (MNHN). *Oculogryphus* is doubtless a member of the newly-defined Ototretinae and appears allied to a subgroup whose lateroposterior angles of the pronotum are less prominent. Following Janisova and Bocakova's (2013) key, *Oculogryphus* falls intermediate between *Falsophaeopterus* Pic and *Stenocladius* in couplet 17 – it shares filiform antennae with *Falsophaeopterus* but has an aedeagal morphology more resembling that of *Stenocladius.* Although similar, the morphological particulars of *Oculogryphus* differ notably from the other two genera. For example, the filiform antennae of *Oculogryphus* are comparatively short and slender in relation to those of *Falsophaeopterus* which are more or less depressed, long and varyingly serrate. As to the aedeagus, the length of the parameres in relation to the phallus (median lobe) and whether the phallobase (basal piece) has a marginal emargination were used to separate *Stenocladius* from *Falsophaeopterus* in Janisova and Bocakova's (2013) key. It is true that the parameres of *Falsophaeopterus* (including its subgenus *Mimophaeopterus* Pic) are about as long as the phallus, but this is quite variable in *Stenocladius* (as long as 2/3 of the phallus to slightly shorter (6/7), (*cf.* Kawashima 1999, Janisova and Bocakova 2013)). The ratios of phallus/phal-

lobase and paramere/phallobase also varied greatly among species of *Stenocladius* but seem stable in *Falsophaeopterus*, which always has the phallobase shortest among the aedeagal sclerites. The ratios of aedeagal sclerites of *Oculogryphus* show a pattern similar to that observed for *Stenocladius* (Jeng et al. 2007, 2011, present study). The notch on caudal margin of the phallobase is quite clear in the type species of *Stenocladius*, *S. davidis* Fairmaire (Janisova and Bocakova 2013), but is faint or absent in some others (Kawashima 1999). Similar variation exists among species of *Oculogryphus*, too (Jeng et al. 2007, 2011, present study). The aforementioned features appear not sufficiently reliable to be diagnostically meaningful in differentiating these genera in a key.

Oculogryphus is distinct from all of the other ototretine genera by its large compound eyes which are nearly contiguous ventrally and significantly emarginate on the posterior upper margin in males. The genae are mostly vertical, deeply lying between the enlarged compound eyes and separated by a fused gular suture (Fig. 2). Within Ototretinae, only a few unidentified species of *Stenocladius* from China and SE Asia are comparable to *Oculogryphus* in terms of compound eye size. Generally the compound eyes of species of *Stenocladius* are of median size, hemispherical frontally, nearly spherical laterally and separated from each other ventrally by 0.9× to 1.5× ventral width of an individual compound eye (Janisova and Bocakova 2013). The genae and gula between the compound eyes are visible ventrally. In contrast, the large-eyed species of *Stenocladius* have their compound eyes approximate ventrally, separated from each other by scarcely visible genae and a narrow gula and are weakly and broadly-rounded emarginate on the posterior margin. Simultaneously, they also possess shorter antennae and antennal branches in contrast to the typical species of the genus. The combination of enlarged compound eyes and short antennae is likely a character suite adapted to a visually-oriented mate-searching strategy at night. Though enlarged and deeply emarginate compound eyes have evolved in parallel or by convergence among several lampyrid (Ototretinae, Luciolinae, and Lampyrinae) and rhagophthalmid (*Rhagophthalmus* Motschulsky, *Menghuoius* Kawashima and Satô, and *Dioptoma* Pascoe) lineages (Jeng et al. 2007), those of *Oculogryphus* are unique to the newly-defined Ototretinae. Herein we proposed a modification to Janisova and Bocakova's (2013) key, partially adopted from Jeng et al. (2007) to include *Oculogryphus*:

17 Tibial spurs present; antennae serrate or filiform, with first flagellomere thicker or broader than scape if filiform .....***Falsophaeopterus* Pic**

– Tibial spurs absent; antennae flabellate or filiform, with first flagellomere as thick as or more slender than scape if filiform **18**

18 Antennae filiform and short, reaching elytral base at most when in repose; compound eyes large, separated from each other by about half compound eye diameter frontally, ovoid in shape laterally, and with posterior upper margin deeply emarginate in about right angle...***Oculogryphus* Jeng, Engel & Yang**

– Antennae flabellate and long, reaching basal third or half of elytra when in repose; compound eyes medium to large, separated from each other by at least one compound eye diameter frontally, more or less round in shape laterally, with posterior upper margin never deeply emarginate in right angle.....***Stenocladius* Fairmaire**

Acknowledgements

We are grateful to Y-T. Wang for sending us material of the new species described herein and to M. Chang for taking photos of the holotype. Thanks are also due to T. Deuve (MNHN) for providing the material of ototretine species in his charge. This study was supported financially by the National Science Council, Republic of China, grants NSC100-2313-B-178-002-MY2 and NSC102-2313-B-178-003-MY3.

References

Holt BG, Lessard JP, Borregaard MK, Fritz SA, Araújo MB, Dimitrov D, Fabre PH, Graham CH, Graves GR, Jønsson KA, Nogués-Bravo D, Wang Z, Whittaker RJ, Fjeldså J, Rahbek C (2013) An update of Wallace's zoogeographic regions of the world. Science 339(6115): 74–78. doi: 10.1126/science.1228282

Janisova K, Bocakova M (2013) Revision of the subfamily Ototretinae (Coleoptera: Lampyridae). Zoologischer Anzeiger 252(1): 1–19. doi: 10.1016/j.jcz.2012.01.001

Jeng M-L (2008) Comprehensive phylogenetics, systematics, and evolution of neoteny of Lampyridae (Insecta: Coleoptera). PhD dissertation, University of Kansas, Lawrence, Kansas.

Jeng M-L, Engel MS, Yang P-S (2007) *Oculogryphus*, a remarkable new genus of fireflies from Asia (Coleoptera: Lampyridae). American Museum Novitates 3600: 1–19. doi: 10.1206/0003-0082(2007)3600[1:OARNGO]2.0.CO;2

Jeng M-L, Branham MA, Engel MS (2011) A second species of *Oculogryphus* (Coleoptera, Lampyridae), with notes on the phylogenetic affinity of the genus. Zookeys 97: 31–38. doi: 10.3897/zookeys.97.1223

Kawashima I (1999) The lampyrid beetles of the genus *Stenocladius* (Coleoptera, Lampyridae) of the Ryukyu Islands, Southwest Japan, with descriptions of two new species. Elytra 27(1): 141–158.

Kukalová-Peck J, Lawrence JF (2004) Relationships among coleopteran suborders and major endoneopteran lineages: Evidence from hind wing characters. European Journal of Entomology 101(1): 95–144.

ZooKeys 378: 49–81 (2014)
doi: 10.3897/zookeys.378.6156
www.zookeys.org

RESEARCH ARTICLE

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

A taxonomic study of Chinese species of the *insidiosus* group of *Metaphycus* (Hymenoptera, Encyrtidae)

Ying Wang[1,†], Cheng-De Li[2,‡], Yan-Zhou Zhang[1,§]

1 *Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China* **2** *School of Forestry, Northeast Forestry University, Harbin, 150040, China*

† *http://zoobank.org/CB084688-7F13-4025-BF31-11551031C777*
‡ *http://zoobank.org/0506228C-0D68-41D8-8FAC-777E81E31FC2*
§ *http://zoobank.org/F61F801F-52C0-4C7A-9331-4F663EC6BB04*

Corresponding author: *Yan-Zhou Zhang* (zhangyz@ioz.ac.cn)

Academic editor: *N. Johnson* | Received 27 August 2013 | Accepted 3 January 2014 | Published 7 February 2014

http://zoobank.org/5802580E-77DD-4DEA-86A1-47B312569B90

Citation: Wang Y, Li C-D , Zhang Y-Z (2014) A taxonomic study of Chinese species of the *insidiosus* group of *Metaphycus* (Hymenoptera, Encyrtidae). ZooKeys 378: 49–81. doi: 10.3897/zookeys.378.6156

Abstract

In this paper, twelve *insidiosus*-group species of the genus *Metaphycus* Mercet from China are reviewed. Five species, *M. corniae* **sp. n.,** *M. cylindricus* **sp. n.**, *M. deltoideus* **sp. n.**, *M. transversus* **sp. n.** and *M. yaanensis* **sp. n.**, are described as new to science. A key to the females of these species is given to facilitate species recognition. Photomicrographs are provided to illustrate morphological characters of these species. All specimens, unless otherwise specified, are deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing.

Keywords

Chalcidoidea, parasitoids, natural enemy, new species, China

Introduction

The present work is the second part of a taxonomic study on the genus *Metaphycus* Mercet from China. In an earlier paper (Wang et al. 2013), we studied 11 *Metaphycus* species of the *alberti*-group, all of which have two segments in the maxillary and labial palpi. The *insidiosus*-group includes the species with both maxillary and labial palpi

three-segmented (Compere and Annecke 1960). Species of the *insidiosus*-group are important biocontrol agents against soft scales, especially *Coccus* and *Saissetia* (Annecke and Mynhardt 1972, Noyes and Hayat 1994, Guerrieri and Noyes 2000). In the 1950s, *M. angustifrons* was introduced from China (Taiwan) to the USA (California) for the biological control of brown soft scale, *Coccus hesperidum* Linnaeus (Compere 1957, Dean and Bailey 1960, Kapranas et al. 2007). Regional revisional works concerning this economically important group include Annecke and Mynhardt (1972) (species of South Africa), Viggiani and Guerrieri (1988) (species of Italy), Guerrieri and Noyes (2000) (species of Europe), and Noyes (2004) (species of Costa Rica). As far as we know, only four species of the *insidiosus-group* are recorded from China. The current study aims to enrich the knowledge of Chinese species of the *insidiosus*-group in *Metaphycus* by providing the descriptions, distribution and host records of the species. A dichotomous key to species of this group known from China is also presented.

Material and methods

Morphological terminology and abbreviations follow those of Noyes (2004) and Wang et al. (2013). Absolute measurements were used for body length. Relative measurements were used for other dimensions and measured with a Motic SMZ-168 stereomicroscope, under 50× magnification, and the absolute measurement of each unit is 0.02 mm. The following abbreviations are used in the text:

BMNH Natural History Museum, London, UK;
IZCAS Institute of Zoology, Chinese Academy of Sciences, Beijing, PR China;
IEEM Instituto Español de Entomología, Madrid, Spain;
USNM United States National Museum, Washington, DC, USA;
ZISP Zoological Institute, St. Petersburg, Russia.

Results

Key to *Metaphycus* species of the *insidiosus*-group (females) from China

1 Mid and hind tibiae immaculate (Figs 5, 12, 27, 33), completely yellow **2**
– Mid and hind tibiae each with two brown bands, or at least mid tibia subbasally marked with a brownish band (Figs 61, 68, 75, 82) **6**
2 Scape flattened and expanded (Figs 1, 8), less than 3× as long as broad.....**3**
– Scape not flattened and expanded (Figs 15, 22, 29), at least 4× as long as broad **4**
3 Scape about 2× as long as broad (Fig. 1); head about 4× as wide as frontovertex; F5 entirely yellowish white..... ***M. orientalis*** **(Compere)**
– Scape about 2.5× as long as broad (Fig. 8); head about 5× as wide as frontovertex; F5 externally marked with dark brown.....***M. angustifrons*** **Compere**

4 Head entirely black.....***M. nitens* (Kurdjumov)**
– Head generally yellow, at most genae and occiput marked dark brown.....**5**
5 Ovipositor about 2× as long as mid tibia (Fig. 28).....***M. gerardi* Sugonjaev**
– Ovipositor less than 1.5× as long as mid tibia (Fig. 35).....
.....***M. garmon* Guerrieri & Noyes**
6 Ovipositor (Figs 42, 49, 52) a little longer than mid tibia.....**7**
– Ovipositor (Figs 63, 65, 77, 79) slightly shorter than mid tibia **9**
7 Ovipositor (Figs 49, 52) less than 5× as long as gonostylus; F1–F4 subequal in length, each segment about 0.7× as long as wide (Figs 43, 50).....**8**
– Ovipositor (Fig. 42) about 6× as long as gonostylus, F1–F4 strongly transverse in length, each segment about 0.4× as long as wide (Fig. 36).....
..... ***M. transversus* sp. n.**
8 Scape slightly expanded, 3–4× as long as broad (Fig. 43) .....
.....***M. eriococci* (Timberlake)**
– Scape not expanded, more than 5× as long as broad (Fig. 50) .....
.....***M. cylindricus* sp. n.**
9 Scape more than 3.2× as long as broad (Fig. 57) .....***M. yaanensis* sp. n.**
– Scape less than 3× as long as broad (Figs 64, 70, 78).....**10**
10 Scape (Fig. 64) about 2.7× as long as broad, maximum width located at subapical part of scape; fore wing (Fig. 66) generally with a distinct infuscation below marginal vein; ovipositor clearly exserted.....***M. deltoideus* sp. n.**
– Scape (Figs 70, 78) less than 2.5× as long as broad, maximum width located at the median part of scape; fore wing (Figs 73, 80) hyaline or at most indistinctly infuscate below marginal vein; ovipositor unclearly exserted or hardly exserted.....**11**
11 Ocelli forming an acute angle about 60°; scape (Fig. 70) expanded, about 2× as long as broad; hind tibia (Fig. 76) subbasally marked with a faintly brown ring.....***M. corniae* sp. n.**
– Ocelli forming an acute angle about 30°, clearly less than 60°; antenna with scape (Fig. 78) expanded, about 2.3× as long as broad; hind tibia (Fig. 83) with two distinctly brown rings ..... ***M. insidiosus* (Mercet)**

***Metaphycus orientalis* (Compere)**
http://species-id.net/wiki/Metaphycus_orientalis
Figs 1–7

Aphycus orientalis Compere, 1924: 120. Holotype. ♀ (USNM, not examined), Japan.
Metaphycus orientalis; Flanders and Bartlett 1964: 39–42; Trjapitzin 1975: 9; Trjapitzin 1989: 234.

Female. Body length, including ovipositor, 0.6–0.8 mm. Frontovertex pale orange; immaculate with yellow from occiput to base of mandible; mouth margin medially yellow below torulus; gena yellowish white; antenna (Fig. 1) with radicle pale brown; scape

with both faces black, only base and apex white, narrowly white along the dorsal margin; pedicel dark brown in proximal one-third, otherwise white; F1–F4 dark brown, F5–F6 yellow-white; basal segment of clava dark brown, remaining segments becoming slightly paler towards apex, apex yellow-white; occiput with a brown area above foramen, otherwise yellow; neck of pronotum pale brown to dark brown, posterior margin white, lateral spots relatively small and distinct; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae inconspicuously bordered brown; setae translucent, silvery in most lights; tegula white with apex pale brown; metanotum orange; mesopleuron white; prosternum and mesosternum white; legs (Figs 4–6) pale yellow, tibiae proximally brown, mid tibiae subbasally with an indistinct brown band; fore wing (Fig. 3) hyaline, linea calva interrupted by two to four lines of setae; venation yellow-brown; hind wing hyaline; propodeum medially orange, laterally yellow; gaster dorsally yellow to very slightly pale brown, ventrally white; gonostylus orange.

