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A new genus (Copepoda, Harpacticoida, Laophontidae) from Jeju Island of Korea

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Abstract

A survey on the harpacticoid copepods from an intertidal zone in Hyeopjae sandy beach, Jeju Island, Korea, resulted in the discovery of an unusual laophontid, *Jejulaophonte hyeopjaeensis* **sp. n.**, which cannot be placed in any extant genus within the family. To accommodate the species, a new genus of the family Laophontidae T. Scott, 1905 is proposed and fully described here. The new species is closely related to the lineage of the five primitive genera, *Carraroenia* McCormack, 2006, *Coullia* Hamond, 1973, *Hemilaophonte* Jakubisiak 1933, *Psammoplatypus* Lee & Huys, 1999, and *Robustunguis* Fiers, 1992 (the CCHPR-lineage) by the reduced P2 endopod, ovate shape of the female P5 exopod and sexual dimorphism in the P3 endopod. However, it displays discrepancies from the species of the CCHPR-lineage in the presence of an inner seta on P3 and P4 exp-2, four setae on P4 enp-2, and an inner seta on P3 and P4 enp-2 in the female. Furthermore, no other species within the family Laophontidae has three setae on P2 exp-3 and a seta on P2 enp-2 at the same time. The new species has sexual dimorphism in the antennule, genital segmentation and the legs from P2 to P5. The terminal seta on the second endopodal segment of P2 in the male is longer than that in the female. The endopod of P3 is 3-segmented and displays a short inner apophysis on the second segment in the male. The outer setae on the exopod of P3 and P4 are distinctly thicker and stronger in the male than in the female. Mitochondrial cytochrome oxidase subunit I (mtCOI) sequencing of the new species has been realized in order to be used in future phylogenetic analysis.

Keywords

Jejulaophonte, Taxonomy, DNA barcode, intertidal, Marine

Introduction

Laophontid harpacticoids inhabit various environments including deep sea (Willen 1996; Lee and Huys 1999; Huys and Lee 2000). However the family Laophontidae is found mainly clinging to epiphytal habitats (Boxshall and Halsey 2004). Furthermore, several genera have been found in association with various organisms, for example, *Hemilaophonte janinae* Jakubisiak, 1933, collected from washings of the spider crab, *Maia squinado* (Herbst, 1788). They have highly reduced and modified appendages as specific adaptations to their host.

The family Laophontidae T. Scott, 1905 is a large group of harpacticoid copepods, comprising over 262 species in 63 genera and two families: Esolinae and Laophontinae (Boxshall and Halsey 2004). The type species, *Laophonte cornuta*, was published by Philippi (1840) and T. Scott (1905) proposed the family name, however he did not define the characters of this taxon. Lang (1944) divided the family in three subfamilies: Laophontinae, Normanellinae, and Donsiellinae. Later, Huys and Willems (1989) upgraded the Normanellinae to family rank and Hicks (1988) revised the Donsiellinae, creating four new genera and removing it to the family Thalestridae. Although many genera and species have been moved to other families, because of the numerous new genera and species described since Lang's (1965) key there is no easy way to identify the genera of Laophontidae. Huys and Lee (2000) provided a key to genera of subfamily Esolinae which included eight genera, and Huys (2009) suggested a key to species of five genera having reduced P2 endopod.

In this study, a survey on the harpacticoid copepods from an intertidal zone in Jeju Island, Korea resulted in the discovery of an unusual laophontid, which could not be allocated to any extant genera in the family Laophontidae. Sandy sediments around Jeju Island originate from volcanic rock called basalt. The sediment type of studied area, Hyeopjae beach, is silvery sand that is mixed with sand and various shell dusts. In addition, there are a lot of marine algae that are washed ashore by waves. The family Laophontidae includes various organisms, which are adapted to a habitat style, namely their cylindrical body shape and a reduced segmentation of their swimming legs (Gheerardyn et al. 2007). These interstitial species including associates with other invertebrates or alga also present a reduced segmentation of the thoracic appendages. To accommodate the new species, a new genus of Laophontidae is proposed and fully described here. In addition the mitochondrial cytochrome oxidase subunit I (mtCOI) sequences are obtained for using as molecular barcode of the new species.

Materials and methods

Sediments were collected by a small shovel and acryl cores (diameter 5.4 cm) in a submerged area of Hyeopjae sandy beach, Jeju island, Korea (about 1 m depth). The sediment samples were fixed in 5% neutralized formalin for taxonomic study. Copepods are extracted from the sediment samples by using the Ludox method (Burgess 2001)

and fixed in 70% ethanol. Specimens were dissected in lactic acid, and the dissected parts were mounted on slides in lactophenol mounting medium. Preparations were sealed with transparent nail varnish. All drawings have been prepared using a camera lucida on an Olympus BX51 differential interference contrast microscope.

For scanning electron microscopy copepods were prefixed in 70% ethanol, dehydrated through graded ethanol for Hitachi S-2380N in Hanyang University or acetone series for Philips XL-30 in the Natural History Museum London, critical point dried, mounted on stubs using double-sided tape, coated with gold, and then examined with a scanning electron microscope (Hitachi S-2380N, Philips XL-30).

The descriptive terminology is adopted from Huys et al. (1996). Abbreviations used in the text are: A1, antennule; A2, antenna; ae, aesthetasc; exp, exopod; enp, endopod; P1–P6, first to sixth thoracopod; exp(enp)-1(2, 3) to denote the proximal (middle, distal) segment of a three-segmented ramus. Specimens are deposited in the National Marine Biodiversity Institute of Korea. Scale bars in figures are indicated in μm.

For DNA sequencing, copepods were collected using hand net (mesh size 63 μm). Salt was washed from these samples on the sieve (mesh size 38 μm) and then, the samples were fixed in pure (100%) ethanol. Mitochondrial cytochrome oxidase subunit I (mt-COI) was amplified by polymerase chain reaction (PCR) using PCR premix (BiONEER Co). The amplification primers used were LCO-1490 (5′-GGT CAA CAA ATC ATA AAG ATA TTG G-3′) and HCO-2198 (5′-TAA ACT TCA GGG TGA CCA AAA AAT CA-3′) (Folmer et al. 1994) and premix (BiONEER). The amplification protocol was: 94 °C (1 min), 46 °C (2 min), 72 °C (3 min) carried out for 40 cycles. PCR products was purified with LAboPass PCR purification Kit (COSMO co, Ltd., Korea) and sequenced in both directions using an ABI 3730XL (COSMO co, Ltd., Korea).

Systematics

Order Harpacticoida Sars, 1903
Family Laophontidae T. Scott, 1904

***Jejulaophonte* gen. n.**
http://zoobank.org/8526EE96-00AC-49D3-AB2C-D6969CF1D4E9

Diagnosis. Laophontidae. Body elongate, sub-cylindrical, not dorsoventrally depressed; genital field with 2 setae each on P6 and small copulatory pore located in median depression; anal operculum well developed. Sexual dimorphism in antennules, P3–P6, and genital segmentation; rostrum small, fused at base; antennule with a small process in segment 2 and 7–segmented subchirocer in male, aesthetasc on segment 4 and 6 in female, 5 and 7 in male; maxillary syncoxa with 2 endites, endopod represented by 2 setae fused basally and 1 small naked seta; P1 exopod–2 with 5 setae; P2 smaller than P3 and P4; P3 enp-2 in male produced into a conspicuous apophysis.

Type and only species. *Jejulaophonte hyeopjaeensis* sp. n.

***Jejulaophonte hyeopjaeensis* sp. n.**
http://zoobank.org/ED9189D2-8C1A-4321-8CDC-65E5E117013E
Figs 1–8

Type locality. Intertidal zone at Hyeopjae beach Jeju island, Korea (33°23'41"N, 126°14'22"E) on 10 April 2004 (type specimen). For DNA analysis, specimens collected on 3 June 2010 (for DNA analysis) at type locality.

Material examined. Holotype 1♀ (CR235161) dissected on 9 slides. Paratypes 1♂ (CR235162) dissected on 8 slides, and 11♀♀ (CR235163), 5♂♂ (CR235164) in 70% alcohol. 9 specimens (6♀♀, 3♂♂) dried, mounted on stubs, and coated with gold for SEM. All specimens are from the type locality.

Etymology. Specific name refers the type locality of new species, Hyeopjae beach, Jeju Island, Korea.

DNA-barcode (mt COI). Sequences and traces were submitted to GenBank (GenBank Accession numbers: KF857218, KF857219)

Description of female. Total body (Fig. 1A, B) length from anterior margin of rostrum to posterior margin of caudal rami 477 μm (n = 6, mean = 472 μm). Maximum width 88 μm measured at midway of cephalothorax.

Body (Fig. 1A, B). Cylindrical and not dorsoventrally depressed with minute sensilla dorsally. Small sensilla well developed on the distal margin of prosomites and urosomites.

Rostrum (Fig. 1A). Diminutive, fused with cephalothorax, no sensilla.

Prosome (Fig. 1A). 4-segmented, comprising cephalothorax (bearing first pedigerous somite) and three free pedigerous somites. Cephalothorax subrectangular, wider than free somites. Cuticula between cephalothorax and first free somite distinctly pursed. Pleural areas of cephalic shield narrow and posterolateral angles rounded. Posterior margin of cephalothorax and all pedigerous somites with a row of long setules dorsally and laterally (Figs 1A, B, 8A). Free prosomites with spinules tuft on dorso-anterior surface and several setules on dorso-lateral margin.

Urosome (Fig. 1A–C). 5-segmented, comprising P5-bearing somite, genital double-somite, and three free abdominal somites. Genital double-somite wide and original segmentation marked by a row of long setules and short spinules row arising from transverse surface ridge dorsally and laterally. Ventral surface bearing spinular tufts laterally. Each P6 (Fig. 2D) well developed opercula closing off paired genital apertures presented by one plate fused in middle, with 2 setae. Genital field (Figs 1C, 2D) located near the upper part of genital double-somite. Penultimate and anal somites distinctly narrow. Penultimate somite without sensilla dorsally. Anal somite with spinular tufts laterally; with well developed and smooth anal operculum (Figs 2C, 8H).