Head about 4× as wide as frontovertex, head with polygonally reticulate sculpture, mesh size slightly less than size of one eye facet; frontovertex about one-fourth head width; ocelli forming an acute angle of about 30°; eye not quite reaching occipital margin, separated by a little less than diameter of a facet; frontovertex not subparallel, becoming wider anteriorly, narrowest about level with anterior margins of posterior ocelli; scrobes deep, U-shaped; antenna with scape about 1.8× as long as broad; funicle with F1–F4 smallest, F5 a little larger than F4 but transverse, F6 largest and wider than long; linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short, slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3 (Fig. 2), notaular lines reaching about 0.4× across mesoscutum; fore wing venation and setation as in Fig. 3; cercal plate about in the 1/3 of gaster; ovipositor (Fig. 7) hardly exserted, about 4.8× as long as gonostylus.

Relative measurements: HW 15, FV 3.5, FVL 7, POL 1.5, AOL 3, OOL 0.5, OCL 2.5, POD 1, AOD 1, EL 9, EW 7, MS 5, SL 6, SW 3, FWL 33, FWW 15, HWL 25, HWW 5, OL 13, GL 3, MT 13.

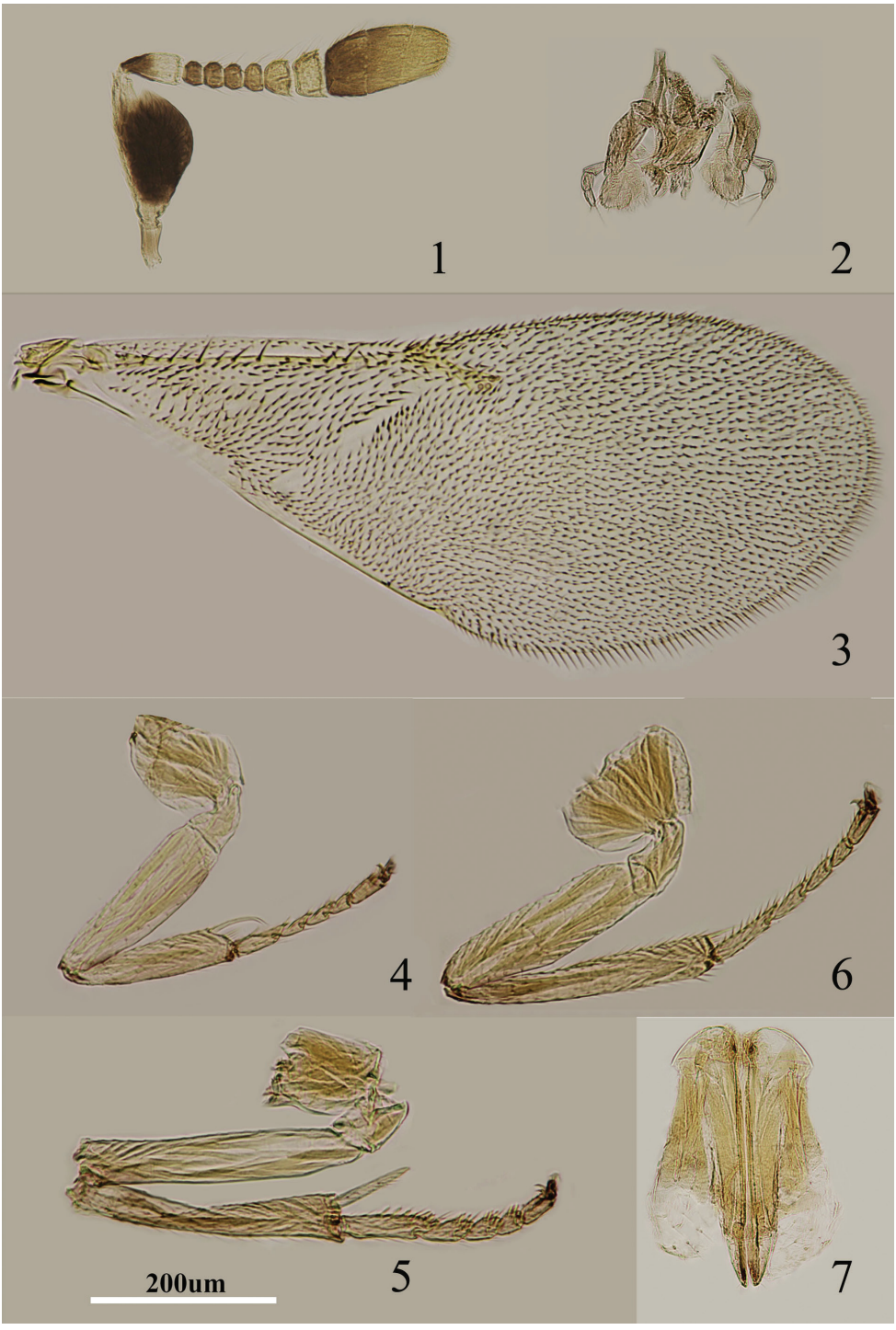
Male. Unknown.

Host. *Coccus hesperidum* Linnaeus, *C. pseudomagnoliarum* (Kuwana), *Saissetia coffeae* (Walker) (Noyes 2002).

Distribution. China (Hainan) (Fig. 84); Japan, USA (Biocontrol introduction) (Noyes 2002).

Material examined. China: 2 ♀♀, Hainan, Diaoluo Mt., 6–7.V.2007, Coll. Y. Z. Zhang; 1 ♀, Hainan, Diaoluo Mt., 6.V.2007.

Diagnosis. Scape with both faces black, apices and dorsal margin of scape white; F5 entirely yellowish white (Fig. 1); gena yellowish white; mid tibia subbasally with a faint brown band (Fig 5); head about 4× as wide as frontovertex; scape about 1.8× as long as broad (Fig. 1); ovipositor (Fig. 7) hardly exserted, about 4.8× as long as gonostylus. *Metaphycus orientalis* is similar to *M. angustifrons* in general appearance but can be separated from the latter by the scape about 1.8× as long as broad (in *angustifrons*, scape about 2.4× as long as broad); head about 4× as wide as frontovertex (in *angustifrons*, head about 5× as wide as frontovertex); F5 entirely yellowish white (in *angustifrons*, F5 marked with brown externally).



Figures 1–7. *Metaphycus orientalis* (Compere) Female: **1** antenna **2** palpi **3** fore wing **4** fore leg **5** mid leg **6** hind leg **7** ovipositor.

***Metaphycus angustifrons* Compere**
http://species-id.net/wiki/Metaphycus_angustifrons
Figs 8–14

Metaphycus angustifrons Compere, 1957: 227–229. Holotype ♀ (USNM) U. S. A. Taiwan. examined part (BMNH).
Metaphycus angustifrons Compere; Tachikawa 1963: 185, 186, 189, 190; Trjapitzin 1975: 9; Trjapitzin 1989: 236.

Female. Body length including ovipositor about 1 mm; frontovertex orange, lower face and gena concolorous, paler yellow; antenna (Fig. 8) with radicle pale brown; scape mostly brown with similar coloration on inner and outer surfaces, apex and base white, dorsal margin white; pedicel yellowish white in apical two-fifths, remainder dark brown; F1–F4 brown, F5 marked with brown externally, F6 white; clava dark brown, apical half paler yellow-brown, more or less yellow apically; occiput dark brown dorsally; neck of pronotum blackish, rest of pronotum pale orange, lateral spots present and faint; mesoscutum and scutellum dusky orange, more or less blackish on it, darker than frontovertex; metanotum largely dark brown; legs (Figs 11–13) including coxae pale orange except for faint dots at base of middle tibia; wing hyaline (Fig. 10), venation pale brown; middle of propodeum dark brown, sides orange; gaster dorsally brown.

Head about 5× as wide as frontovertex; head with fine, reticulate sculpture on frontovertex; ocelli forming an acute angle; frontovertex narrowest slightly in front of posterior ocelli; antenna (Fig. 8) with scape about 2.4× as long as broad; F1–F4 relatively small, subequal in size, F5 larger than F4, F6 largest and widest, F5 and F6 with linear sensilla; apex of clava more or less rounded, hardly with transverse truncation; mandible relatively broad with three, apical teeth; palpal formula 3-3 (Fig. 9); fore wing with venation and setation as in Fig. 10; gaster with ovipositor (Fig. 14) slightly exserted, exserted part about 0.3× as long as mid tibial spur; ovipositor about 5× as long as gonostylus.

Relative measurements: HW 16, FV 3, FVL 8, POL 0.5, AOL 2, OOL 0.5, OCL 0.5, POD 1, AOD 1, SL 6, SW 3, FWL 36, FWW 15, OL 14, GL 3, MT 13.

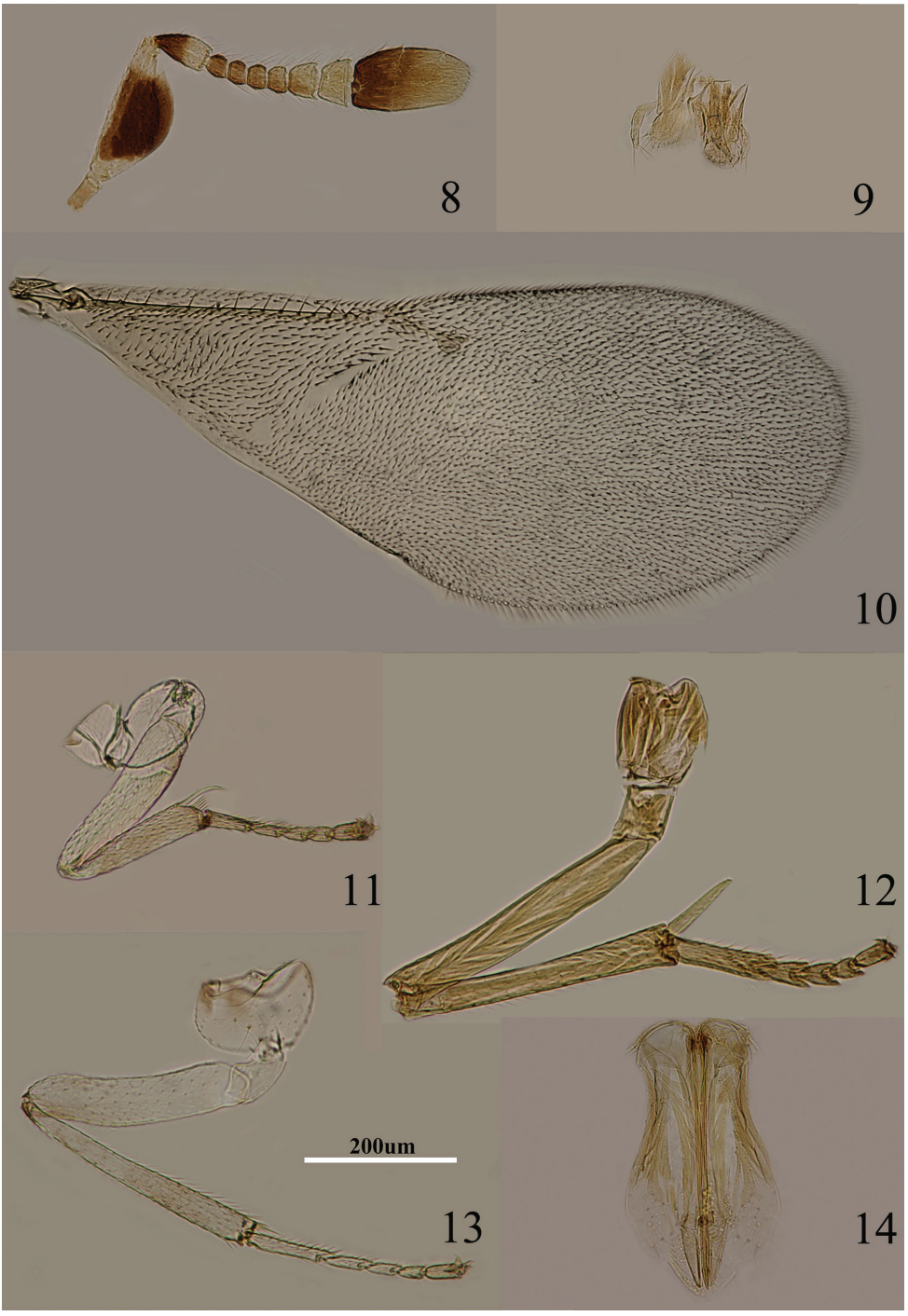
Male. Scape expanded, and about 2.5× as long as wide; funicle blackish or brown; clava similar to the funicle except for dilute yellowish apically (Compere 1957).

Host. *Coccus hesperidum* Linnaeus, *C. pseudomagnoliarum* (Kuwana), *Pulvinaria psidii* Maskell, *Saissetia oleae* (Olivier) (Noyes 2002).

Distribution. China (Fujian, Hainan, Hong Kong) (Fig. 84), Bermuda, Japan, USA (Noyes 2002).

Material examined. China: 1 ♀, Fujian, Youxi, 12.V.1965; 1 ♀, Hainan, 11.VIII.2009, Coll. G. Zheng; USA: 1 ♀, Florida, 12.V.1992, Coll. Patrick Gr.; 2 ♀♀, Ins. C.E.S., 29.III.1954, Coll. Bartlett (BMNH).

Diagnosis. Scape with both faces brown, only base and apex white, dorsal margin white; F5 marked with brown externally (Fig. 8); gena pale yellow; mid tibia with faint brown spot subbasally (Fig. 12); head about 5× as wide as frontovertex; scape about 2.4× as long as broad; ovipositor (Fig. 14) slightly exserted, about 5× as long as gonostylus.



Figures 8–14. *Metaphycus angustifrons* Compere Female: **8** antenna **9** palpi **10** fore wing **11** fore leg **12** mid leg **13** hind leg **14** ovipositor.

***Metaphycus nitens* (Kurdjumov)**
http://species-id.net/wiki/Metaphycus_nitens
Figs 15–21

Aphicus[*sic*] *nitens* Kurdjumov, 1912: 334. Syntypes ♀♂, Ukraine, not examined.
Anaphycus nitens (Kurdjumov); Sugonjaev 1960: 372.
Metaphycus nitens (Kurdjumov); Trjapitzin 1975: 12; Guerrieri and Noyes 2000: 159.