Caudal rami (Fig. 2C). Parallel, widely separated, dorsal surface with small minute spinules, and proximal inner margin with a lateral row of stout spinules. Each ramus with 7 setae: seta I smallest, setae II and III well developed and naked, seta IV naked,

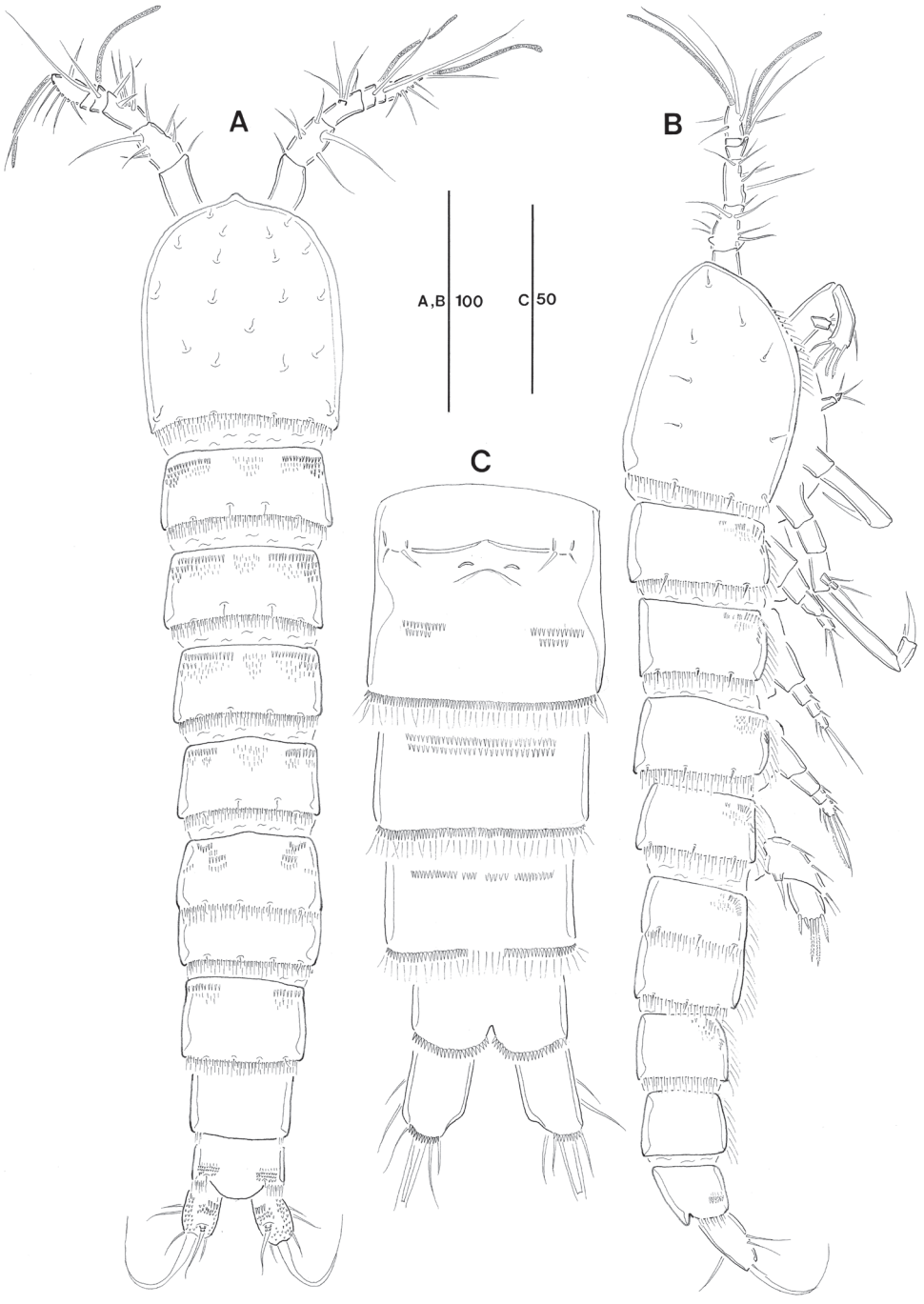

Figure 1. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. (♀). **A** habitus, dorsal **B** habitus, lateral **C** urosome, ventral.

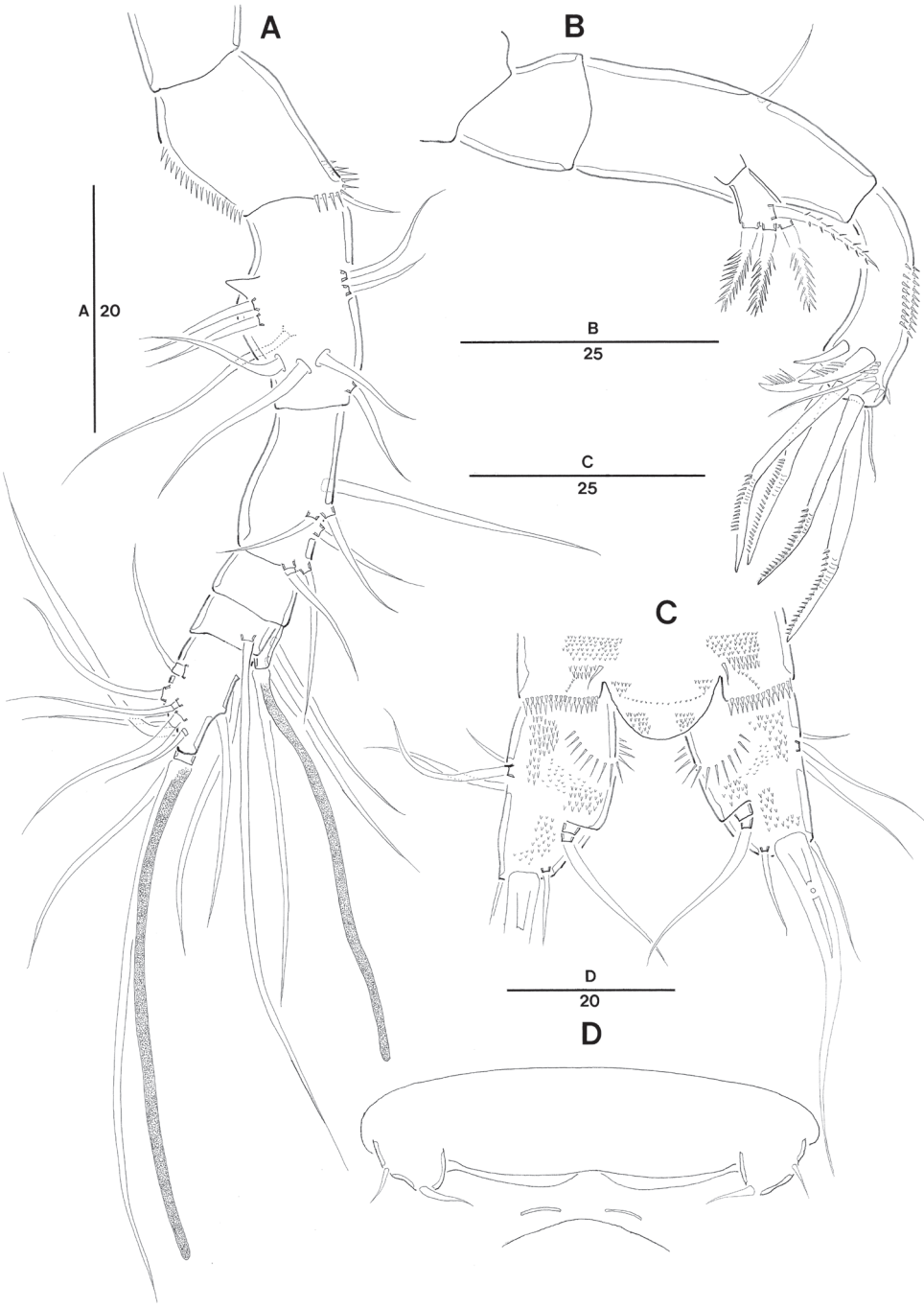

Figure 2. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. (♀). **A** antennule, dorsal **B** antenna **C** anal somite and caudal rami, dorsal **D** genitial area with P6.