Female. Body length, including ovipositor, 0.9–1.0 mm. Head black; antenna (Fig. 15) with radicle dark brown; scape brown, apically yellow; pedicel brown in proximal half, otherwise pale brown; F1–F3 brown, F4 very pale brown, F5–F6 brown-yellow, clava dark brown, becoming slightly paler toward apex; dorsum of thorax black; mesoscutum, axillae, scutellum with blue-green reflections, setae translucent pale brown; tegula white with apex black; mesopleuron yellow; prosternum and mesosternum black; legs (Figs 18–20) mainly yellow, but hind femur pale brown; fore wing (Fig. 17) hyaline, linea calva interrupted; venation brown-yellow; hind wing hyaline; propodeum black; gaster black and gonostylus pale yellow-brown.

Head about 3× as wide as frontovertex, head with polygonally reticulate sculpture, mesh size slightly greater than size of one eye facet; frontovertex about one-third head width; ocelli forming an acute angle of about 45°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex subparallel; scrobes shallow and U-shaped; antenna with scape 4–5× as long as broad; funicle with F1–F4 smallest, F5 a little larger than F4, F6 largest and wider than long; linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short, slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3 (Fig. 16), notaular lines indistinct but almost complete; fore wing venation and setation as in Fig. 17; cercal plate about in the 1/2 of gaster; ovipositor (Fig. 21) hardly exserted, about 4× as long as gonostylus.

Relative measurements: HW 17, FV 5, FVL 11, POL 3, AOL 3.5, OOL 1, OCL 2, POD 1, AOD 1, EL 11, EW 8, MS 4, SL 9, SW 2, FWL 48, FWW 18, HWL 31, HWW 7, OL 18, GL 4, MT 17.

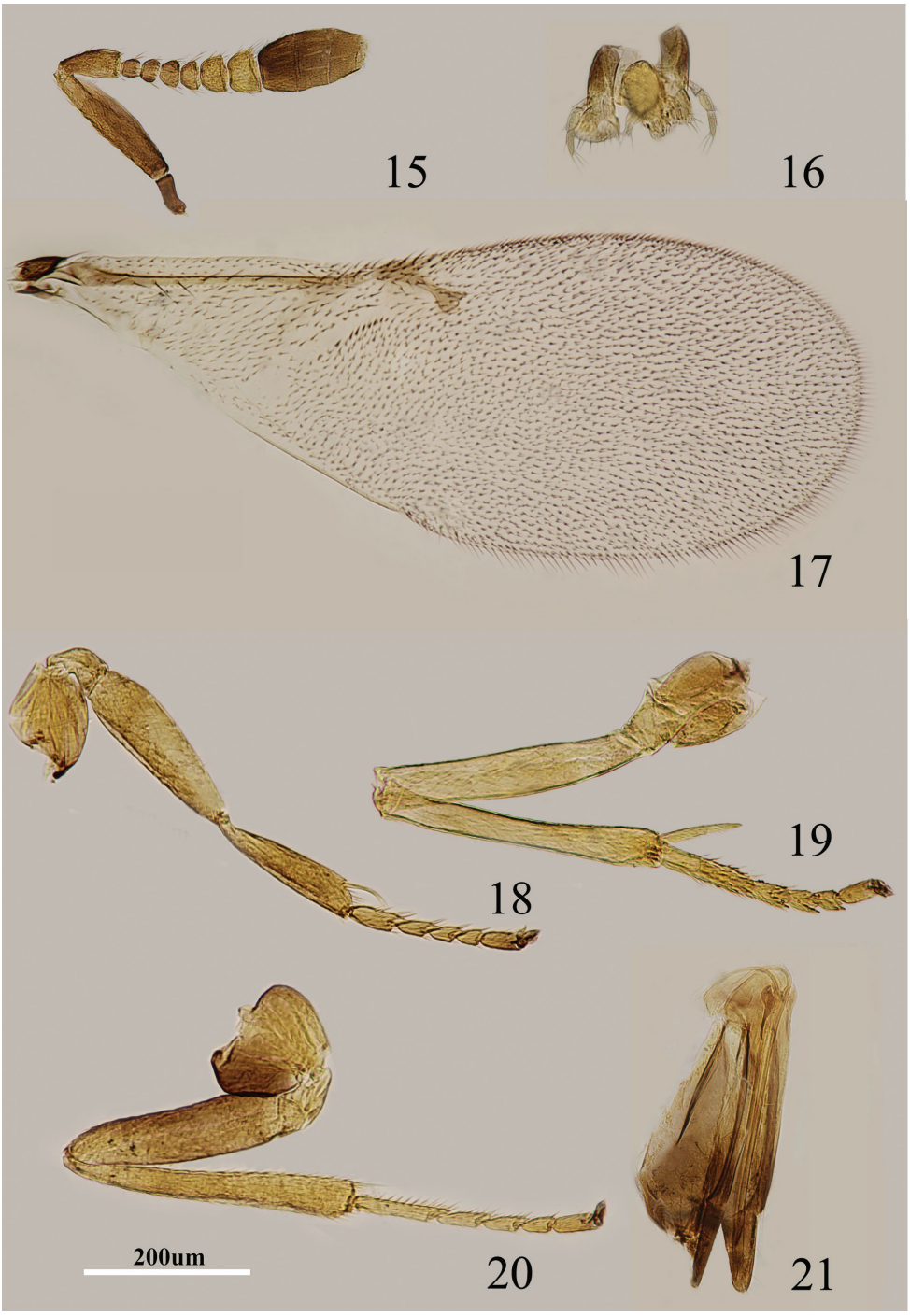
Male. Very similar to female except for antenna and genitalia (Guerrieri and Noyes 2000).

Host. *Eriococcus agropyri* (Borchsenius), *E. greeni* Newstead, *E. insignis* Newstead and *E. obscurus* Hoy (Noyes 2002).

Distribution. China (Shanxi) (Fig. 85); Bulgaria, Croatia, Czechia, Slovakia, Finland, Hungary, Moldova, Russia, Former Yugoslavia, Ukraine (Noyes 2002).

Material examined. China: 2 ♀♀, Shanxi, Wutai Mt., 18.VII.2006, 2500m, Coll. Y. Z. Zhang.

Diagnosis. Body entirely black; scape (Fig. 15) brown with apex yellow; legs mainly yellow, but hind femur generally pale brown (Figs 18–20); gonostylus (Fig. 21) pale yellow-brown; antenna with scape 4–5× as long as broad; ovipositor hardly



Figures 15–21. *Metaphycus nitens* (Kurdjumov) Female: **15** antenna **16** palpi **17** fore wing **18** fore leg **19** mid leg **20** hind leg **21** ovipositor.

exserted, about 4× as long as gonostylus. According to Guerrieri and Noyes (2000), in *nitens* the legs are largely brown, but with the base and apex of femora, tibiae and tarsi pale brown, whereas in Chinese specimens, the legs are mainly yellow; only the hind femur pale brown (Figs 18–20).

Metaphycus gerardi Sugonjaev

http://species-id.net/wiki/Metaphycus_gerardi
Figs 22–28

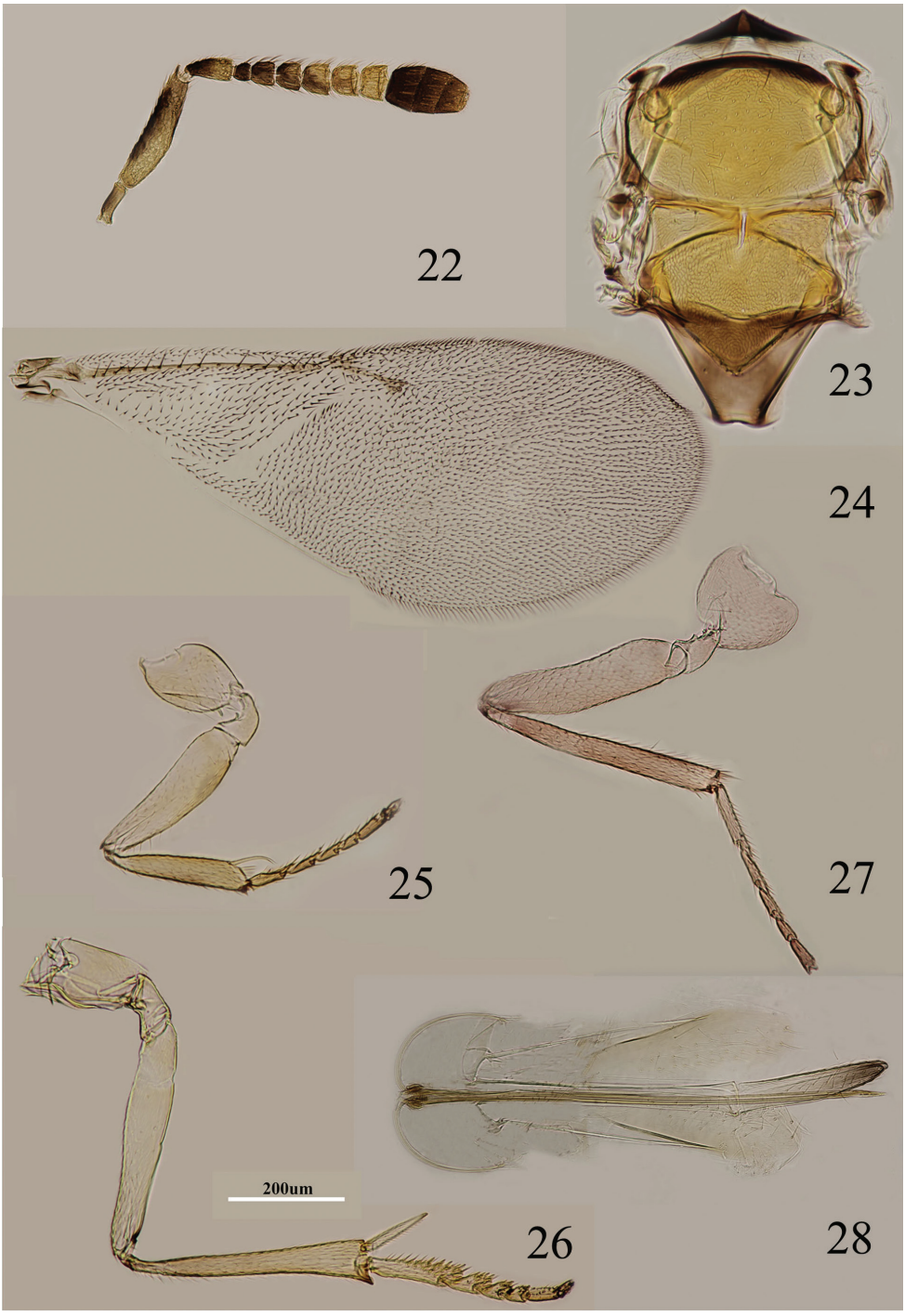
Metaphycus gerardi Sugonjaev, 1996: 421–422. Holotype ♀ (ZISP), Vietnam.

Female. Body length including ovipositor about 1.4 mm. Frontovertex orange; immaculate yellow from occiput to base of mandible; mouth margin below torulus medially yellow; rest of head, except occiput, yellow; antenna (Fig. 22) with radicle yellow; scape not expanded and inner side yellow, outer face yellow but with broad black strip along the dorsal margin; pedicel dark brown in proximal half, otherwise white; F1–F4 dark brown, F5 brown in proximal half, otherwise yellow, brown area extending slightly towards apex, F6 yellow; clava dark brown, apex brown; occiput with brown area above foramen, otherwise yellow; neck of pronotum black, posterior margin brown, otherwise yellow-white, lateral spots relatively large and distinct; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae inconspicuously pale brown; setae translucent yellow, silvery in most lights; tegula mainly pale brown; metanotum orange; mesopleuron yellow; prosternum, mesosternum yellow-white; legs (Figs 25–27) mainly very pale yellow, only tarsi slightly brown-yellow; fore wing (Fig. 24) hyaline, linea calva almost uninterrupted; venation yellow-brown; hind wing hyaline; propodeum medially orange, laterally black; gaster dorsally orange, side and venter yellow; gonostylus dark brown.

Head about 4× as wide as frontovertex, head with polygonally reticulate sculpture on frontovertex of mesh size about two-thirds size of eye facet; irregular sculpture on frontovertex of rather silky appearance; ocelli forming an acute angle of about 45°; eye reaching occipital margin; frontovertex subparallel and from anterior ocellus slightly wider anteriorly; scrobes deep and U-shaped; antenna with scape 4.0–4.8× as long as broad; funicle with F1 smallest, F2 a little larger than F1, F6 the largest, F2–F6 becoming larger towards apex, F6 slightly wider than long; linear sensilla on F2–F6; clava 3-segmented, its apex rounded; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3, notaular lines reaching about 0.6× across mesoscutum (Fig. 23); fore wing venation and setation as in Fig. 24; cercal plate about in the 0.4× of gaster; ovipositor (Fig. 28) strongly exserted, about 3× as long as gonostylus.

Relative measurements: HW 21, FV 5, FVL 10, POL 3, AOL 4, OOL 0.5, OCL 2, POD 2, AOD 2, EL 13, EW 9, MS 6, SL 8, SW 2, FWL 50, FWW 17, HWL 26, HWW 5, OL 40, GL 13, MT 19.

Male. Length about 1mm. Dark brown in ocellar area, dark brown between occipital margin and posterior ocelli; scape mainly yellow-white, only dorsal margin of



Figures 22–28. *Metaphycus gerardi* Sugonjaev Female: **22** antenna **23** thorax **24** fore wing **25** fore leg **26** mid leg **27** hind leg **28** ovipositor.

scape with brown; F1 smallest, funicle becoming gradually larger distad with F6 largest; clava solid; dorsum of thorax with black.

Host. *Ceroplastes ceriferus* (Fabricius) (Noyes 2002), *C. rubens* Maskell on *Ilex purpurea* Hassk. (new host record), *C. rusci* (Linnaeus) on *Ficus microcarpa* Linnaeus (new host record).

Distribution. China (Sichuan, Yunnan) (Fig. 85); Vietnam (Thanh Hoa, Hanoi) (Sugonjaev 1996).

Material examined. China: 2 ♀♀, Sichuan, Panzhihua, 28.IV.2012, Coll. Y. Wang & H.B. Li; 1 ♀, Sichuan, Panzhihua, 2.V.2012, Coll. Y. Wang & H.B. Li; 1 ♀, Yunnan, Kunming, 10.V.2010, Coll. H.L. Shi; 5 ♀♀, 1♂, Yunnan, Kunming, 13.V.2010; 4 ♀♀, 1 ♂, Yunnan, Mengzi (Min'an street), 18.IV.2013. 4 ♀♀, Yunnan, Kunming, 13.V.2013, Coll. J. Deng & X.B. Wang; 1 ♀, Hainan, Diaoluo Mt., N18°09', E109°53',930m, 4.V.2007, Coll. Y.Z. Zhang.