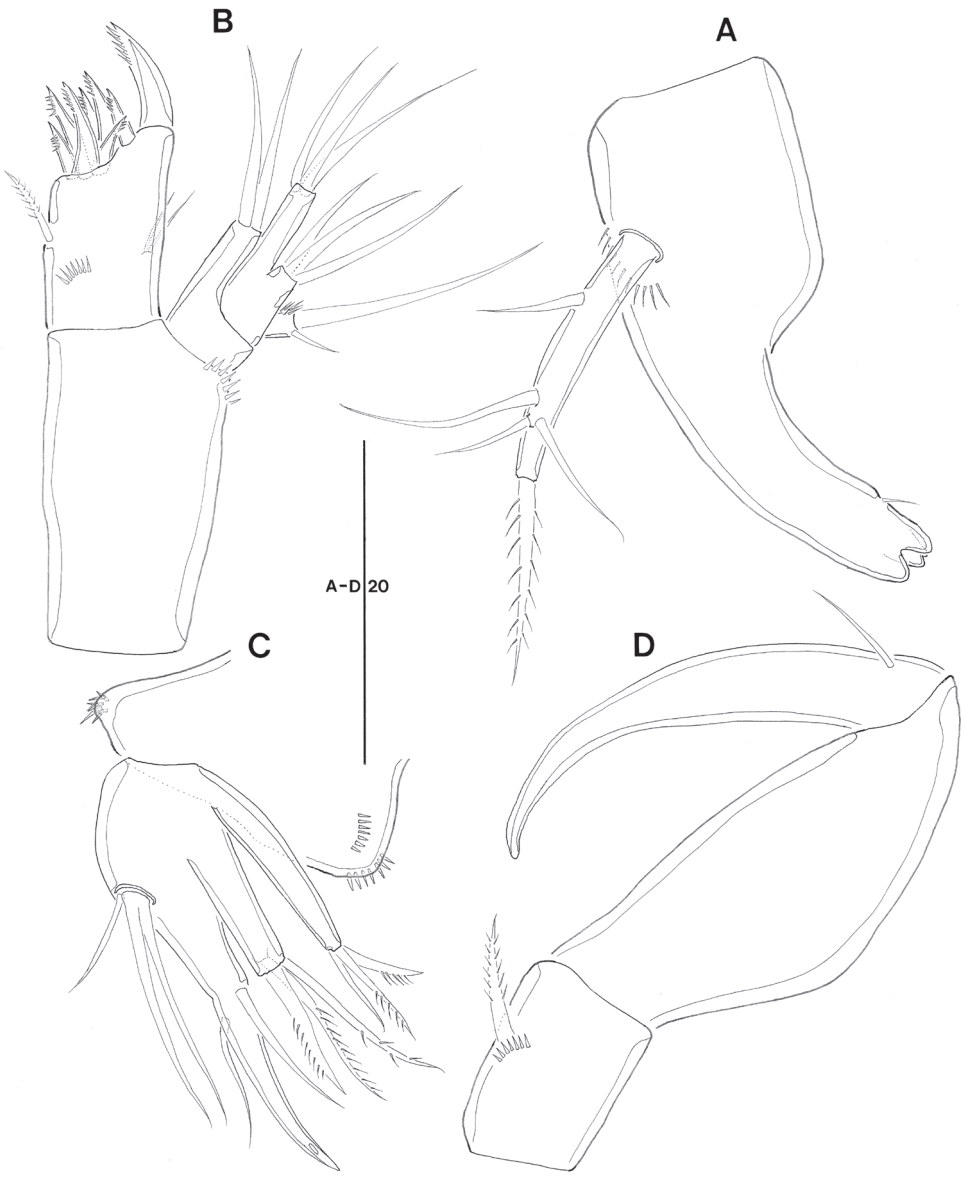

Figure 3. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. (♀) . **A** mandible **B** maxillule **C** maxiila **D** maxilliped.

seta V longest and strongest, seta VI bare at the inner distal corner, seta VII naked and triarticulate at base.

Antennule (Fig. 2A). Slender, 6-segmented. Segment-2 with 1 small blunt process and 9 bare setae. Segment-4 carrying sub-cylindrical process furnished with 2 bare setae and 1 slender seta fused basally with aesthetasc. Apical acrothek consisting of an aesthetasc fused basally to 2 slender naked setae. Armature formula : 1–[1 bare], 2–[9 bare], 3–[6 bare], 4–[2 bare + (1+ae)], 5–[1 bare], 6–[9 bare + acrothek].

Antenna (Figs 2B, 8F). 3-segmented, comprising coxa, allobasis, and free 1-segmented endopod. Coxa small and bare. Allobasis with 1 bare abexopodal seta located about halfway along the segment. Exopod 1-segmented with 4 pinnate setae. Endopod, subtriangular pyramid-shaped, shorter than allobasis, spinule tuft on medial surface and with lateral armature consisting of 3 spines, 2 bare and 4 geniculate setae.

Labrum (Fig. 8B) with spinular ornamentation around distal margin; dense pattern of fine spinules anteriorly and distal patch of overlapping scales.

Mandible (Fig. 3A). Small gnathobase armed with 1 slender bare seta on dorsal side and several blunt teeth. Mandibular palp probably representing fused basis and endopod; with 1 lateral (basal) bare seta, 3 sub-distal bare setae, and 1 distal pinnate seta.

Maxillule (Figs 3B, 8B). Praecoxa trapezoidal shape armed with a few spinules around outer margin; Arthrite well-developed with 2 juxtaposed setae near halfway on anterior surface, 1 plumose seta laterally, and 8 elements around distal margin. Coxa bearing cylindrical endite with 2 bare setae. Basal endite with 3 distal naked setae. Exopod 1-segmented, armed with 1 distal naked seta and 1 short bared seta. Endopod incorporated into basis, forming small peduncle with 3 naked setae.

Maxilla (Figs 3C, 8B). Syncoxa without spinules on surface and armed with 2 slender endites. Proximal and distal endites armed with 1 spine and 2 setae. Allobasis produced into a strong curved claw; accessory armature consisting of 2 naked setae proximally and 1 pore distally. Endopod incorporated into allobasis, consisting of 2 bare setae fused basally and 1 small naked seta.

Maxilliped (Fig. 3D). 3-segmented. Syncoxa with 1 plumose seta. Basis elongate without ornamentation. Enodpod drawn out as a smooth claw with 1 accessory naked seta anteriorly.

P1 (Fig. 4A). Coxa ornamented with inner and outer spinules. Basis armed with 1 outer and 1 inner plumose setae. Exopod 2-segmented; exp-1 with 1 outer seta; exp-2 equal in length of exp-1, with 5 setae. Endopod 2-segmented; enp-1 over 3 times longer than exopod, longitudinal coarse spinules proximally; enp-2 (Fig 8C) with 1 small accessory seta, 1 large strong claw, and ornamented with 4 big spinules arranged around distal inner margin.

P2 (Fig. 4B). Coxa with dense ornamentation on anterior surface and along outer margin. Basis with 1 outer plumose seta near outer distal corner. Exopod 3-segmented, about 2 times longer than endopod; exp-1 ornamented with spinules along lateral and anterior margin, setules along inner margin and 1 pinnate spine; exp-2 with 1 stout pinnate spine and spinules along outer margin; exp-3 with 3 elements. Endopod 2-segmented, enp-1 larger than enp-2; enp-1 without seta; enp-2 with 1 distal plumose seta.

P3 (Fig. 5A). Coxa with dense ornamentation on surface and along outer margin. Basis with 1 outer naked seta and ornamented with row of spinules on middle surface and along inner margin. Exopod 3-segmented; exp-1 armed with 1 strong outer spine; exp-2 with 1 inner and 1 outer setae; exp-3 with 2 inner, 2 distal, and 2 outer setae. Endopod 2-segmented, each segment furnished with a row of spinules on outer margin and long setules along inner margin; enp-1 without seta; enp-2 with 1 inner, 2 distal, and 1 outer setae.

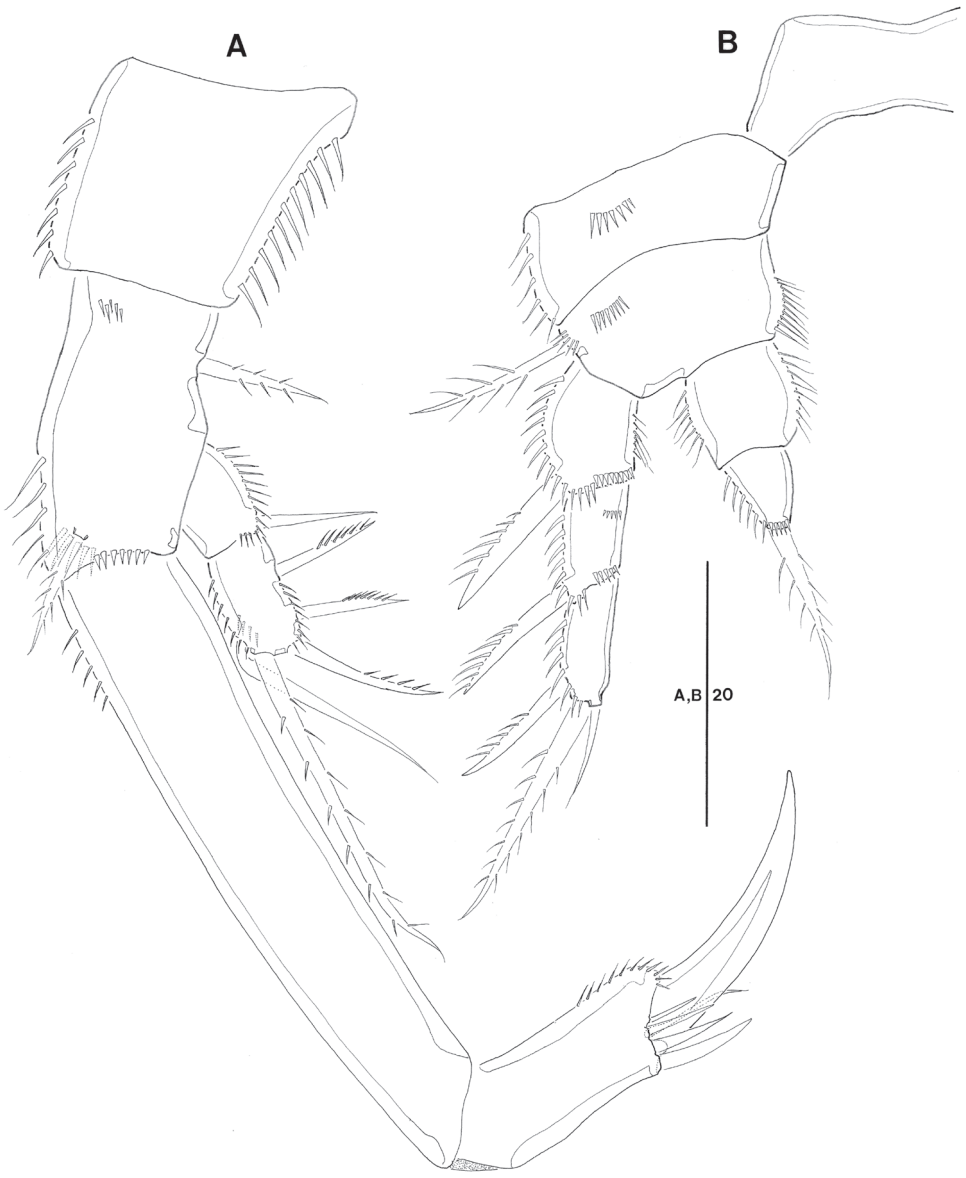

Figure 4. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. (♀). **A** P1, anterior **B** P2, anterior.

P4 (Fig. 5B). Coxa with a row of spinules along outer margin. Basis with 1 naked seta. Exopod 3-segmented, 2 times longer than endopod; exp-1 with 1 outer spine; exp-2 with 1 outer spine and 1 inner seta; exp-3 with 2 inner, 3 distal, and 2 outer setae. Endopod 2-segmented; enp-1 bare, ornamented with long setules on inner margin; enp-2 with 4 setae.

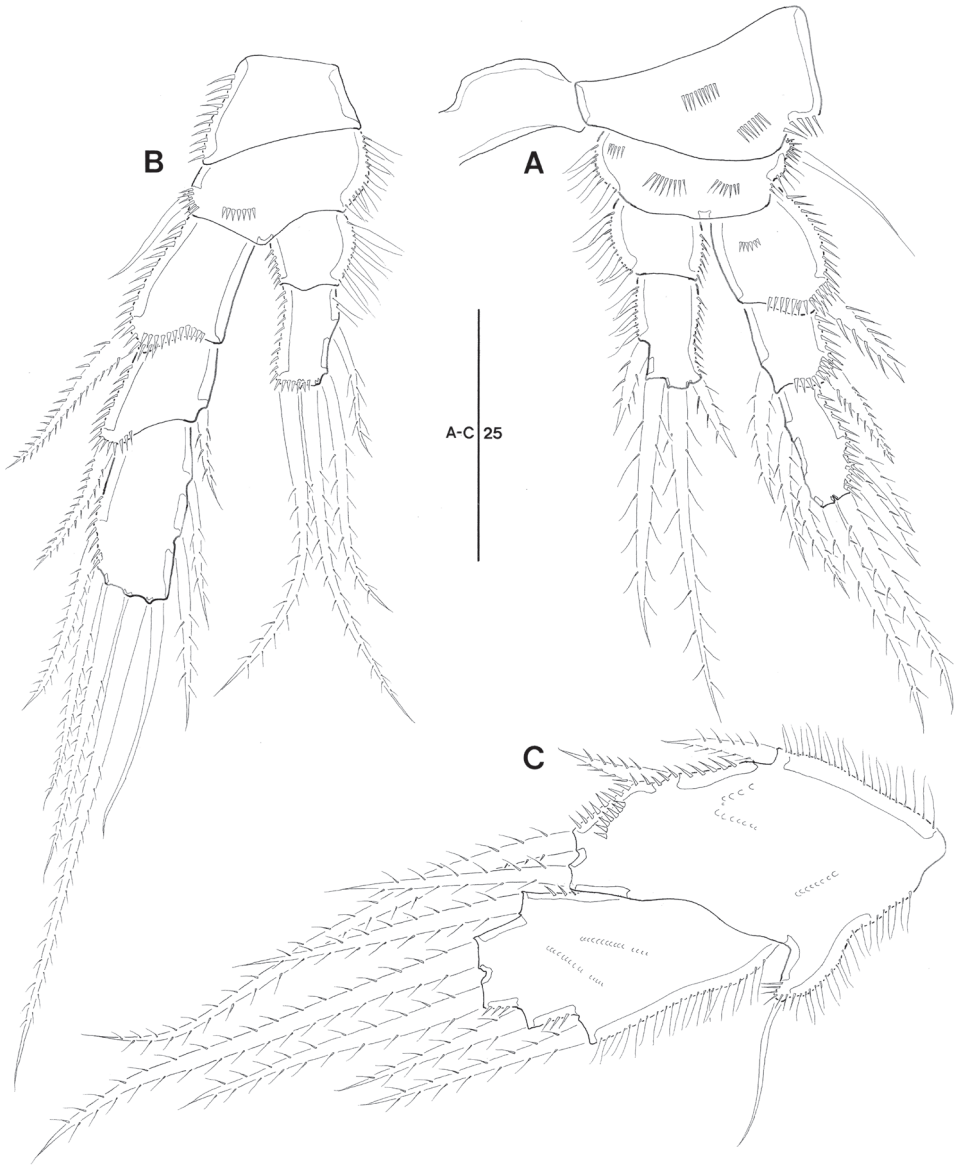

Figure 5. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. (♀). **A** P3, anterior **B** P4, anterior **C** P5, anterior.

Armature formulae as follows:

	Exopod	Endopod
P2	0.0.021	0.010
P3	0.1.222	0.121 (0.0.111 in ♂)
P4	0.1.232 (0.1.231 in ♂)	0.121

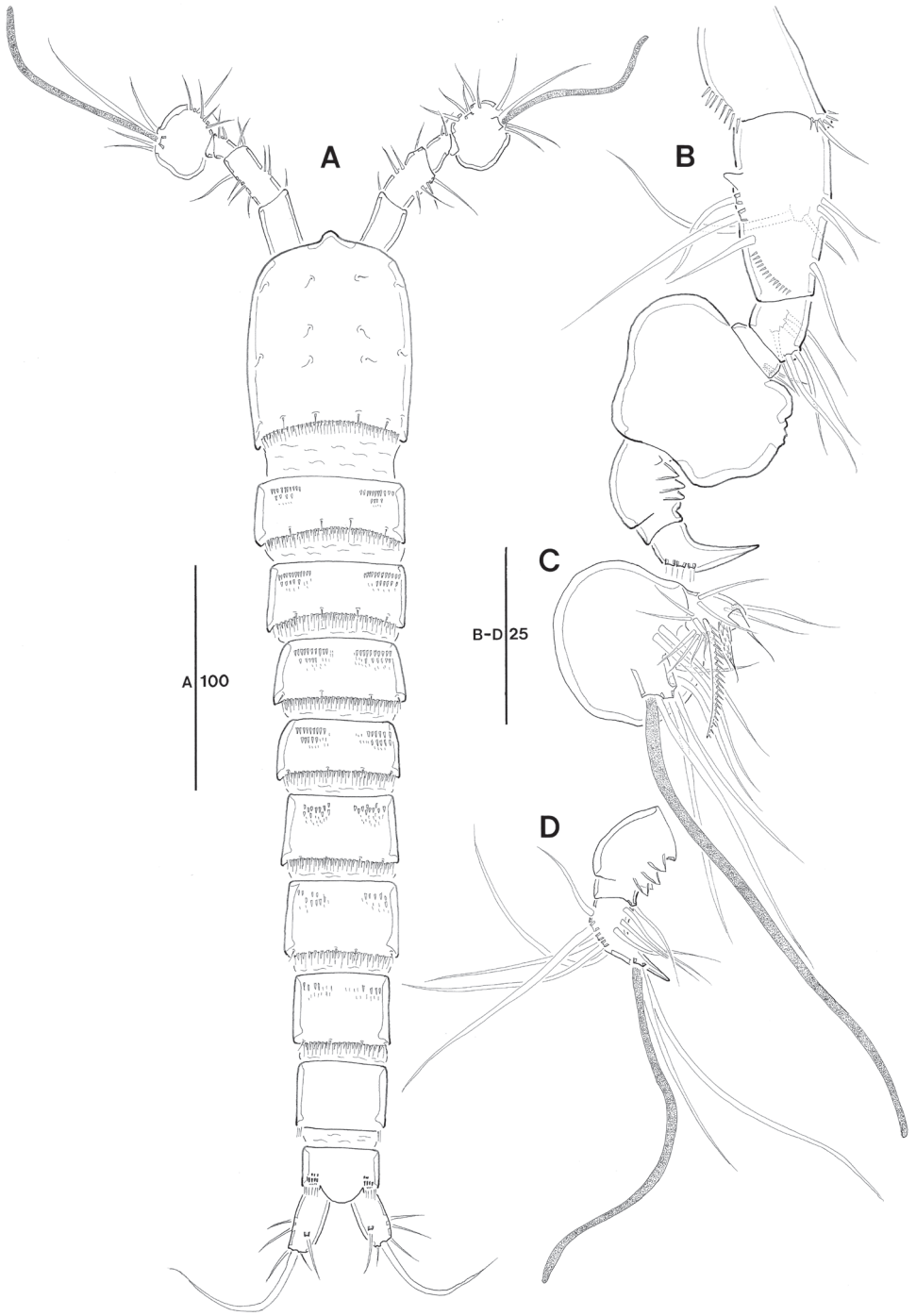

Figure 6. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. (♂). **A** habitus, dorsal **B** antennule **C** antennulary segment 5 **D** antennulary segments 6 and 7.