Diagnosis. Scape with outer face yellow but with black strip along dorsal margin; scape 4.0–4.8× as long as broad; funicle with F1 smallest, F2–F6 becoming larger towards apex, F2–F6 with linear sensilla (Fig. 22); fore wing hyaline, with linea calva uninterrupted (Fig. 24); ovipositor strongly exserted, and about 2× as long as mid tibia (Fig. 28). *Metaphycus gerardi* is very close to *Metaphycus eruptor* (Howard, 1881) in appearance. They share similar antennal structure, fore wing shape and ovipositor dimensions. Further studies may show they are synonyms.

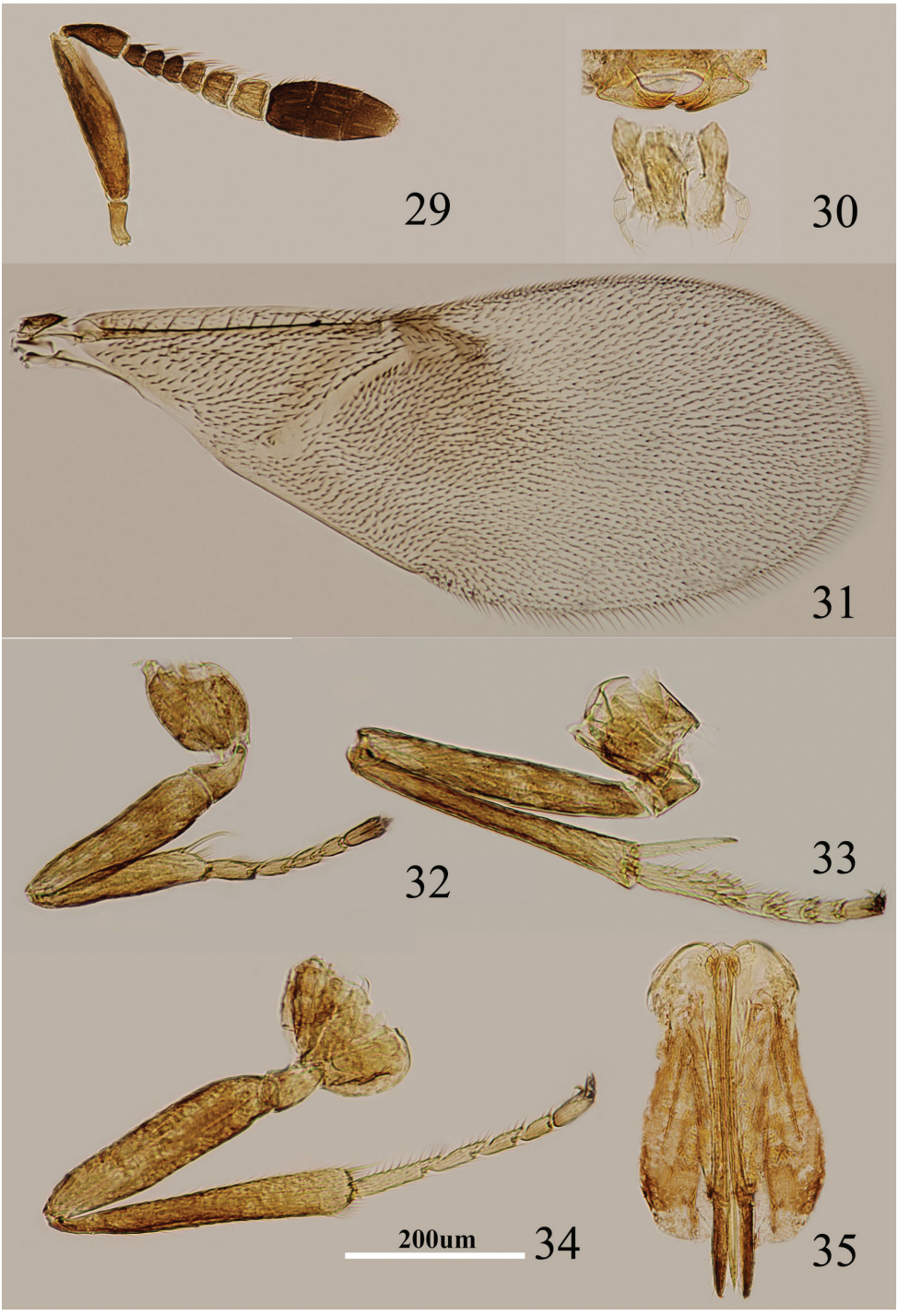
Metaphycus garmon Guerrieri & Noyes

http://species-id.net/wiki/Metaphycus_garmon
Figs 29–35

Metaphycus garmon Guerrieri and Noyes 2000: 181. Holotype ♀ (BMNH), Italy.

Female. Body length, including ovipositor, 0.8–1.2 mm. Head orange yellow; antenna (Fig. 29) with radicle brown except pale base; scape brown yellow with an elongate black strip on dorsal margin on outer surface except base; pedicel pale yellow in apical half, dark brown in basal half; F1–F3 black, F4 pale brown and becoming progressively paler to apex, F5–F6 white, clava black; neck of pronotum dark brown, posterior margin white, lateral spots relatively small but distinct; mesoscutum and scutellum orange, sometimes anterior margin of mesoscutum brown; sides and posterior margin of mesoscutum and axillae conspicuously bordered brown; setae translucent, silvery in most lights; tegula white with apex brown; metanotum orange; mesopleuron yellow; prosternum and mesosternum pale yellow; legs (Figs 32–34) mainly pale yellow except pretarsus brownish; fore wing infuscate in basal 3/5, with a darker area beneath marginal vein; venation yellow-brown; hind wing hyaline; propodeum medially orange; gaster orange, gonostylus orange.

Head about 4× as wide as frontovertex, head with polygonally reticulate sculpture, mesh size slightly less than size of one eye facet; frontovertex about one-fourth



Figures 29–35. *Metaphycus garmon* Guerrieri & Noyes Female: **29** antenna **30** palpi **31** fore wing **32** fore leg **33** mid leg **34** hind leg **35** ovipositor.

head width; ocelli forming an acute angle about 40°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex subparallel and from anterior ocellus slightly wider anteriorly; scrobes shallow and U-shaped; antenna with scape 4–5× as long as broad; funicle with F1–F3 smallest, subequal and subquadrate, F4–F6 becoming larger towards apex; linear sensilla only on F5 and F6; clava 3-segmented, its apex rounded; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3 (Fig. 30), notaular lines reaching about 0.7× across mesoscutum; fore wing venation and setation as in Fig. 31; cercal plate about in the 0.6× of gaster; ovipositor (Fig. 35) slightly exserted, 4–5× as long as gonostylus.

Relative measurements: HW 19, FV 5, FVL 8, POL 3, AOL 4, OOL 0.5, OCL 2, POD 1, AOD 1, EL 11, EW 9, MS 4, SL 10, SW 2, FWL 36, FWW 17, HWL 31, HWW 7, OL 16, GL 4, MT 18.

Male. Generally very similar to female except for body length, coloration of antenna, genitalia and solid clava. Antenna flagellum generally pale brown; aedeagus with two digital spines.

Host. Unknown.

Distribution. China (Beijng, Jiangsu, Shanxi) (Fig. 85); France, Greece, Italy, Spain, Turkey (Guerrieri and Noyes 2000).

Material examined. China: 1 ♀, Beijing, Haidian, 20.VI.2010, Coll. D. K. Zhou; 1 ♀, Beijing, Changping, 20.IX.2008, Coll. F Yuan; 1 ♀, Jiangsu, Nanjing, 18.VI.2012; 1 ♂, Jiangsu, Nanjing, VI. 2011; 2 ♀♀, Shanxi, Wutai Mt., 16.VII.2006, Coll. Y. Z. Zhang

Diagnosis. Scape brown yellow, the outer surface with an elongate black strip along dorsal margin (Fig. 29); fore wing infuscate in basal 3/5, with a darker area beneath marginal vein; scape 4–5× as long as broad; ovipositor slightly exserted, 4–5× as long as gonostylus (Fig. 35). This species is similar to *M. petitus* in general coloration, antennal structure and ovipositor length. *Metaphycus garmon* can be separated from *M. petitus* by the coloration of the fore wing and black strip along dorsal margin (Guerrieri and Noyes 2000).

Metaphycus transversus sp. n.

http://zoobank.org/B5355014-6542-4EE6-B1B2-D555F79F1FE2
http://species-id.net/wiki/Metaphycus_transversus
Figs 36–42

Holotype. China: ♀, Yunnan, Xishuangbanna, 2009.XI.16, Coll. Y. Z. Zhang (IZCAS).

Paratypes. 3 ♀♀, the same as holotype (IZCAS).

Female. Body length, including ovipositor, 1.2–1.3 mm. Frontovertex pale yellow; gena with fairly broad, oblique brown area near mouth margin; mouth margin medially pale yellow below torulus; rest of head, except occiput, white; antenna (Fig.

36) with radicle brown; scape with both faces black, dorsal margin black, white at extreme apex; pedicel dark brown in proximal half, white distally, dark brown area extending slightly towards apex externally and internally; F1–F4 brown, F5–F6 pale brown and becoming slightly paler towards apex; clava pale brown, extreme base brown like F6, becoming slightly paler towards apex; occiput with a black area above foramen, otherwise white; neck of pronotum black, posterior margin very pale brown, lateral spots relatively small and distinct; dorsum of thorax mainly orange; sides and posterior margin of mesoscutum and axillae conspicuously bordered brown; setae translucent brown, silvery in most lights; tegula pale yellow; metanotum brown; mesopleuron yellow-white; prosternum white; mesosternum white, sometimes pale brown; legs (Figs 39–41) mainly pale yellow; tibiae proximally dark brown; mid tibia and hind tibia with a pair of dark brown rings at about 0.2× and 0.5×; fore wing (Fig. 38) hyaline, with linea calva interrupted by two setae; venation yellow-brown; hind wing hyaline; propodeum medially dark brown, sides pale yellow; gaster dorsally brown, side and venter white; gonostylus orange.

Head about 4× as wide as frontovertex, head with polygonally reticulate sculpture and mesh size slightly less than size of one eye facet; frontovertex about one-fourth head width; ocelli forming an acute angle about 60°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex subparallel and from anterior ocellus slightly wider anteriorly; scrobes shallow; antenna (Fig. 36) with scape about 2.5× as long as broad; funicle with all funicular segments transverse, F1–F4 small, F5 and F6 a little larger, linear sensilla only on F5 and F6; clava 3-segmented, its apex rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3 (Fig. 37), notaular lines reaching about 0.8× across mesoscutum; fore wing venation and setation as in Fig. 38; cercal plate about in the 1/2 of gaster; ovipositor (Fig. 42) hardly exserted, about 5.8× as long as gonostylus.

Relative measurements: HW 19, FV 5, FVL 8, POL 2.5, AOL 2.5, OOL 1.5, OCL 1, POD 1.5, AOD 1.5, EL 11, EW 8, MS 5, SL 7, SW 2.5, FWL 43, FWW 18, HWL 31, HWW 7, OL 15, GL 3, MT 14.

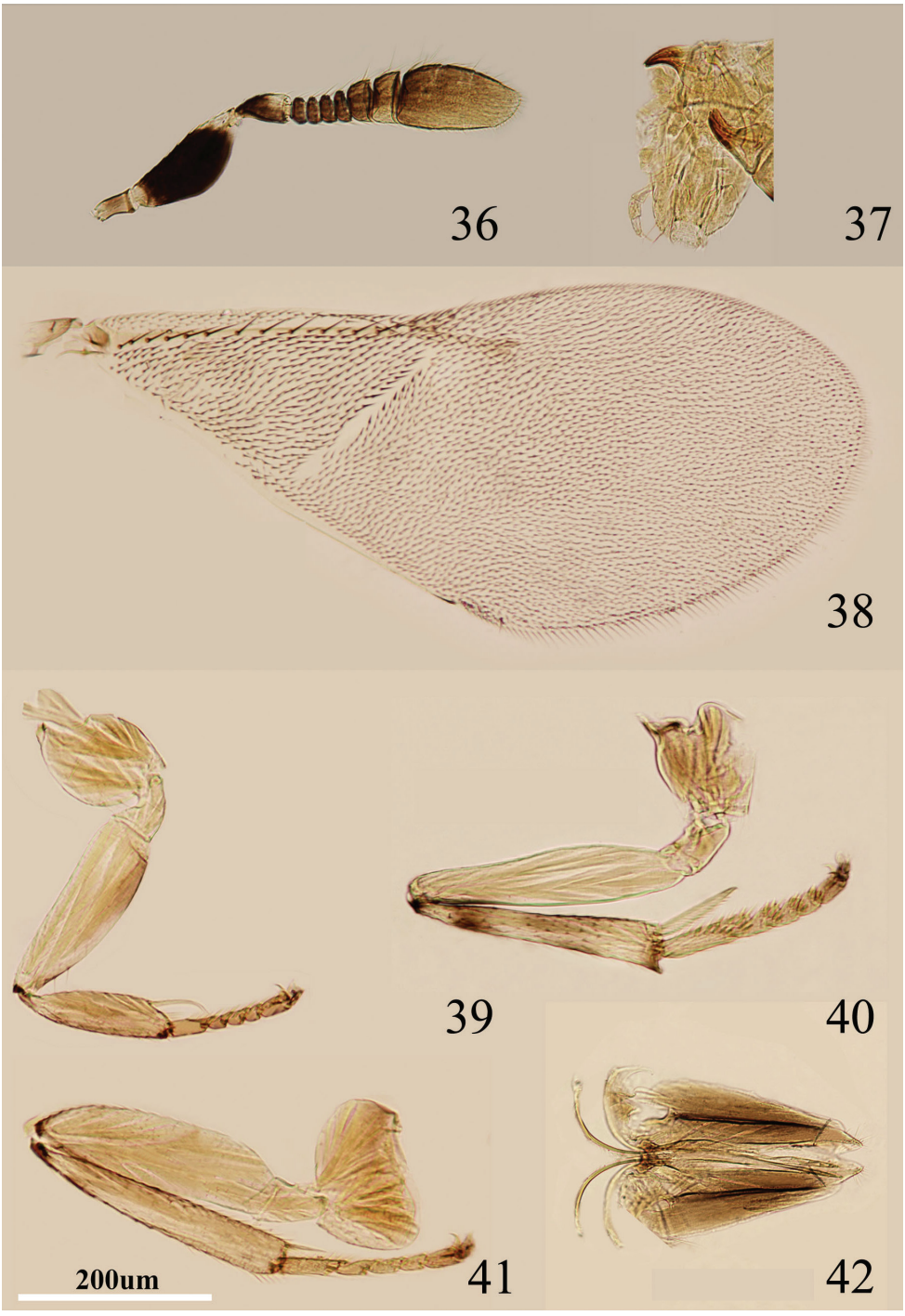
Male. Unknown.

Host. Unknown.

Distribution. China (Yunnan) (Fig. 84).

Etymology. The new species name is derived from the fact that each funicle segment is strongly transverse .