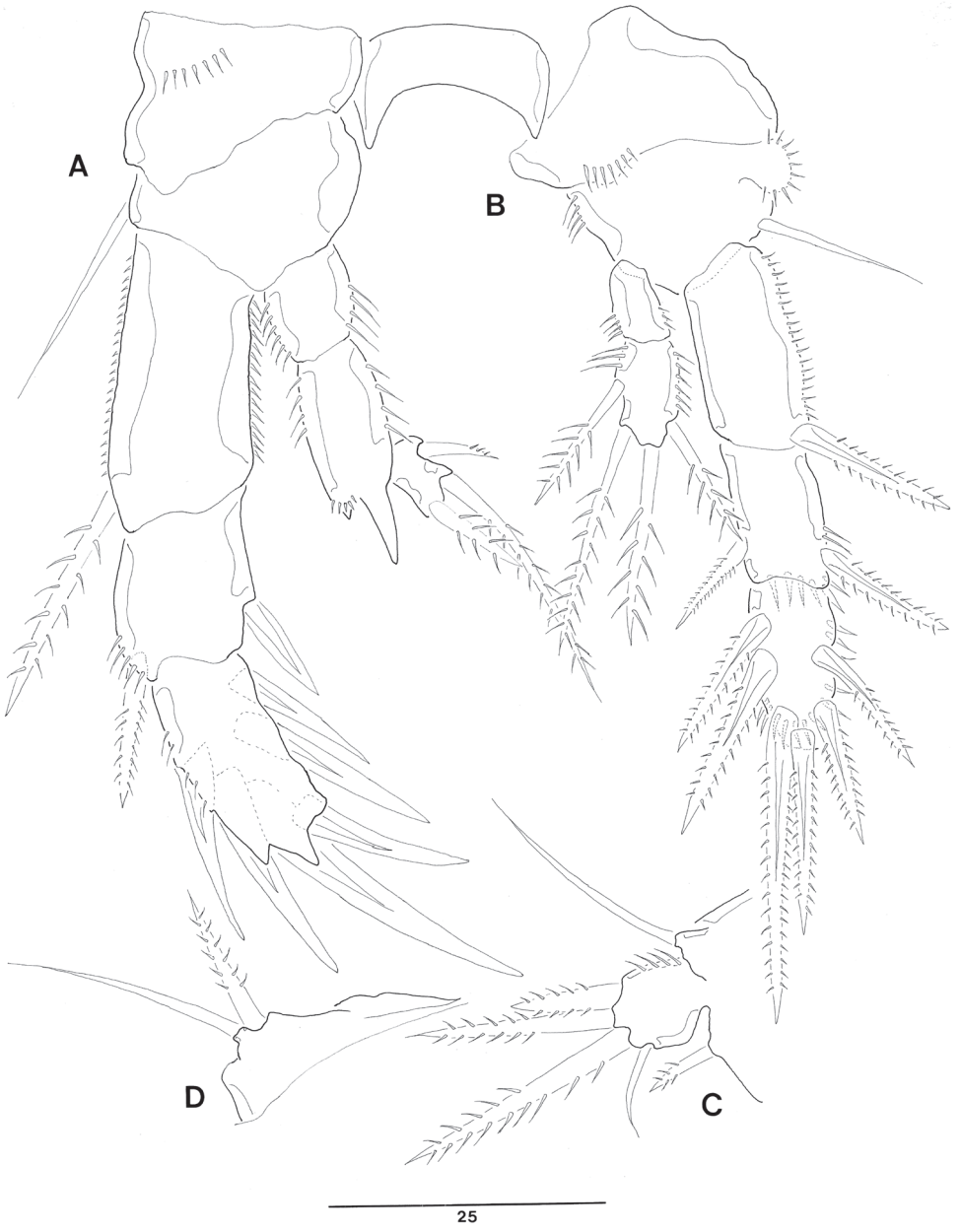

Figure 7. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. (♂). **A** P3, anterior **B** P4, anterior **C** P5, anterior **D** P6, anterior.

P5 (Fig. 5C). Baseoendopod ornamented with long setules along inner and outer margins and 1 basal naked seta. Endopodal lobe small, with 4 pinnate setae. Exopod oblong, with 5 plumose setae, a row of short spinules on outer margin and long setules along inner margin.

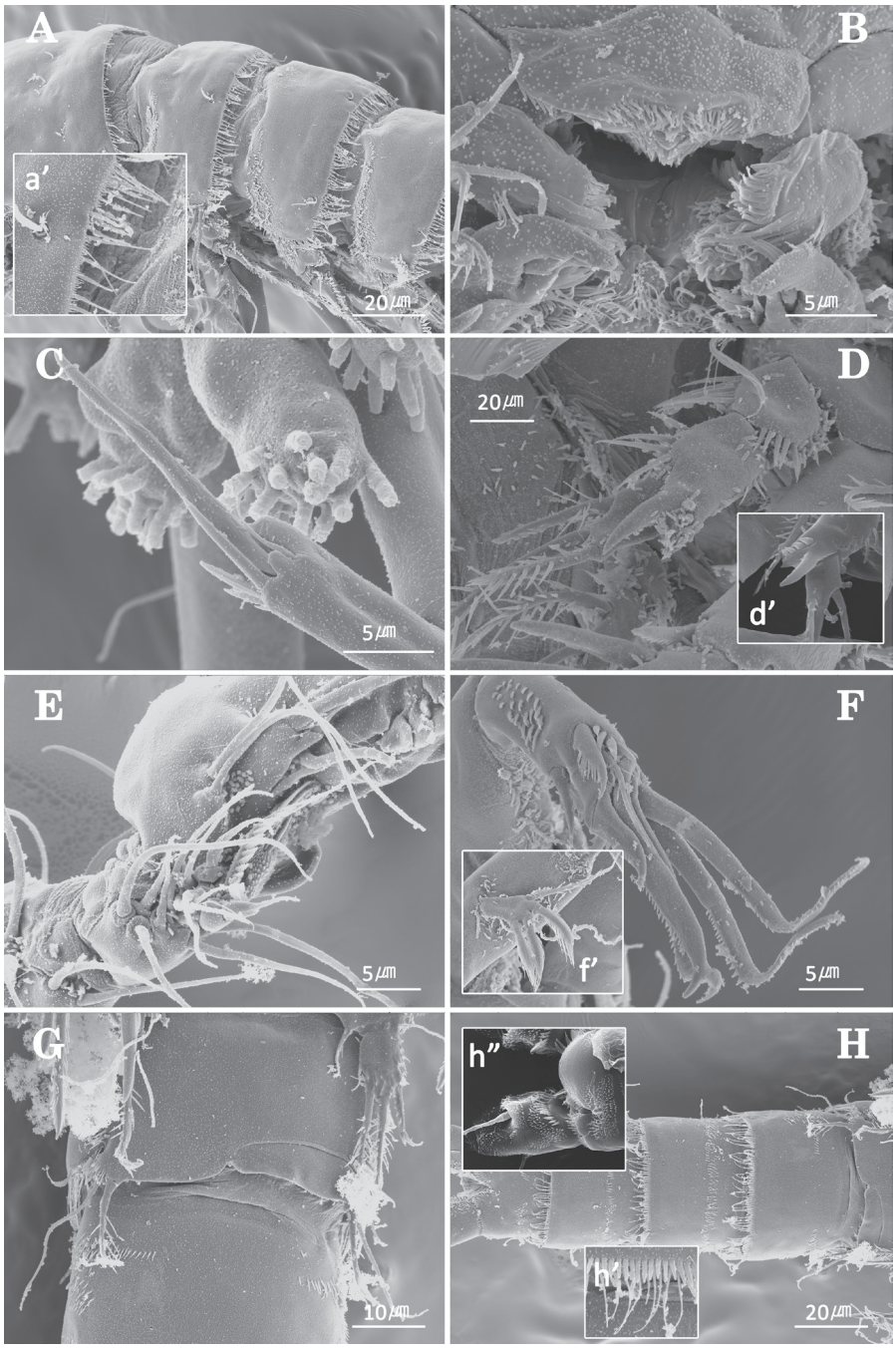

Figure 8. *Jejulaophonte hyeopjaeensis* gen. n., sp. n. **A** prosome in ♀, lateral, a', dorso-posterior margin of prosomites **B** mouthparts part in ♀ **C** distal part of P1 endopod-2 in ♀ **D** apophysis of P3 endopod in ♂, d'; small processes on distal outer corner of P3 endopod-2 **E** antennulary segments 3, 4 and 5 in ♂ **F** A2 endopod in ♂, f' antennary exopod **G** P6 in ♂ **H** urosome, ventral, h', ventro-posterior margin of urosomite, h'', anal somite in ♂, dorsal.

Description of male. Body (Fig. 6A) cylindrical, more compact than in female; length 450 μm (n = 4, mean = 451 μm) measured from anterior margin of cephalic shield to posterior margin of caudal ramus. Maximum width 76 μm at posterior margin of cephalothorax.

General body shape, ornamentation and sensilla pattern as in female. Sexual dimorphisms in A1, P3, P4, P5, and P6.

Antennule (Figs 6B–D, 8E). 7-segmented, robust, subchirocer. Segment-1 with 1 small seta on posterior margin. Segment-2 longest, with 1 small projection and 8 bare setae. Segment-5 with a proximal process anteriorly, and swollen. Segment-6 formed by 2 incompletely fused segments with 1 seta and 4 processes at inner margin. Distal position of segment-7 pointed, subtriangular, displacing acrothek to position isolated from other armature. Armature formula; 1–[1 bare], 2–[8 bare], 3–[5 bare], 4–[2 bare], 5–[17 bare + 1 modified + 1 pinnate + (1+ae)], 6–[1 + 4 processes], 7–[8 + acrothek]. Apical acrothek consisting of an aesthetasc and two naked setae.

Swimming legs 1–2 similar to those of female.

P3 (Figs 7A, 8D). Coxa with dense ornamentation on anterior surface. Basis with 1 naked outer seta. Exopod 3-segmented, more robust than in female; exp-1 ornamented with a row of spinules along inner and outer margin with 1 modified outer spine longer than female; exp-2 the shortest, with 1 outer, and 1 inner spine; exp-3 with 6 modified stout spines. Endopod 3-segmented; enp-1 ornamented a row of spinules on outer margin and long setules along inner margin, without seta; enp-2 with distal inner corner produced as an apophysis without ornamentation and 4 small processes on distal outer corner (Fig. 8D); enp-3 shortest, located next to apophysis of exp-2 with 1 inner and 2 distal setae.

P4 (Fig. 7B). Coxa with dense ornamentation on posterior surface. Basis with 1 naked outer seta. Exopod 3-segmented, exp-1 and exp-2 with modified outer spines; exp-3 with 6 modified spines. Endopod 2-segmented, enp-1 without seta; enp-2 with 1 outer, 2 apical, and 1 inner setae, all setae pinnate.

P5 (Fig. 7C). Fused medially; baseoendopod plate flattened, defined at the base. Baseoendopod with 1 outer basal seta, and endopodal lobe represented by 1 bare seta. Exopod small, with 1 bare, and 3 pinnate setae.

P6 (Fig 7D, 8G). Symmetrical, represented on both sides by a small plate(fused to ventral wall of supporting somite along one side; articulating at base and covering gonopore along one side); outer distal corner produced into a cylindrical process with 1 inner pinnate and 1 outer naked setae.

Discussion

The new species has a unique character set including the seta formula of P2–P4, and the shape of P5. Based on the Wells' key (2007), there is no extant genus that can harbor the specific character combination of the present new species. Especially, within the family Laophontidae the new species has a unique combination of three setae on P2 exp-3 and only one seta on P2 enp-2. The new genus, *Jejulaophonte* is placed in the subfamily

Table 1. Armature formulae of five genera in the CCHPR-lineage related to the new genus, *Jejulaophonte*.