Diagnosis. Scape black, but apex yellowish white; gena with a fairly broad, oblique brown area near mouth margin; funicle with F1–F6 transverse (Fig. 36); ovipositor (Fig. 42) hardly exserted, about 5.8× as long as gonostylus. Using the key of Guerrieri and Noyes (2000), *M. transversus* runs couplet 27 and is close to *M. lounsburyi*. Females of *M. transversus* can be separated from *lounsburyi* as follows: scape (Fig. 36) about 2.5× as long as broad (in *lounsburyi*, scape about 3× as long as broad); dorsal margin of scape black (in *lounsburyi*, dorsal margin white).



Figures 36–42. *Metaphycus transversus* sp. n. Female: **36** antenna **37** palpi **38** fore wing **39** fore leg **40** mid leg **41** hind leg **42** ovipositor.

***Metaphycus eriococci* (Timberlake)**
http://species-id.net/wiki/Metaphycus_eriococci
Figs 43–49

Aphycus eriococci Timberlake, 1916: 631. Holotype ♀, USNM.
Metaphycus eriococci; Tachikawa 1968: 111.

Female. Body length, including ovipositor, 0.7–0.9 mm. Frontovertex pale orange; gena yellow to brownish yellow, gena with brown stripe extending to upper mouth margin; mouth margin medially yellow below torulus; rest of head, except occiput, yellow; antenna (Fig. 43) with radicle dark brown; scape with both faces dark brown, only apex yellowish; pedicel dark brown in proximal half, otherwise yellowish; F1–F4 dark brown, F5–F6 brownish yellow, clava dark brown, becoming slightly paler towards apex and apex very pale brown; occiput with a brown area above foramen, otherwise white; neck of pronotum dark brown to black, posterior margin white, lateral spots relatively large and distinct; dorsum of thorax orange to pale brown; sides and posterior margin of mesoscutum and axillae conspicuously bordered dark brown; setae translucent, silvery in most lights; tegula white with apex pale brown; metanotum orange to brown; mesopleuron yellow-white; prosternum and mesosternum pale yellow; legs (Figs 46–48) mainly pale yellow, mid tibia and hind tibia with faintly brown mark; fore wing hyaline, linea calva interrupted; venation yellow-brown; hind wing hyaline; propodeum medially orange-brown, laterally yellow; dorsum of gaster pale brown and ventral yellow-white; gonostylus orange.

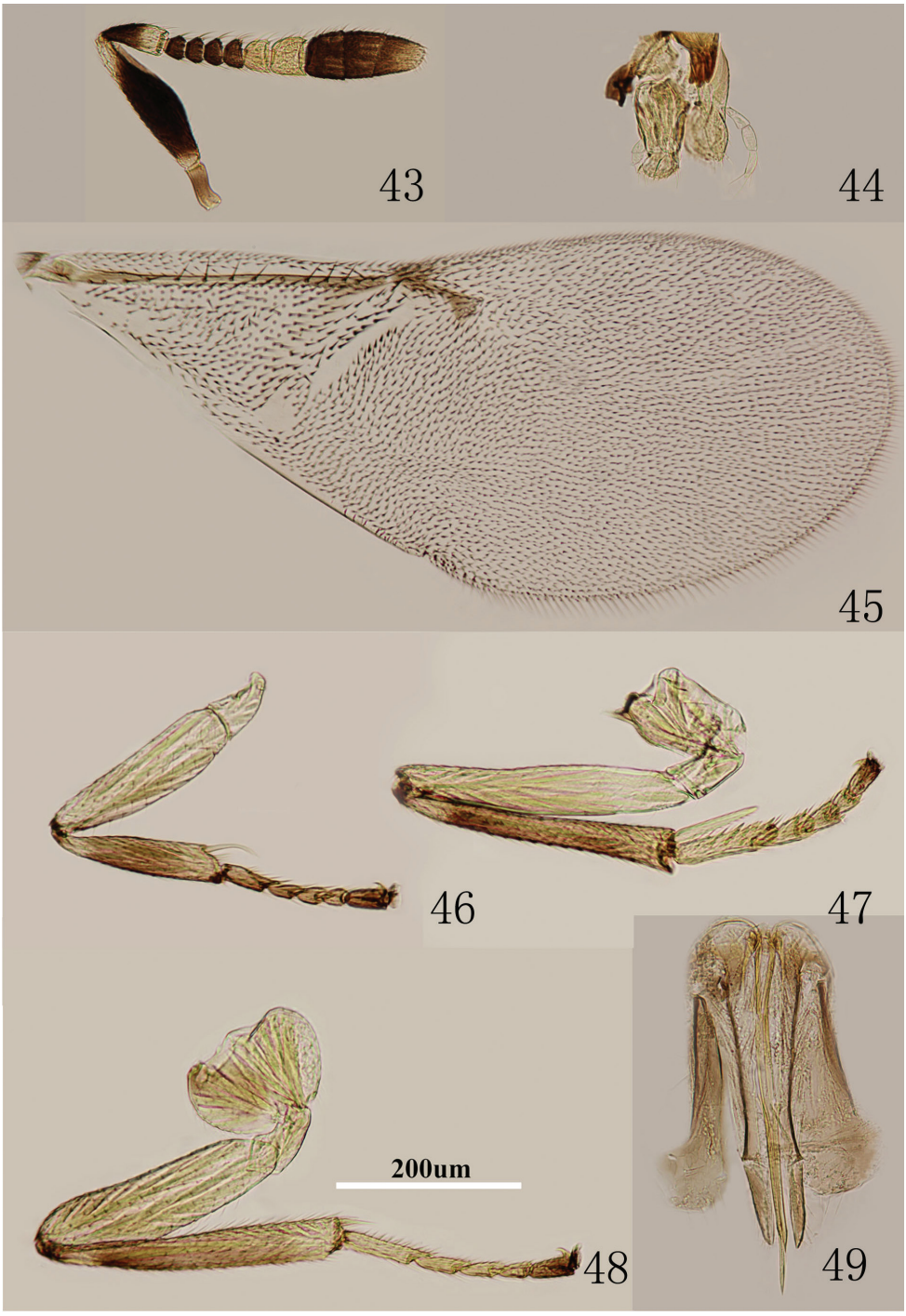
Head about 4× as wide as frontovertex, head with polygonally reticulate sculpture and mesh size slightly less than size of one eye facet; ocelli forming an acute angle about 50°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex subparallel and from anterior ocellus slightly wider anteriorly; scrobes shallow and U-shaped; antenna (Fig. 43) with scape 3.2–3.7× as long as broad; funicle with F1–F4 smallest, F5 a little larger than F4, F6 largest; linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short, slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3 (Fig. 44), notaular lines reaching about 0.6× across mesoscutum; fore wing venation and setation as in Fig. 45; cercal plate about in the 1/2 of gaster; ovipositor (Fig. 49) slightly exserted, 4–5× as long as gonostylus.

Relative measurements: HW 17, FV 4.5, FVL 9, POL 2, AOL 3, OOL 1, OCL 2, POD 1, AOD 1, EL 12, EW 10, MS 5, SL 9, SW 3, FWL 45, FWW 20, OL 17, GL 5, MT 15.

Male. Body length 0.7–0.8 mm, dark brown in coloration. Otherwise very similar to female but for antenna and genitalia.

Host. *Eriococcus howardi* Ehrhorn; *E. quercus* (Comstock), *Coccus hesperidum* (Linnaeus) (Noyes 2002); and *E. lagerstroemiae* Kuwana on pomegranate (new host record).

Material examined. China: Beijing, Haidian: 23 ♀♀, 4.IV.2006, Coll. Y. Z. Zhang; 22 ♀♀, 2 ♂♂, 6.VI.2006, Coll. Y. Z. Zhang; 20 ♀♀, 5 ♂♂, 11.VIII.2003,



Figures 43–49. *Metaphycus eriococci* (Timberlake) Female: **43** antenna **44** palpi **45** fore wing **46** fore leg **47** mid leg **48** hind leg **49** ovipositor.

Coll. Y. Z. Zhang; 29 ♀♀, 8 ♂♂, ex *E. lagerstroemiae* on pomegranate, 12.IX.2006, Coll. Y. Z. Zhang; 19 ♀♀, 1 ♂, ex *E. lagerstroemiae* on pomegranate, 8.X.2004, Coll. Y. Z. Zhang; 1 ♀, 17.VII.2012, Coll. Q. S. Zhou; 1 ♀, Nanjing, V.2010.

Distribution. China (Beijing, Jiangsu); USA (California, Florida, Texas, Utah) (Noyes 2002) (Fig. 84).

Diagnosis. Antenna with radicle dark brown; scape with both faces dark brown, only apex yellowish; scape 3.2–3.7× as long as broad (Fig. 43); ovipositor (Fig. 49) slightly exserted, 4–5× as long as gonostylus. The Chinese material examined almost agrees with the original description of *eriococci* by Timberlake (1916). The female specimens here have the scape 3.2–3.7× as long as broad, while in original description of *eriococci* the scape is a little over 4× as long as wide (Timberlake 1916).

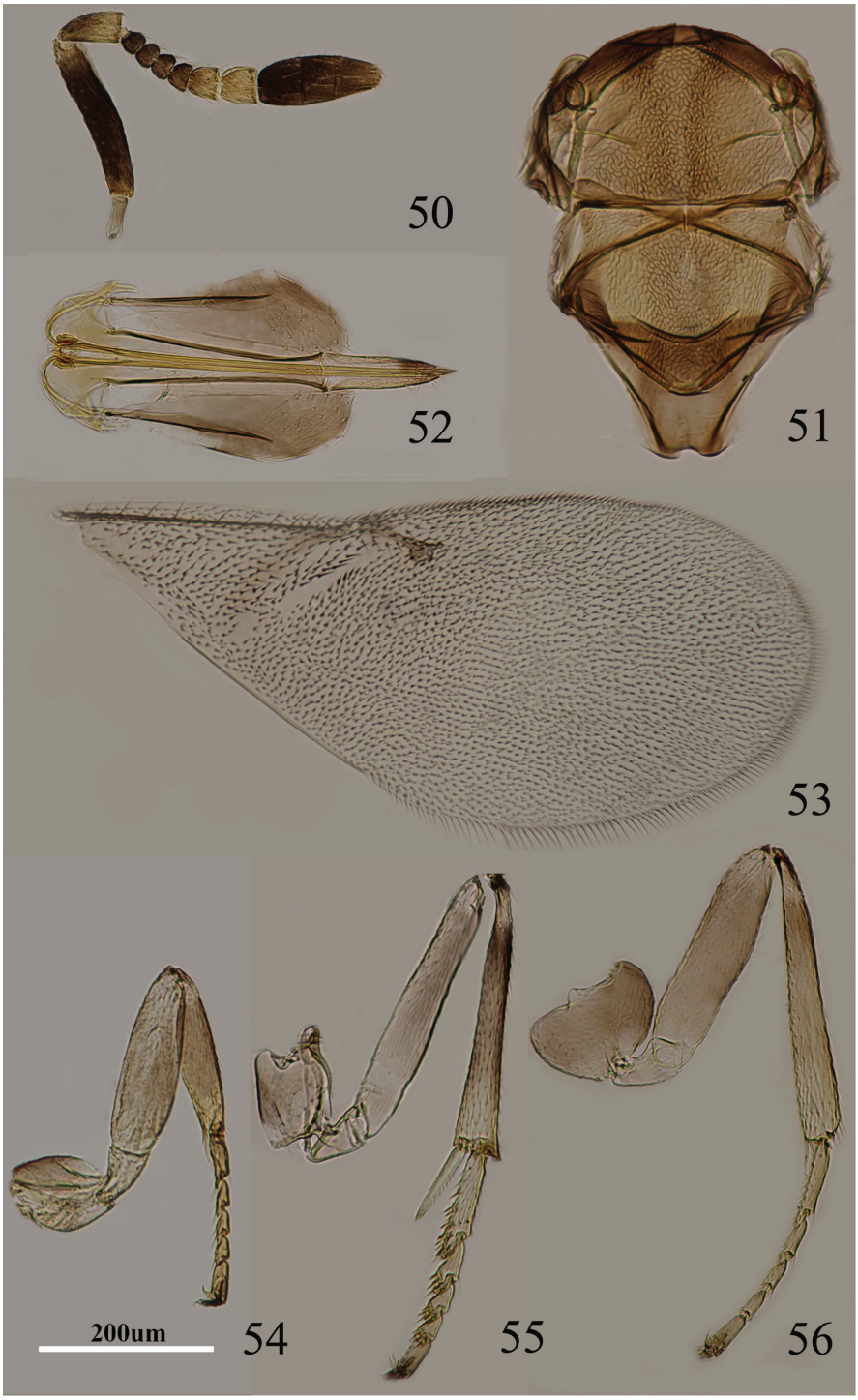
***Metaphycus cylindricus* sp. n.**
http://zoobank.org/A3785B09-DD24-42D0-AAAB-ACF69ADF87A9
http://species-id.net/wiki/Metaphycus_cylindricus
Figs 50–56

Holotype. China: ♀, Hunan, Chenzhou, 13.IV.2012. Coll. Y. Wang, J. Deng, H.B. Li (IZCAS).

Paratypes. 25 ♀♀, 3 ♂♂, same as holotype (IZCAS).

Female. Body length, including ovipositor, 1 mm. Frontovertex yellow-brown; occiput largely dark brown; gena and face brown; dark brown on mouth margin below torulus; antenna (Fig. 50) with radicle brown; scape black, only extreme apex slightly yellow; pedicel with proximal half dorsally and laterally brown, remainder yellow; funicle with F1–F4 dark brown, F5–F6 pale yellow; clava dark brown, apical segment yellow; neck of pronotum black, remainder yellow, posterior margin more or less translucent pale yellow, lateral spots present and distinct; mesoscutum, axillae and scutellum brown; dorsum of thorax clothed in scattered, short, translucent setae; tegula proximally pale brown, apex brown; side and venter of mesosoma pale brown; legs brown-yellow (Figs 54–56); mid tibia with faintly brown mark (Fig 55); fore wing hyaline (Fig. 53), venation pale yellow-brown; propodeum medially brown; gaster mainly brown; gonostylus pale orange.

Head with reticulate sculpture of mesh size the same as eye facet; ocelli forming an acute angle; frontovertex margins subparallel; antennal scrobes fairly deep, U-shaped and meeting dorsally; torulus separated from mouth margin by less than its own length; antenna with scape subcylindricusl, about 5× as long as broad; funicle with F1–F4 subequal, F5 larger, F6 largest and subquadrate; apex of clava more or less rounded; mandible relatively broad with three, acute, subequal apical teeth; palpal formula 3-3; notaular lines present and reaching more than 0.5× across mesoscutum (Fig. 51); fore wing venation and setation as in Fig. 53, gaster with ovipositor clearly exserted**;** ovipositor (Fig. 52) about 3.3× as long as gonostylus**.**



Figures 50–56. *Metaphycus cylindricus* sp. n. Female: **50** antenna **51** mesoscutum **52** ovpositor **53** fore wing **54** fore leg **55** mid leg **56** hind leg.

Relative measurements: HW 18, FV 5, POL 3, AOL 3, OOL 1, OCL 2, POD 1, AOD 1, EL 13, EW, 8, MS 4, SL 10, SW 2, FWL 45, FWW 19; HWL 31, HWW 8, OL 20, GL 6, MT 15.

Male. Length about 0.7mm, almost identical to female but for genitalia, solid clava and all funicle segments pale brown.

Host. *Eriococcus lagerstroemiae* Kuwana.

Material examined. China: 35 ♀♀, 1 ♂, Beijing, Mentougou, 14.VIII.2012, Coll. X. Zhang, Q. S. Zhou; 3 ♀♀, 1 ♂, Shandong, Laizhou, 14.X.2012, Coll. F. Yu.

Distribution. China (Beijing, Hunan, Shandong) (Fig. 85).

Etymology. The new species name is derived from the cylindricusl shape of the scape.

Diagnosis. Frontovertex yellow-brown; gena brown; scape black, extreme apex slightly yellow (Fig. 50); scape cylindricusl, about 5× as long as broad; ovipositor (Fig. 52) about 3.3× as long as gonostylus. *Metaphycus cylindricus* is similar to *M. piceus* in general coloration, antennal structure and ovipositor length. *Metaphycus cylindricus* can be separated from the latter as follows: ovipositor about 1.4× as long as mid tibia, about 3.3× as long as gonostylus (Fig. 52) (in *piceus*, ovipositor about 1.2× as long as mid tibia, 4–5× as long as gonostylus); mid tibia subbasally marked dark brown (in *piceus*, mid tibia yellowish); antenna with pedicel with basal half brown (in *piceus*, pedicel with basal 2/3 brown).

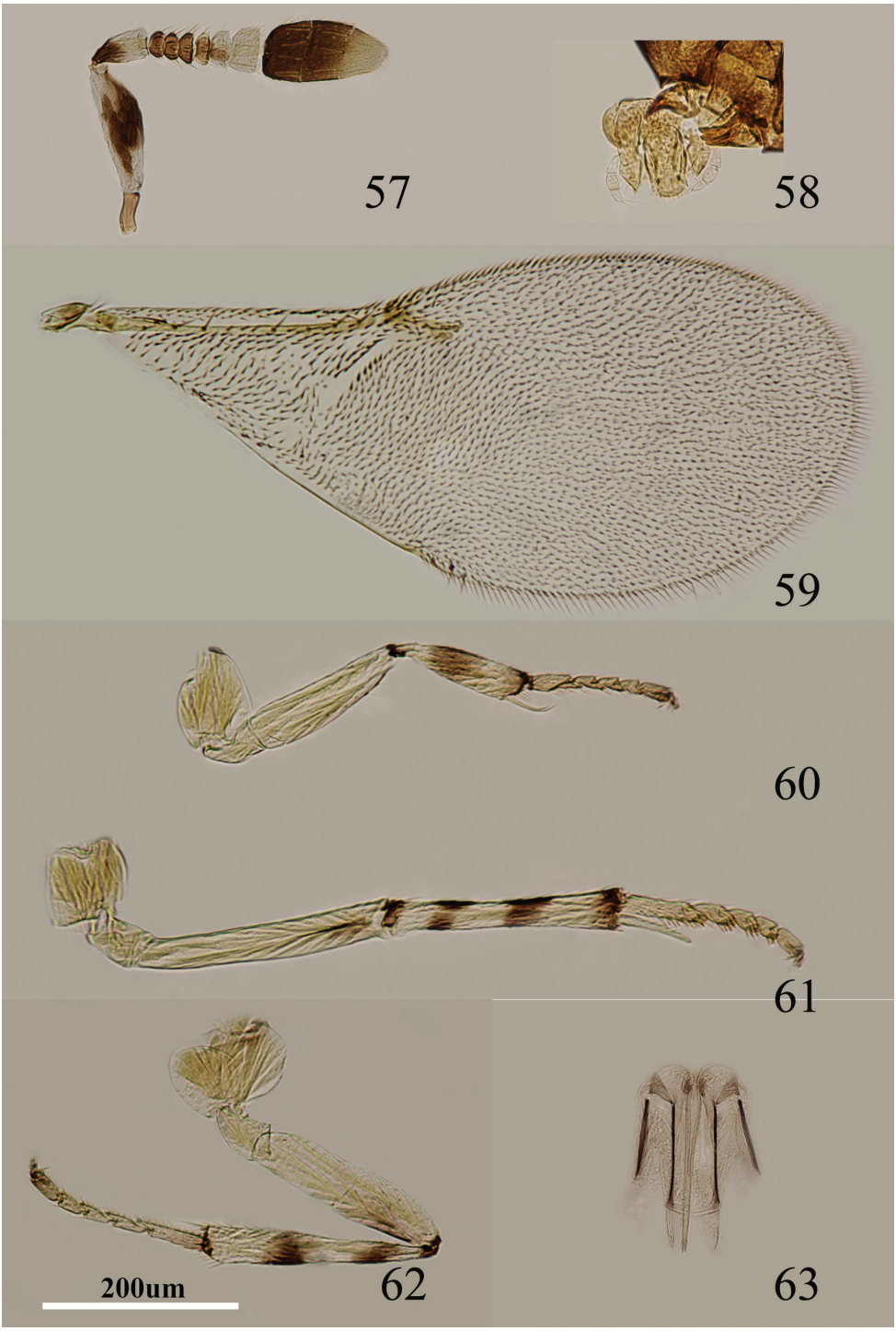
***Metaphycus yaanensis* sp. n.**

http://zoobank.org/E8507DAA-D044-4A33-84F4-60C596AF35EB
http://species-id.net/wiki/Metaphycus_yaanensis
Figs 57–63

Holotype. ♀, China, Sichuan, Ya'an (Tianquan, Erlang Mt.), 2006. V., Coll. W. Li (IZCAS).

Paratypes. 6 ♀♀, 3 ♂♂, the same as holotype (IZCAS).

Female. Body length, including ovipositor, 1.0–1.2 mm. Yellow in ocellar area, pale orange between occipital margin and posterior ocelli, otherwise pale yellow; lower half of gena with oblique brown stripe, stripe close to scrobe interrupted by a yellow line; upper half yellow; medially yellow below torulus, mouth margin dark brown; rest of head, except occiput, white; antenna (Fig. 57) with radicle dark brown; both faces of scape, dorsal margin, ventral margin with yellow, both sides with broad black strip; pedicel pale yellow (whitish) in apical half, dark brown in basal half; F1–F3 dark brown, F4 very pale brown, F5 venter sometimes with very pale brown strip, F6 white, clava dark brown, becoming slightly paler towards apex, apex very pale brown; occiput brown; neck of pronotum black, posterior margin white, lateral spots relatively large and distinct; dorsum of thorax yellow-brown; sides and posterior margin of mesoscutum and axillae conspicuously bordered dark brown; setae translucent, silvery in most lights; tegula white; metanotum dark brown; mesopleuron very pale yellow, margin of mesopleuron with conspicuously bordered dark



Figures 57–63. *Metaphycus yaanensis* sp. n. Female: **57** antenna **58** palpi **59** fore wing **60** fore leg **61** mid leg **62** hind leg **63** ovipositor.

brown; prosternum and mesosternum pale brown; legs (Figs 60–62) mainly pale yellow to pale orange; tibiae proximally brown; fore femur yellow, fore tibia with single, broad, interrupted, median dark brown ring; mid tibia and hind tibia with two interrupted conspicuous dark brown rings at 0.2× and 0.7×, extreme apex marked with dark brown; tarsi dusky pale yellow; fore wing (Fig. 59) hyaline, linea calva interrupted; venation pale yellow-brown; hind wing hyaline; propodeum medially brown, blackish, laterally brown-yellow; gaster mainly pale brown, but slightly darker brown dorsally from cercal plates to near apex, gonostylus yellowish, 2nd valvifer and outer plate of ovipositor with brown out margin.

Head about 3× as wide as frontovertex, head with polygonally reticulate sculpture, mesh size slightly less than size of one eye facet; frontovertex about one-third head width; ocelli forming an acute angle of about 30°; eye not quite reaching occipital margin, separated by one or two diameters of a facet; frontovertex parallel; scrobes shallow and U-shaped; antenna with scape 3.2–3.5× as long as broad; funicle with F1–F4 smallest, closely adpressed, F5 a little larger than F4 but transverse, F6 largest; linear sensilla only on F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3 (Fig. 58), notaular lines reaching about 0.4× across mesoscutum; fore wing venation and setation as in Fig. 59; cercal plate about in the 1/2 of gaster; ovipositor (Fig. 63) slightly exserted, about 5× as long as gonostylus.

Relative measurements: HW 15, FV 5, FVL 9, POL 2, AOL 3, OOL 1, OCL 1.5, POD 1, AOD 1, EL 10, EW 7, MS 4.5, SL 7, SW 2, FWL 40, FWW 18, HWL 25, HWW 5, OL 10, GL 4, MT 12.

Male. Length about 1.2mm. Virtually identical to female except for genitalia and solid clava. Frontovertex pale yellow but ocellar area brown.

Host. Unknown.

Distribution. China (Sichuan) (Fig. 85).

Etymology. The new species name is derived from the origin of the holotype.

Diagnosis. Scape yellow, both surfaces with an broad black mark in the middle (Fig. 57); lower half of gena with an oblique brown stripe which is interrupted by a yellow line outside of scrobe; mid and hind tibiae with two interrupted dark brown rings (Figs 61–62); scape 3.2–3.5× as long as broad (Fig. 57); ovipositor slightly exserted, about 5× as long as gonostylus (Fig. 63). Using the key of Guerrieri and Noyes (2000), this species runs to couplet 27 and is similar to *M. lounsburyi* (Howard). It can be separated from *M. lounsburyi* as follows: scape (Fig. 57) 3.2–3.5× as long as broad (in *lounsburyi*, scape about 2.9× as long as broad); ovipositor about 0.8× as long as mid tibia (in *lounsburyi*, ovipositor as long as mid tibia); clava a little longer than funicle (in *lounsburyi*, clava distinctly shorter than funicle). *Metaphycus yaanensis* sp. n. is also similar to *M. transversus* sp. n. in appearance, but it can be separated from *transversus* by characters in the key.

***Metaphycus deltoideus* sp. n.**
http://zoobank.org/8D957C3B-C442-49CF-A149-F0534B676847
http://species-id.net/wiki/Metaphycus_deltoideus
Figs 64–69

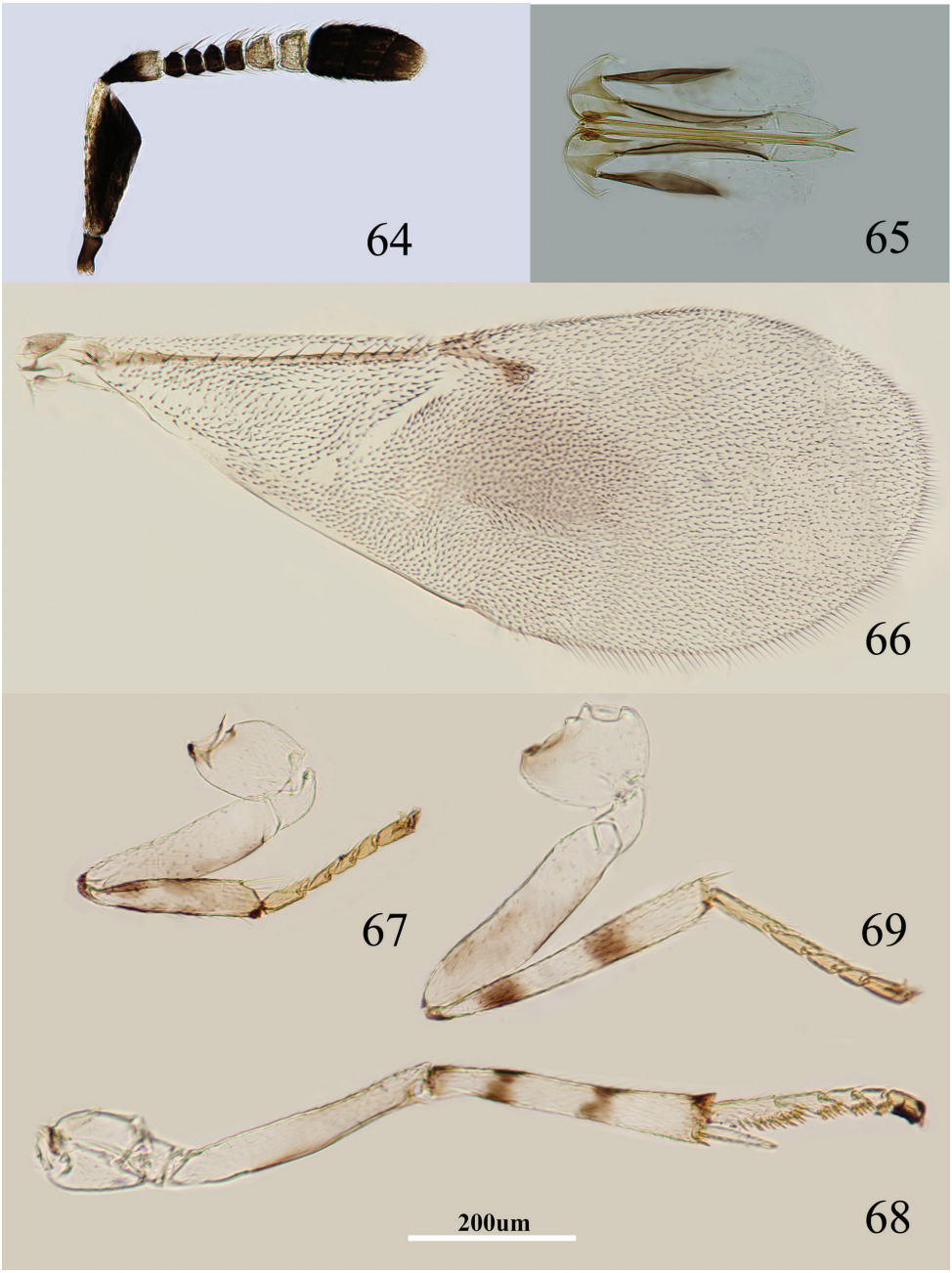
Holotype. China: ♀, Beijing Mentougou (Donglingshan), 2008.VIII.28, Coll. F. Yuan (IZCAS).

Paratypes. 1 ♀, Beijing (Mentougou): 2011.VI.20; 1 ♀, Beijing Mentougou: 2011. VI. 10–VIII. 6. (IZCAS).