Genus	species	A1	P1	P2		P3		P4		P5	
			exp-2	exp	enp	exp	enp	exp	enp	exp	benp
Robustunguis	*ungulatus* (♀)	6	4	0.0.022	010	0.0.022	020	0.0.022	020	6	4
	(♂)	6	4	0.1.022	0.010	0.0.022	0.020	0.0.022	0.021	5	2
	minor (♀)	6	4	0.022	010	0.022	0.020	0.022	1	5	0
	(♂)	6	4	0.022	010	0.022	0.020	0.022	1	1	?
Carraroenia	*ruthae* (♀)	6	4	0.1.023	0.010	0.1.123	0.121	0.1.123	0.220	6	5
	(♂)	8	4	0.1.023	0.010	0.1.123	0.0.020	0.1.123	0.111	5	2
Psammoplatypus	*discipes* (♀)	6	5	0.0.023	0.020	0.1.023	0.121	0.1.023	0.121	4	5
	(♂)	6	4	-	0.120	-	0.0.120	-	-	4	2
	proprius (♂)	8	4	0.0.023	0.120	0.1.023	0.0.020	0.1.023	0.120	4	2
Hemilaophonte	*janinae* (♀)[1]	6	4	0.0.023	0.020	0.0.023	0.020	0.022	0.021	6	4
	janinae (♂)[1]	6		0.0.023	0.020	0.0.023	0.020	0.022	0.021	5	2
	janinae (♀)[2]	6	4	0.0.022	020	-	-	0.022	0.011	6	3
	janinae (♂)[2]	-	-	-	-	-	-	-	-	4	3
Coullia[3]	*clysmae* (♀)	6	4	0.0.023	absent	0.0.023	021	0.0.022	021	6	4
	heteropus (♀)	6	4	0.0.023	010	0.0.023	021	0.0.022	020	6	3
	platychelipusoides(♀)	7	4	0.0.023	0.020	0.0.023	0.021	0.0.022	0.011	6	5
	mediterranea (♀)	?	4	0.0.023	0.020	0.0.023	0.010	0.0.022	0.021	6	4
	insularis (♀)	6	5	0.0.023	020	0.0.023	0.021	0.0.023	0.021	6	5
	(♂)	?	5	0.1.023	0.020	0.1.023	0.020	0.0.022	0.021	5	2
	tongariki (♀)	6	5	0.1.023	0.020	0.0.023	0.021	0.0.023	0.021	6	5
Jejulaophonte	*hyeopjaeensis* (♀)	6	5	0.0.021	0.010	0.1.222	0.121	0.1.232	0.121	5	4
	(♂)	7	5	0.0.021	0.010	0.1.222	0.0.111	0.1.231	0.121	4	1

[1] Based on Fiers 1992b.

[2] Based on Jakubisiak 1932[put in the Literature cited].

[3] Based on Huys 2009.

Laophontinae based on character sets including the sub-chirocer male antennule, the typically uniramous mandible, the syncoxa of maxilliped armed with maximum only two setae, the P1 enp-1 without inner seta, the reduced P2 enp-2 without outer spine, and the proximal outer setae of female P5 exopod with a distinctly separated insertion site. *Jejulaophonte* is closely related to five genera (*Carraroenia* McCormack, 2006, *Coullia* Hamond, 1973, *Hemilaophonte* Jakubisiak 1933, *Psammoplatypus* Lee & Huys, 1999, and *Robustunguis* Fiers, 1992), the CCHPR-lineage, based on the reduced P2 endopod (Laophontidae typically has P2 larger than P3), the ovate shape of female P5 exopod, and the sexual dimorphism in the P3 endopod (Gomez and Boyko 2006, Huys 2009, McCormack 2006). Fiers (1992a, b) claimed that the main reason for some species of the genera *Robustunguis* and *Hemilaophonte* having reduced appendages is to adapt to their host. Lee and Huys (1999) discussed the relationship between *Psammoplatypus* and related genera based on the reduced P2 endopod, the swimming leg sexual dimorphism and the ovate shape of female P5 exopod. Additionally, McCormack (2006) observed that the species *Carraroenia ruthae* McCormack, 2006 shares some characters with this lineage. Huys (2009) consequently suggested that *Phycolaophonte* and *Eolaophonte* should be sub-

sumed into the synonymy of *Coullia* and provided a key to genera which have reduced P2 including the five genera *Carraroenia*, *Coullia*, *Hemilaophonte*, *Psammoplatypus* and *Robustunguis*. Especially, he recognized the reduced P2 endopod, sexual dimorphism in P3 endopod of male, and ovate shape of P5 as the shared characters. Importantly, the new genus shares those characters with the CCHPR-lineages.

While the new genus shares the reduced P2 endopod with the CCHPR-lineage, there are several conspicuous differences in the seta formula of appendages (Table 1). *Jejulaophonte*, *Psammoplatypus*, and *Carraroenia* differ from its congeners in the presence of an inner seta on P3–P4 exp-2, four setae on P4 enp-2 (instead of 2 or 3 setae in other genera), one inner seta on P3–P4 enp-2 (instead of 0) in the female. On the other hand, *Jejulaophonte* shares the primitive characters of five setae on P1 exp-2 with *Coullia insularis* (Pallares, 1975), *C. tongariki* (Gomez & Boyko, 2006), and *Psammoplatypus discipes* (Noodt, 1958), one or two inner setae on P4 exp-3 with *C. insularis*, and *C. tongariki* (Table 1). However, *Carraroenia* can be regarded as the most primitive genus in the lineage rather than *Jejulaophonte* and *Psammoplatypus*, by having two inner setae in P4 enp-2, the retention of a inner seta on P2 exp-2 and the primitive P5 armed with six setae on exopod and with five setae on baseoendopod (Mccormack 2006). According to Huys' (2009) key, the new genus belongs to the group with *Carraroenia* and *Pasmmoplatypus* by having an inner seta on P4 exp-2. The genus *Psammoplatypus* can be regarded as the closest sister group of *Jejulaophonte*, new genus, because of the absence of inner seta of P2 exp-2.

An updated key including *Jejulaophonte* is as follows (amended from Huys 2009)

1	P1 well developed; longer than half of body length; P2 endopod 1-segmented; distal segment of P3 exopod with 4 elements in both sexes	***Robustunguis***
–	P1 shorter than half of body, these characters not combined	**2**
2	P4 exp-2 with inner seta in both sexes; P4 enp-2 with 4 elements in female	**3**
–	P4 exp-2 without inner seta; P4 enp-2 with 3 elements at most in female	**5**
3	P2 exp-2 with inner seta	***Carraroenia***
–	P2 exp-2 without inner seta	**4**
4	P2 and P3 exp-3 with 5 elements in both sexes	***Psammoplatypus***
–	P2 exp-3 with 3 elements and P3 exp-3 with 6 elements in both sexes	***Jejulaophonte* gen. n.**
5	P4 exopod 2-segmented	***Hemilaophonte***
–	P4 exopod 3-segmented	***Coullia***

Although the female of *Psammoplatypus proprius* (Lang, 1965) has not yet been described, we suppose that the seta formula in the distal segment of P2 and P3 exopod is common in both sexes as the other species in this group do not have sexual dimorphism in the seta formula on the distal segment of P2 and P3 exopod (Table 1).

While *Jejulaophonte* shares some primitive characters with the lineage, the new species can be distinguished from the species of CCHPR-lineage by the reduced P5

Table 2. List of harpacticoid species with mt COI gene in the GenBank.

Family	Genus	species	Reference
Canthocamptidae	*Australocamptus*	*hamondi*	Karanovic and Cooper 2011b
	Cletocamptus	*deitersi*	Rocha-Oliveres et al. 2001
	Cletocamptus	*helobius*	Rocha-Oliveres et al. 2001
	Elaphoidella	*humphreysi*	Karanovic and Cooper 2011b
Darcythompsoniidae	*Leptocaris*	*canariensis*	Unpublished
Harpacticidae	*Tigriopus*	*brevicornis*	Jung et al. 2006
	Tigriopus	*californicus**	Burton 1998
	Tigriopus	*fulvus*	Edmands 2001
	Tigriopus	*japonicus**	Peterson et al. 2013
Laophontidae	*Jejulaophonte*	*hyeopjaeensis*	This study
Miraciidae	*Macrosetella*	*gracilis*	Eberl et al. 2007
	Miracia	*efferata*	Bucklin et al. 2010
	Schizopera	*akation*	Karanovic and Cooper 2012
	Schizopera	*akolos*	Karanovic and Cooper 2012
	Schizopera	*analspinulosa*	Karanovic and Cooper 2012
	Schizopera	*analspinulosa linel*	Karanovic and Cooper 2012
	Schizopera	cf. *uranusi*	Karanovic and Cooper 2012
	Schizopera	*emphysema*	Karanovic and Cooper 2012
	Schizopera	*kronosi*	Karanovic and Cooper 2012
	Schizopera	*leptafurca*	Karanovic and Cooper 2012
	Schizopera	*uranusi*	Karanovic and Cooper 2012
Paramesochridae	*Remanea*	*naksanensis*	Back et al. 2011
Parastenocarididae	*Dussartstenocaris*	*idioxenos*	Karanovic and Cooper 2011b
	Kinnecaris	*lined*	Karanovic and Cooper 2011a
	Kinnecaris	*linel*	Karanovic and Cooper 2011b
	Kinnecaris	*linesae*	Karanovic and Cooper 2011a
	Kinnecaris	*uranusi*	Karanovic and Cooper 2011b
	Parastenocaris	*jane*	Karanovic and Cooper 2011b

*There are many references of cytochrome c oxidase subunit I (mt COI) on NCBI, and a recent data was selected for the table.

setation. Except for *Robustunguis minor* Fiers, 1992 and *Psammoplatypus discipes*, all species in the CCHPR-lineage share the characters of the reduced P2, and the six setae on the P5 exopod in the female. However, the new species possesses a reduced setation of five setae on the P5 exopod in the female and four setae in the male. Furthermore, endopodal lobe of the male has only one seta (the others of CCHPR-lineage have at least two setae except for *Robustunguis minor*).

The nuclear ribosomal genes are useful for phylogenetic study (Huys et al. 2006, Huys 2009), however the mitochondrial cytochrome c oxidase subunit I (mtCOI) gene was proposed as a 'barcode' (Hebert et al. 2003; Bradford et al. 2010). Until now, mtCOI sequences of 27 harpacticoid species including the new species and the unpublished species *Leptocaris canariensis* were updated on GenBank (Table 2). The sequences of the new species are the first barcode in the family Laophontidae, and it would be a useful template for laophontid barcode study.

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A new species of *Labidocera* (Copepoda, Calanoida, Pontellidae) collected from Okinawa, southwestern Japan, with establishment of five Indo-West Pacific species groups in the *L. detruncata* species complex

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Abstract

Labidocera churaumi **sp. n.** is described from Okinawa, southwestern Japan. The female of the new species differs from other congeners in genital compound somite with right postero-lateral and left antero-lateral processes. The male is distinguished from other congeners by the structure of the fifth leg. This new species is assigned to a newly proposed species group, the *L. madurae* species group, within the *L. detruncata* species complex. In this species complex five Indo-West Pacific species groups are recognized (*cervi*, *detruncata*, *gangetica*, *madurae*, and *pavo*) and defined on the basis of difference in sexual dimorphism.

Keywords

Indo-West Pacific, *Labidocera*, Okinawa, Pontellidae, species group, taxonomy

Introduction

We have been carrying out intensive faunistic surveys of marine invertebrates around the Nansei Islands, in the subtropical region of southwestern Japan, since 1988 and have discovered many new crustacean taxa, especially copepods. For example the copepod order Platycopioida was first reported from the Indo-Pacific in this region

in 1994 (Ohtsuka and Boxshall 1994). The systematics of shallow- and deep-water copepods from these waters, have been a major focus of research and some of discoveries have been important in elucidating aspects of the evolutionary history and zoogeography of copepods (Barr and Ohtsuka 1989, Ohtsuka et al. 1991, 1996, 1998, 2002, 2003, 2004, 2005, Barthélémy et al. 1998).

In May 2011 we found an undescribed species of the calanoid genus *Labidocera* Lubbock, 1853 (Family Pontellidae) from Okinawa Island and neighboring islands. It clearly belongs to the *L. detruncata* species complex (Fleminger 1967, Greenwood and Othman 1979, Mulyadi 2002), due to its characteristic sexual dimorphism. This species complex mainly consists of coastal species from tropical and subtropical Indo-West Pacific waters and also two Atlantic species (Fleminger 1967, Greenwood and Othman 1979, Mulyadi 2002). The present paper provides a description of the new species, and remarks on species groups within the *detruncata* species complex.

Materials and methods

A fish collection light (KU-5MB, MW50S-G, KOTO electric Co., Ltd.) was deployed at Naha Port (May 2011) and Tokashiki Port (May 2011) after sunset. Conical plankton nets (diameter 30 cm, mesh size 0.1 mm) were towed around the light several times. Copepod specimens were fixed with 10% neutralized formalin/seawater or 70% ethanol immediately after collection. Copepods were dissected under a binocular microscope and examined and illustrated using a compound microscope fitted with differential interference contrast lighting (Optiphoto, Nikon Co., Ltd.) and a drawing tube.

In describing the features of the new species, we have followed the terminology of Huys and Boxshall (1991). We followed Fleminger (1967) and Fleminger et al. (1982) about species complexes (=superspecies) and groups in the genus *Labidocera*.

Type specimens are deposited at the Kitakyushu Natural History and Human History Museum (KMNH IvR 500,734 – KMNH IvR 500,783).

Systematics

Order Calanoida Sars, 1903
Family Pontellidae Dana, 1853
Genus *Labidocera* Lubbock, 1853

***Labidocera churaumi* sp. n.**
http://zoobank.org/E4C58DC0-DDE3-4808-B7D1-5925D444280B
Figs 1–4

Material examined. Tokashiki Port, Tokashiki Island, Okinawa Prefecture, Japan, (26°12'0.98"N; 127°22'8.77"E), 21 May 2011 (8 ♀♀, 3 ♂♂); (26°12'1.21"N;

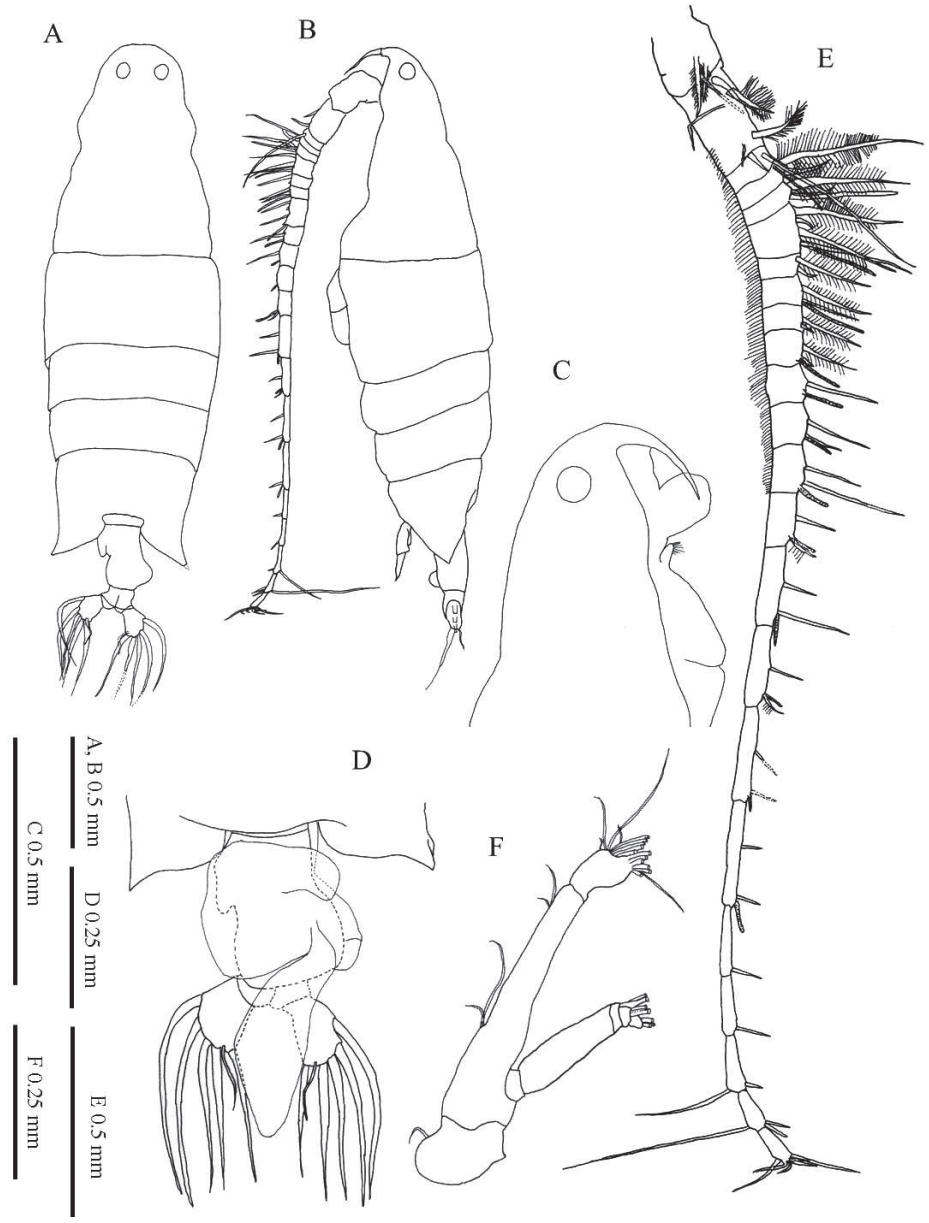

Figure 1. *Labidocera churaumi* sp. n., female (Paratype). **A** habitus, dorsal view **B** habitus, lateral view **C** anterior part of cephalosome, lateral view **D** urosome with outline of attached spermatophore and coupler, dorsal view **E** left antennule **F** antenna.

127°22'10.20"E), 27 May 2012 (21♀♀, 11♂♂). Naha New Port, Okinawa Prefecture, Japan, (26°14'8.22"N; 127°40'47.56"E), 20 May 2011, (1 ♀, 6 ♂♂).

Types. Holotype : 1♀, Tokashiki Port, 27 May 2012, whole specimen (KMNH IvR 500,759). Allotype: 1♂Tokashiki Port, 27 May 2012, whole specimen (KMNH

IvR 500,783). Paratypes: 1♀, 6♂♂, Naha New Port, 20 May 2011, whole specimen (♀ KMNH IvR 500,734; ♂♂ KMNH IvR 500,764-KMNH IvR 500,769); 8 ♀♀, 3 ♂♂, Tokashiki Port, 21 May 2011 partly dissected and mounted on 11 glass slides (♀♀KMNH IvR 500,735-KMNH IvR 500,742; ♂♂KMNH IvR 500,770-KMNH IvR 500,772); 20 ♀♀, 10♂♂, Tokashiki Port, 27 May 2012, whole specimen (♀♀KMNH IvR 500,743-KMNH IvR 500,758 and KMNH IvR 500,760-KMNH IvR 500,763; ♂♂KMNH IvR 500,773-KMNH IvR 500,782).

Type locality. Tokashiki Port, Tokashiki Island, Okinawa Prefecture, Japan (26°12'1.21"N; 127°22'10.20"E).

Female. Body (Fig. 1A, B) length of females ranging between: 2225 and 2790 μm (average 2475 μm, n=29), measured from frontal margin of cephalosome to end of caudal rami excluding caudal setae. Ratio of prosome to urosome lengths 4:1, prosome length to width ratio 2.85:1. Cephalic profile rounded in dorsal view, without lateral cephalic hooks. Paired dorsal eyes with cuticular lenses; protuberant ventral eye extending anteroventrally between rostral processes (Fig. 1C). Rostrum bifid, directed posteroventrally. Posterior margins of prosome almost symmetrical in dorsal view, tapering to simple abbreviated, pointed process at each lateral corner. Urosome 2-segmented of highly characteristic shape. Genital compound somite strongly asymmetrical; anterior left surface with posteriorly-directed rod-like process and posterior right smoothly rounded. Spermatophore (Fig. 1D) attached dorsally to genital compound somite.