Female. Body length, including ovipositor, about 0.9 mm. Frontovertex brownish yellow, but brown between occipital margin and posterior ocelli; gena mainly yellow, with a brown mark extending to oral rim; mouth margin medially yellow below torulus, oral rim brown; antenna (Fig. 64) with radicle dark brown; scape with both faces blackish, and only dorsal margin, venter of base and apex white; pedicel dark brown in proximal half otherwise white; F1–F4 dark brown, F5–F6 white-yellow; clava dark brown, becoming slightly paler towards apex, apex brown; occiput with a brown area above foramen, otherwise yellow; neck of pronotum dark brown, posterior margin translucent yellow, otherwise white, lateral spots relatively large and distinct; dorsum of thorax brown-yellow; sides and posterior margin of mesoscutum and axillae conspicuously bordered dark brown; setae translucent yellow, silvery in most lights; tegula white with apex pale brown; metanotum dark brown; mesopleuron yellowish white; prosternum and mesosternum yellowish white, but with narrow pale brown margin; legs (Figs 67–69) yellowish white, but femur very slightly brown on inner side, tibiae proximally dark brown; each tibia with a pair of dark brown rings at about 0.2× and 0.5× (fore tibia with one faint ring at about 0.5×); fore wing (Fig. 66) hyaline, but generally infuscate below marginal vein; linea calva interrupted by two lines of setae; venation yellow-brown; hind wing hyaline; propodeum medially dark brown, laterally black; gaster dorsally dark brown, side and venter white; gonostylus white.

Head about 4× as wide as frontovertex, head with moderately deep, regular, polygonally reticulate sculpture on frontovertex of mesh size about two-thirds eye facet; irregular sculpture on frontovertex of rather silky appearance; ocelli forming an acute angle of about 30°; eye not quite reaching occipital margin, separated by 1.5× diameter of a facet; frontovertex subparallel; scrobes deep and U-shaped; antenna with scape about 2.7× as long as broad; funicle with F1–F4 smallest, F4–F6 gradually becoming larger distally; linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3, notaular lines reaching about 0.8× across mesoscutum; fore wing venation and setation as in Fig. 66; cercal plate about in the 1/2 of gaster; ovipositor (Fig. 65) clearly exserted, about 4.5× as long as gonostylus.

Relative measurements: HW 13, FV 3, FVL 10, POL 2, AOL 2.5, OOL 1, OCL 2, POD 1, AOD 1, EL 11, EW 8, MS 3, SL 8, SW 3, FWL 47, FWW 15, OL 14, GL 3, MT 15.



Figures 64–69. *Metaphycus deltoideus* sp. n. Female: **64** antenna **65** ovipositor **66** fore wing **67** fore leg **68** mid leg **69** hind leg.

Male. Unknown.
Host. Unknown.
Distribution. China (Beijing) (Fig. 84).

Etymology. The new species name is derived from the shape of the scape.

Diagnosis. Scape with both faces blackish, and only dorsal margin, venter of base and apex white; fore wing hyaline but generally infuscate below marginal vein (Fig. 66); scape triangular in shape, about 2.7× as long as broad (Fig. 64); ovipositor (Fig. 65) about 4.5× as long as gonostylus. Using the key of Guerrieri and Noyes (2000), *M. deltoideus* runs to couplet 29 and can be separated from *insidiosus* as follow: scape triangular, and strongly expanded subapically, scape with venter of base yellow (Fig. 64) (in *insidiosus*, scape strongly expanded in the median part, scape with venter of base blackish); head mainly yellow-brown (in *insidiosus*, head mainly yellow); fore wing (Fig. 66) with a distinctly infuscate spot below marginal vein (in *insidiosus*, fore wing hyaline or at most slightly infuscate); occiput above foramen brown, rest yellow (in *insidiosus*, occiput almost entirely blackish).

***Metaphycus corniae* sp. n.**

http://zoobank.org/481A86E7-1FFE-439F-886E-E3658CECCCBC
http://species-id.net/wiki/Metaphycus_corniae
Figs 70–77

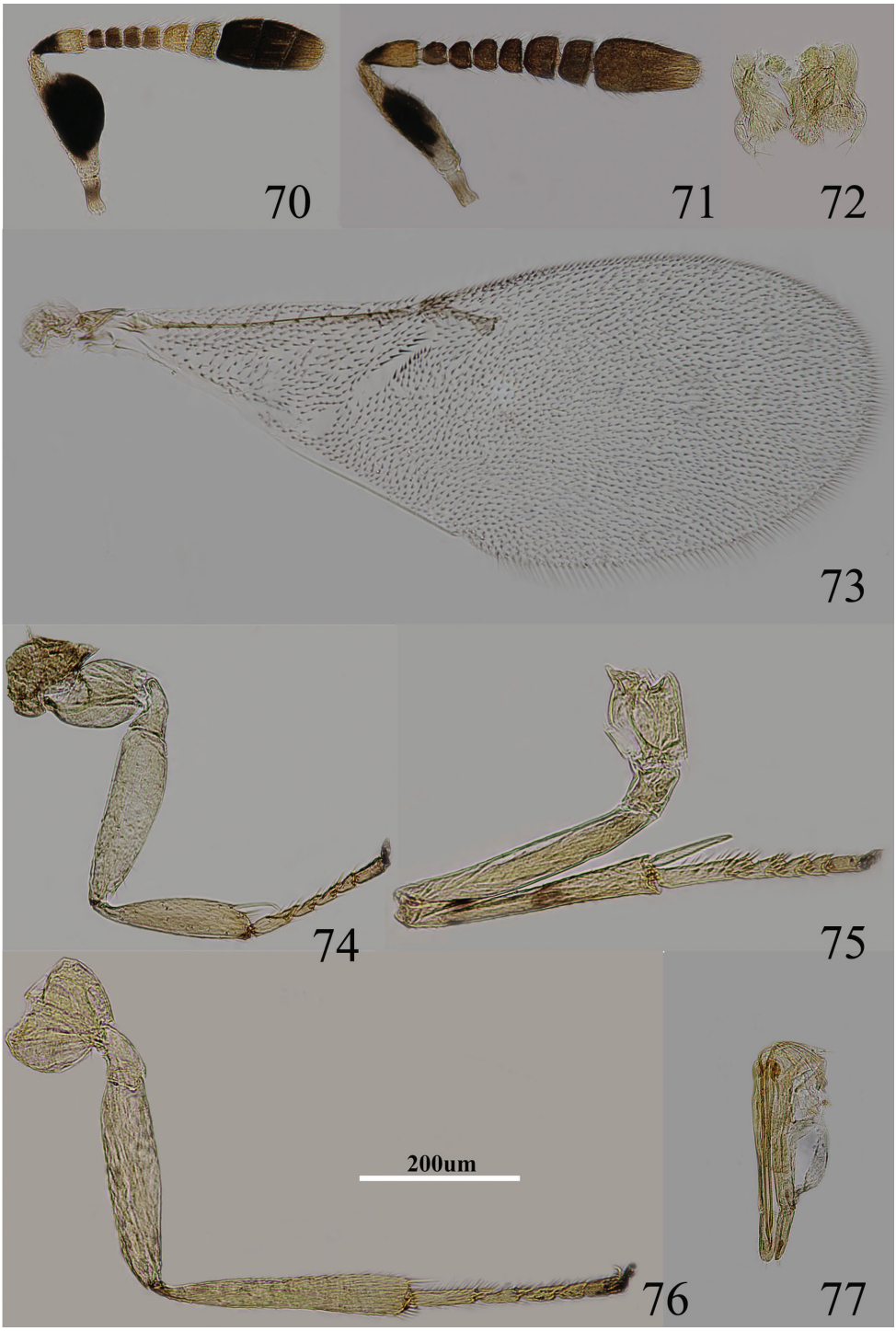
Holotype. China: ♀, Beijing, Haidian, 10.V.2013, Coll. S. A. Wu & W. C. Li (IZCAS).

Paratypes. 8 ♀♀, 6 ♂♂, same as holotype; 30 ♀♀, Beijing, Chaoyang. 14.V.2013, Coll. X. Zhang (IZCAS).

Female. Body length 0.8–1.0 mm. Frontovertex brown, but between occipital margin to posterior ocelli orange, gena yellowish, unmarked; occiput dark brown; antenna (Fig. 70) with scape entirely black, only extreme base and apex white, dorsal margin white; basal half of pedicel black, apex white; F1–F4 blackish, F5–F6 yellowish; clava blackish, but extreme apex brown; pronotum white with a brown spot on each side, mesoscutum, axillae and scutellum pale orange, tegulae white with apex brown, metanotum and propodeum blackish; legs (Figs 74–76) yellowish, proximal tibiae and tarsi brownish, fore tibia and hind tibia with one dark brown ring, mid tibia with two dark brown rings; fore wing hyaline, venation yellow-brown; gaster dorsally black, ventrally white.

Head 3–4× as wide as frontovertex, ocelli forming an acute angle of slightly less than 60°; posterior ocellus closer to occipital margin than eye; antenna with scape expanded, 2.0×–2.3× as long as broad; F1–F4 transverse and F5–F6 gradually increasing in size, F6 largest, linear sensilla present on F5–F6; clava 3-segmented, and apical very slightly oblique; mandible broad with three, subequal apical teeth; palpal formula 3-3 (Fig. 72); notaular lines incomplete and reaching about 0.6× across mesoscutum; fore wing venation and setation as in Fig. 73; cercal plate about in the 1/3 of gaster; ovipositor (Fig. 77) hardly exserted, 4–5× as long as gonostylus.

Relative measurements: HW 16, FV 5, FVL 9, POL 2.5, AOL 3.5, OOL 1, OCL 1.5, POD 1, AOD 1, EL 9, EW 7.5, MS 5.5, SL 7.5, SW 3.5, FWL 47.5, FWW 17.5, HWL 30, HWW 6, OL 13, GL 2.5, MT 15.



Figures 70–77. *Metaphycus corniae* sp. n. Female: **70** antenna **72** palpi **73** fore wing **74** fore leg **75** mid leg **76** hind leg **77** ovipositor. male: **71** antenna.

Male. Length 0.8–1.0 mm. Generally very similar to female but for relatively narrower scape, coloration of antenna, genitalia and solid clava. Antenna (Fig. 71) with scape 2.8–3.0× as long as broad, flagellum generally pale brown.

Host. *Parthenolecanium corni* (Bouché) on *Fraxinus chinensis* Roxburgh.

Distribution. China (Beijing) (Fig. 84).

Etymology. The new species named for its host "*Parthenolecanium corni* (Bouché)".

Diagnosis. Scape entirely black, only extreme base and apex white, dorsal margin white (Fig. 70); fore and hind tibiae with one dark brown ring, but mid tibia with two dark brown rings (Figs 74–76); scape expanded, 2.2×–2.3× as long as broad; ovipositor hardly exserted, 4–5× as long as gonostylus (Fig. 77). This species is very similar to *M. stanleyi*. In *M. corniae* sp. n. the ovipositor is about 0.9× as long as mid tibia, and 4–5× as long as gonostylus (Fig. 77). In *M. stanleyi* ovipositor is about 0.7× as long as mid tibia, about 3× as long as gonostylus.

Metaphycus insidiosus (Mercet)

http://species-id.net/wiki/Metaphycus_insidiosus

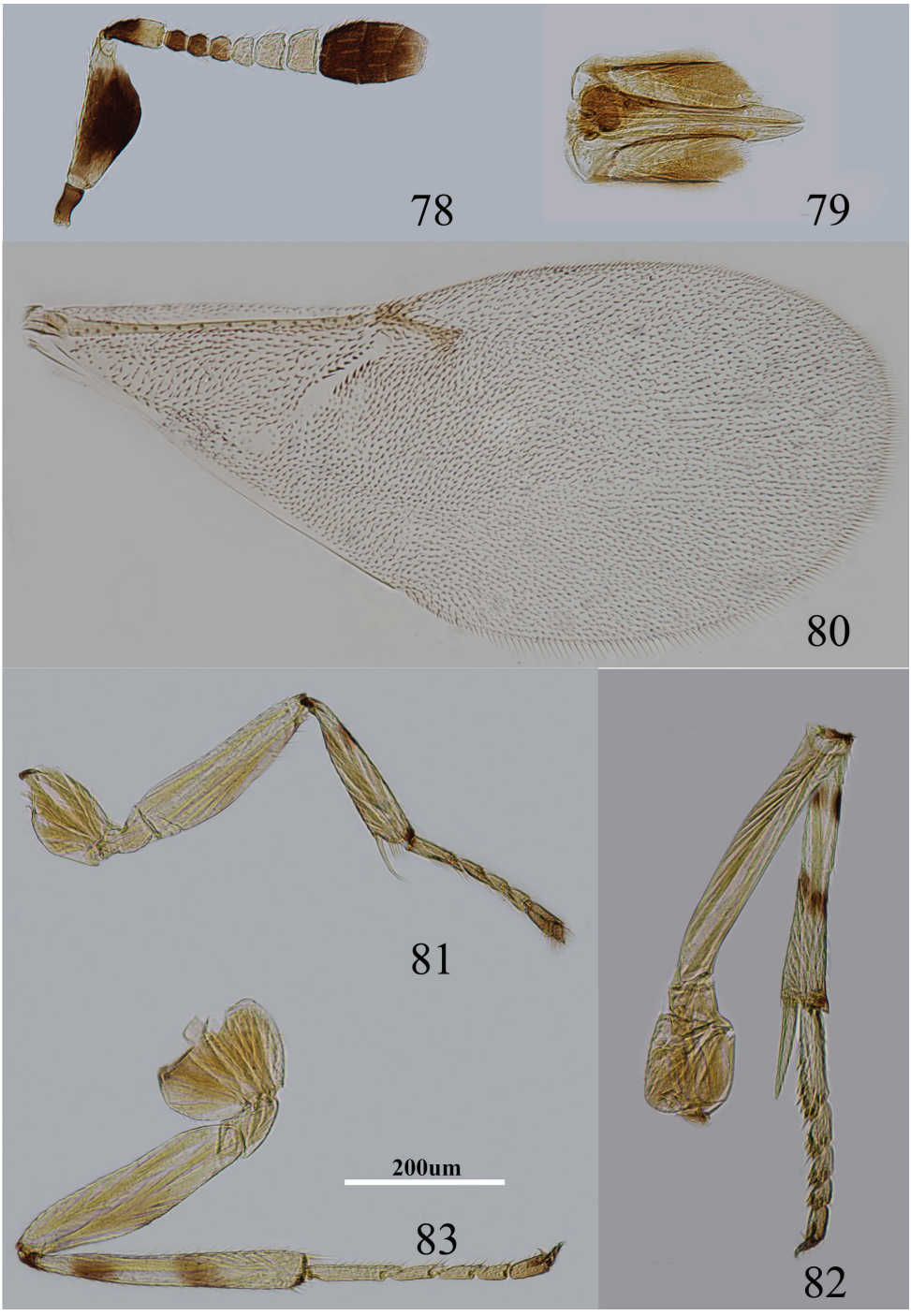
Figs 78–83

Aphycus (*Metaphycus*) *insidiosus* Mercet (1921): 218–220. Lectotype ♀ (IEEM, not examined), Spain.

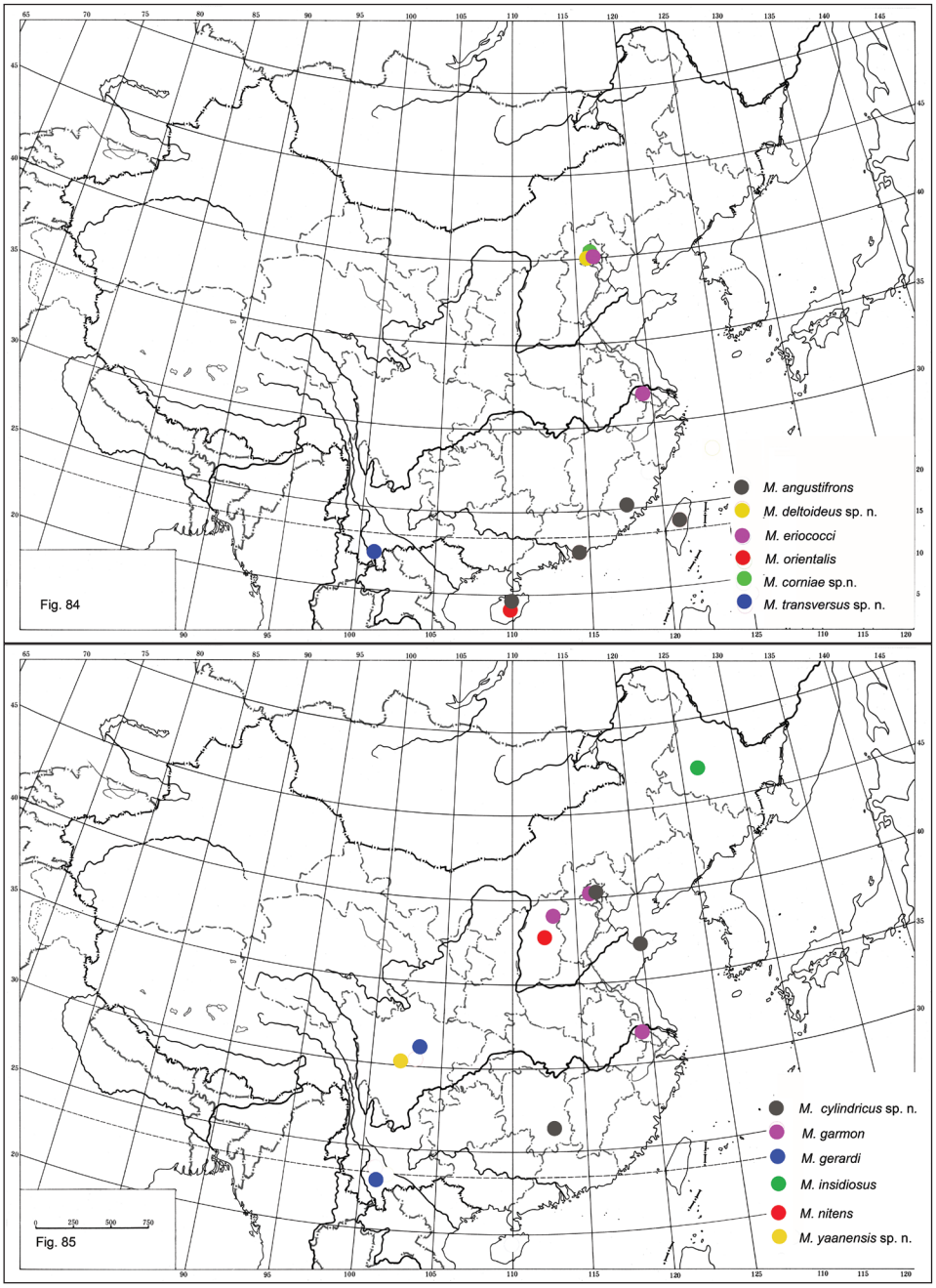
Metaphycus insidiosus; Mercet (1925): 28; Trjapitzin (1975): 9; Noyes (1981): 168; Viggiani and Guerrieri (1988): 117; Li and Li (2008): 134.

Metaphycus taxi Alam (1957): 426. Synonymy by Noyes (1981): 168.

Female. Body length, including ovipositor, about 1.0 mm. Frontovertex yellow; gena with a brown mark extending to oral rim; mouth margin medially pale yellow below torulus; rest of head, except occiput, white; antenna (Fig. 78) with radicle brown; scape with both faces dark brown to blackish, only base, apex white and dorsal margin with a narrow stripe; pedicel dark brown in proximal half, otherwise white; F1–F2 dark brown, F3 slightly pale brown, F4–F6 yellowish; clava dark brown, becoming slightly paler towards apex, extreme apex very pale brown; occiput with a brown area above foramen, rest yellow; neck of pronotum dark, posterior margin white, lateral spots relatively large and distinct; dorsum of thorax pale orange; sides and posterior margin of mesoscutum and axillae conspicuously bordered brown; setae translucent yellow, silvery in most lights; tegula white with apex pale brown; metanotum dark brown; mesopleuron yellow; prosternum yellow and mesosternum pale brown; legs (Figs 81–83) mainly pale yellow, tibiae proximally dark brown; mid tibia and hind tibia with a pair of dark brown rings at about 0.2× and 0.5×, fore tibia with one dark brown ring; fore wing (Fig. 80) hyaline, with linea calva interrupted by several line setae; venation yellow-brown; hind wing hyaline; propodeum medially dark-brown, sides pale yellow; dorsum of gaster largely blackish, sides and ventral parts whitish and gonostylus yellow.



Figures 78–83. *Metaphycus insidiosus* (Mercet) Female: **78** antenna **79** ovipositor **80** fore wing **81** fore leg **82** mid leg **83** hind leg.



Figures 84–85. Distribution of *Metaphycus* spp. in China.

Head about 5× as wide as frontovertex, head with polygonally reticulate sculpture and mesh size as long as one eye facet; ocelli forming an acute angle of about 30°; eye not quite reaching occipital margin, separated by much less than diameter of a facet;

frontovertex parallel; scrobes deep and U-shaped; antenna with scape about 2.3× as long as broad; funicle with F1–F3 smallest, F4–F6 gradually increasing in size, F6 largest and slightly wider than long; linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 3-3, notaular lines reaching about 0.7× across mesoscutum; fore wing venation and setation as in Fig. 80; cercal plate about in the 0.4× of gaster; ovipositor (Fig. 79) slightly exserted, about 4× as long as gonostylus.

Relative measurements: HW 15, FV 3, FVL 9, POL 2, AOL 3, OOL 0.5, OCL 2, POD 1, AOD 1, EL 10, EW 6, MS 5, SL 7, SW 3, FWL 54, FWW 22, OL 12, GL 3, MT 13.

Male. Very similar to female except for antenna, genitalia and generally darker coloration with mesoscutum brownish (Guerrieri and Noyes 2000).

Host. *Eulecanium coryli* (Linnaeus), *E. taxi* Habib, *E. tiliae* (Linnaeus), *Parthenolecanium corni* (Bouché), *P. persicae* (Fabricius), *P. pomeranicum* (Kawecki), *P. rufulum* (Cockerell), *Pulvinaria* sp., *P. vitis* (Linnaeus) and *Sphaerolecanium prunastri* (Fonscolombe) (Noyes 2002).

Distribution. China (Heilongjiang) (Fig. 85); Andorra, Armenia, Austria, Azerbaijan, Bulgaria, Canary Islands, Caucasus, Czechia, Denmark, Finland, France, Georgia, mainland Greece, Hungary, Italy, Kazakhstan, Romania, Russia, Slovakia, Spain, Switzerland, United Kingdom (Noyes 2002).

Material examined. China: 3 ♀♀, Heilongjiang, Shangzhi, 15.VI.1993, Coll. C.D. Li.

Diagnosis. Scape with both faces dark brown to blackish, only base and apex white and dorsal margin with a narrow stripe; gena with a brown mark extending to oral rim; scape about 2.3× as long as broad (Fig. 78); mid and hind tibiae with a pair of dark brown rings at about 0.2× and 0.5×, fore tibia with one dark brown ring (Figs 81–83); ovipositor slightly exserted, about 4× as long as gonostylus (Fig. 79). According to Guerrieri and Noyes (2000), in *insidious* the fore wing is slightly infuscate, the head is about 4× as wide as frontovertex, and the occiput is almost entirely blackish, whereas in Chinese specimens, the fore wing is hyaline, the head is about 5× as wide as frontovertex, and the occiput has a brown area above the foramen.

Acknowledgements

This project was supported by the National Natural Science Foundation of China (NSFC grant no. 31071950, 31272350), by the Department of Science and Technology of China (2012FY111100) and partially by the Chinese Academy of Sciences (KSCX2-YW-NF-02). Special thanks are due to Dr. John S. Noyes (BMNH) for his help in preparing this paper. We also thank Dr. Douglas Chesters (IZCAS) for reading and correcting the English of this paper.

References

Alam SM (1957) Taxonomy of some encyrtid parasites (Hymenoptera, Chalcidoidea) of British scale insects. Transactions of the Royal Entomological Society of London 109: 421–466. doi: 10.1111/j.1365-2311.1957.tb00333.x

Annecke, DP, Mynhardt MJ (1972) The species of the *insidiosus*-group of *Metaphycus* Mercet in South Africa with notes on some extra-limital species (Hymenoptera Encyrtidae). Revue de Zoologie et de Botanique Africaines 85: 227–274.

Compere H (1924) A preliminary report on the parasitic enemies of the citricola scale (*Coccus pseudomagnoliarum* (Kuwana)) with descriptions of two new chalcidoid parasites. Bulletin of the Southern California Academy of Science 23(4):113–123.

Compere H (1957) Descriptions of species of *Metaphycus* recently introduced into California and some corrections. Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri', Portici 15: 221–230.

Compere H, Annecke DP (1960) A reappraisal of *Aphycus* Mayr, *Metaphycus* Mercet and related genera (Encyrtidae). Journal of the Entomological Society of Southern Africa 23: 375–389.

Dean HA, Bailey JC (1960) Introduction of beneficial insects for the control of *Citrus* scale insects and mites. Journal of the Rio Grande Valley Horticultural Society 14: 40–46.

Flanders SE, Bartlett BR (1964) Observations on two species of *Metaphycus* (Encyrtidae, Hymenoptera) parasitic on citricola scale. Mushi 38(8): 39–42.

Guerrieri E, Noyes JS (2000) Revision of European species of genus *Metaphycus* Mercet (Hymenoptera: Chalcidoidea: Encyrtidae), parasitoids of scale insects. Systematic Entomology 25: 147–222. doi: 10.1046/j.1365-3113.2000.00099.x

Howard LO (1881) Report of the parasites of Coccidae in the collections of the U.S. Department of Agriculture Part III. Report. United States Department of Agriculture. Washington. (Entomology) 1880: 350–372.

Kapranas A, Morse JG, Pacheco P, Forster LD, Luck RF (2007) Survey of brown soft scale *Coccus hesperidum* L. parasitoids in southern California *citrus*. Biological Control 42: 288–299. doi: 10.1016/j.biocontrol.2007.05.012

Kurdjumov NV (1912) Six new species of chalcid flies parasitic upon *Ericoccus greeni* Newstead. Russkoe Entomologicheskoe Obozrenie 12(2): 329–335.

Li CD, Li JW (2008) Description of a new species and two new record species of *Metaphycus* Mercet (Hymenoptera: Encyrtidae) from China. Entomotaxonomia 30 (2): 131–139.

Mercet RG (1921) Fauna Iberica. Himenópteros Fam. Encírtidos. Museo Nacional de Ciencias Naturales, Madrid, 727pp.

Mercet RG (1925) El género *Aphycus* y sus afines. Eos, Revista Española de Entomología 1: 7–31.

Noyes JS (1981) On the types of the species of Encyrtidae described by R. Garcia Mercet (Hymenoptera: Chalcidoidea). Eos, Revista Española de Entomología 55/56: 165–189.

Noyes JS (2002) Interactive catalogue of World Chalcidoidea, second edition. CDrom, Taxapad, Vancouver and The Natural History Museum, London.

Noyes JS (2004) *Metaphycus* and related genera, parasitoids of scale insects (Coccoidea) and whiteflies (Aleyrodidae). Encyrtidae of Costa Rica (Hymenoptera: Chalcidoidea). Memoirs of the American Entomological Institute 73(2): 1–460.

Noyes JS, Hayat M (1994) Oriental mealybug parasitoids of the Anagyrini (Hymenoptera: Encyrtidae). CAB International, Oxon, UK, 554 pp.

Sugonjaev ES (1960) On the species of the genera allied to *Aphycus* Mayr (Hymenoptera, Chalcidoidea) from the European part of the USSR. Entomologicheskoe Obozrenie 39(2): 364–383.

Sugonjaev ES (1996) Chalcid wasps (Hymenoptera, Chalcidoidea) parasites of soft scales (Coccinea, Coccidae) in Vietnam. IV. New species of the genus *Microterys* Thomson and *Metaphycus* Mercet (Encyrtidae), partly inhabiting ants' nests, with morphological notes. Entomologicheskoe Obozrenie 75(2): 417–425.

Tachikawa T (1963) Revisional studies of the Encyrtidae of Japan (Hymenoptera, Chalcidoidea). Memoirs of Ehime University 6(9): 1–264.

Tachikawa T (1968) A new name for *Metaphycus eriococci* Alam (Hymenoptera, Chalcidoidea - Encyrtidae). Transactions of the Shikoku Entomological Society 9(4): 111.

Timberlake PH (1916) Revision of the parasitic hymenopterous insects of the genus *Aphycus* Mayr, with notice of some related genera. Proceedings of the United States National Museum 50: 561–640. doi: 10.5479/si.00963801.50-2136.561

Trjapitzin VA (1975) Contribution to the knowledge of parasitic Hymenoptera of the genus *Metaphycus* Mercet, 1917 (Hymenoptera, Chalcidoidea, Encyrtidae) of the Czechoslovakian fauna. Studia Entomologica Forestalia 2(1): 5–17.

Trjapitzin VA (1989) Parasitic Hymenoptera of the fam. Encyrtidae of Palaearctics. Opredeliteli po Faune SSSR. Zoologicheskii Institut Akademii Nauk SSR, Leningrad 158: 1–489.

Viggiani G, Guerrieri E (1988) Italian species of the genus *Metaphycus* Mercet (Hymenoptera: Encyrtidae). Bollettino del Laboratorio di Entomologia Agraria ‚Filippo Silvestri', Portici 45: 113–140.

Wang Y, Li CD, Zhang YZ (2013) A taxonomic study of Chinese species of the *alberti* group of *Metaphycus* (Hymenoptera, Encyrtidae). Zookeys 285: 53–88. doi: 10.3897/zookeys.285.4142