Antennules (Fig. 1E) symmetrical, 23-segmented: segments armed as follows (Arabic numbers=setae; sp=spines, aes=aesthetasc): (I) 2+aes, (II-IV) 4+aes, (V) 2+aes, (VI) 2, (VII) 2+aes, (VIII-IX) 4+aes, (X) 2, (XI) 2+aes, (XII) 1+sp, (XIII) 1+sp+aes, (XIV) 1+sp+aes, (XV) 2+aes, (XVI) 2+aes, (XVII) 1+sp+aes, (XVIII) 2+aes, (XIX) 1+sp+aes, (XX) 2+aes, (XXI) 2+aes, (XXII) 1, (XXIII) 1, (XXIV) 1+sp, (XXV) 1+sp+aes, (XXVI-XXVIII) 6. Larger and longer setae on segments 3-6. Antenna (Fig. 1F) biramous: coxa with short plumose distal seta, basis and first endopodal segment fused to from elongate allobasis, setation formula 2, 2. Compound distal endopodal segment with 9 and 7 setae on proximal and distal lobes, respectively; exopod 5-segmented, setation formula 0, 0, 2, 2, 3. Mandible (Fig. 2A) with wide, heavily chitinized gnathobase; mandibular palp biramous, basis robust, armed with 4 inner setae. Endopod 2-segmented, first segment armed with 1 short and 3 long setae; second segment with 7 terminal setae. Exopod 2-segmented, first segment unarmed, second segment with 6 terminal setae. Mandibular gnathobase distal edge bearing 8 teeth comprising: from ventral margin 1 apical, 1 subapical, 3 compound medial, and 3 basal (see Fig. 2A); medial teeth with bifurcated cusps; dorsal end of gnathobase with 1 seta. Maxillule (Fig. 2B) praecoxal arthrite with 15 setal elements, 4 on posterior surface; coxal endite with 2 long and 1 short elements on endite and 9 setae on epipodite; basis with 3 setae on proximal and distal endites; and 1 large seta on basal exite; proximal endopod segment and endpod segment 2 incorporated into basis, proximal endopod segments with 2 setae, endopod segment 2 with 2 setae and distal endopod segment with 5 apical setae; exopod with 10 setae. Maxilla (Fig. 2C) with first praecoxal endite bearing 6 setae, second with 3 seta; coxa with 3 setae each

Figure 2. *Labidocera churaumi* sp. n., female (Paratype). **A** mandible **B** maxillule **C** maxilla **D** maxilliped.

on proximal and distal endites. Basis with 3 setae; endopod 3-segmented, setal formula of endopod: 1, 1, 4. Maxilliped (Fig. 2D) with praecoxa and coxa fused, three syncoxal endites well developed, with setal formula 2, 2, 4; endite setae strong, spinulose. Basis

fringed with medial row of spiniform processes and 2 distal setae. Endopod 4-segmented, setal formula of endopod as: 2, 1, 1, 2.

Legs 1–4 (Fig. 3A–D) with 2-segmented endopods and 3-segmented exopods. Coxae with plumose inner seta. Seta and spine formula (Arabic numbers=setae, Roman numerals=spines) of legs 1–4 as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	0-0	I-1; I-1; II, I, 4	0-3; 1, 2, 3
Leg 2	0-1	0-0	I-1; I-1; III, I, 5	0-3; 2, 2, 4
Leg 3	0-1	0-0	I-1; I-1; III, 1, 5	0-3; 2, 2, 4
Leg 4	0-1	0-0	I-1; I-1; III, 1, 5	0-3; 2, 2, 3

Leg 5 (Fig. 3E) biramous, slightly asymmetrical; coxa and intercoxal sclerite fused. Basis subrectangular, with posterior seta. Endopod rounded distally, about 0.3 times as long as exopod. Exopods of both legs 1-segmented, bifurcated tip and with 2 outer spines; outer process on left slightly larger than right and with small spine-like process on proximal part.

Male. Body (Fig. 4A, B) slightly smaller than female (1819–2531 μm, average: 2219 μm, n=20). Prosome about 4 times as long as urosome, Urosome (Fig. 4A) symmetrical with 5 somites; anal somite and caudal rami asymmetrical.

Right antennule (Fig. 4C) with 15 segments geniculate between segments 11 and 12, reaching middle of third pedigerous somite. Antennular segments armed as follows (Arabic numbers=setae; sp=spines, aes=aesthetasc): (I) 2+aes, (II-IV) 4+aes, (V) 2+aes, (VI) 2, (VII) 2+aes, (VIII-XIV) 8+6sp+4aes, (XV-XVI) 4+2aes, (XVII) 2+aes, (XVIII) 2+aes, (XIX) 1+aes, (XX) 1+aes, (XXI-XXIII) 2+aes, (XXIV) 2, (XXV) 2+aes, (XXVI-XXVIII) 6; Segments 11 and 12 with row of teeth.

Left antennule, antenna, mouthparts and swimming legs as in female.

Leg 5 (Fig. 4D) asymmetrical. Left leg 5 short; intercoxal sclerite and left coxa fused. Basis cylindrical with seta near base. Exopod 2-segmented: first segment cylindrical; second segment triangular short with protruding hairy medial surface and 3 distal and 1 lateral spines, one of them long. Right leg 5 basis with seta. Exopod 2-segmented, forming chela; thumb of chela large, triangular, arising near base of first exopodal segment. First exopodal segment with 2 small setae. Second exopodal segment elongate and curved, with 3 slender marginal setae.

Remarks. The present new species is similar to *Labidocera madurae* Scott, 1909 and *L. tasmanica* Taw, 1974 in having the following features: (1) the posterolateral margins of the prosome are symmetrical, each triangular with a sharply pointed tip; (2) the female urosome is moderately or markedly asymmetrical; (3) the caudal rami are symmetrical and not highly modified; (4) the endopods of female leg 5 are nearly symmetrical, short, conical, and not bifid at the tip; (5) the thumb of the right leg 5 of the male is triangular with a broad base, and is slightly recurved; (6) the distal part of terminal segment of the left leg 5 of the male bears 3 spines, the outermost of which is the longest. These 3 species constitute a species group within the *Labidocera detruncata* species complex (see Discussion). *Labidocera churaumi* sp. n. can be dis-

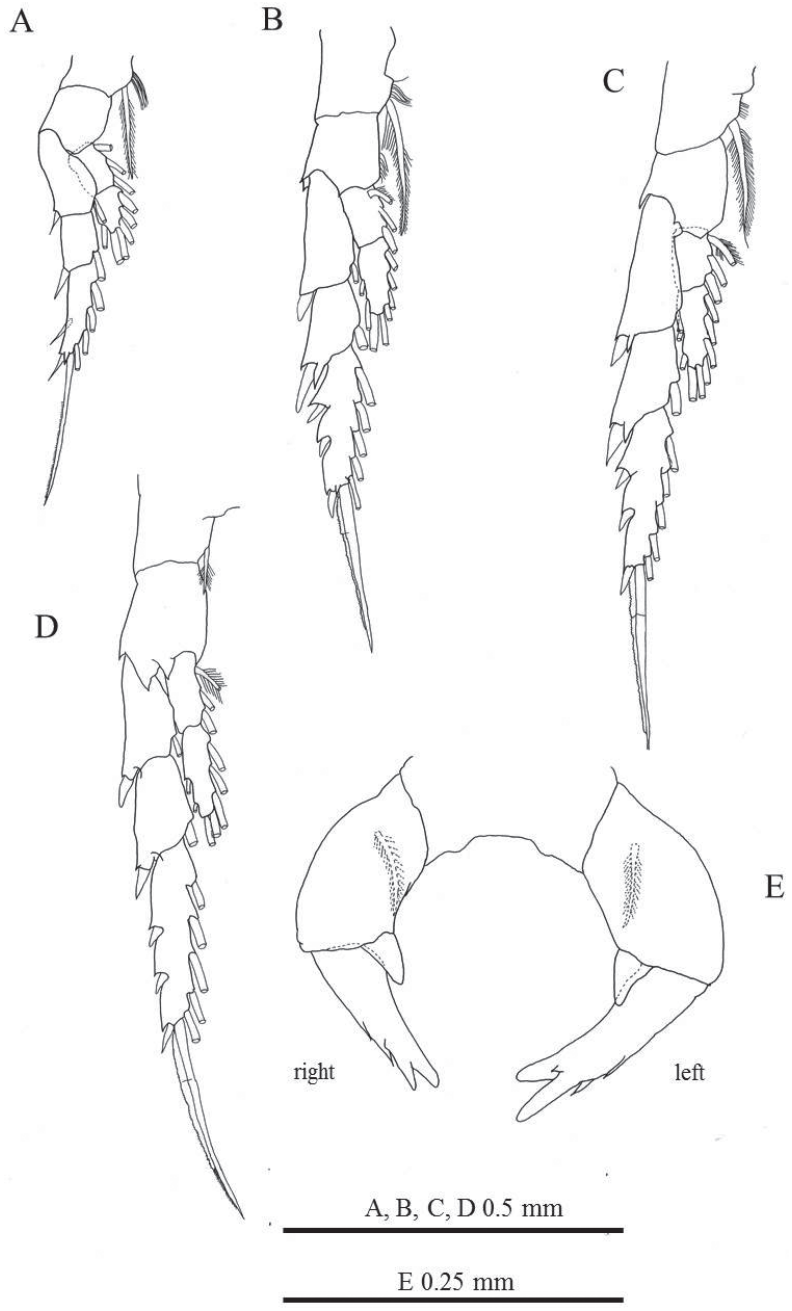

Figure 3. *Labidocera churaumi* sp. n., female (Paratype). **A** leg 1 **B** leg 2 **C** leg 3 **D** leg4 **E** leg 5.

tinguished from *L. madurae* and *L. tasmanica* by: (1) the presence of right postero-lateral and left antero-lateral processes on the female genital compound somite; (2) the exopod of the female leg 5 is very short, only as long as the basis, and has a bi-

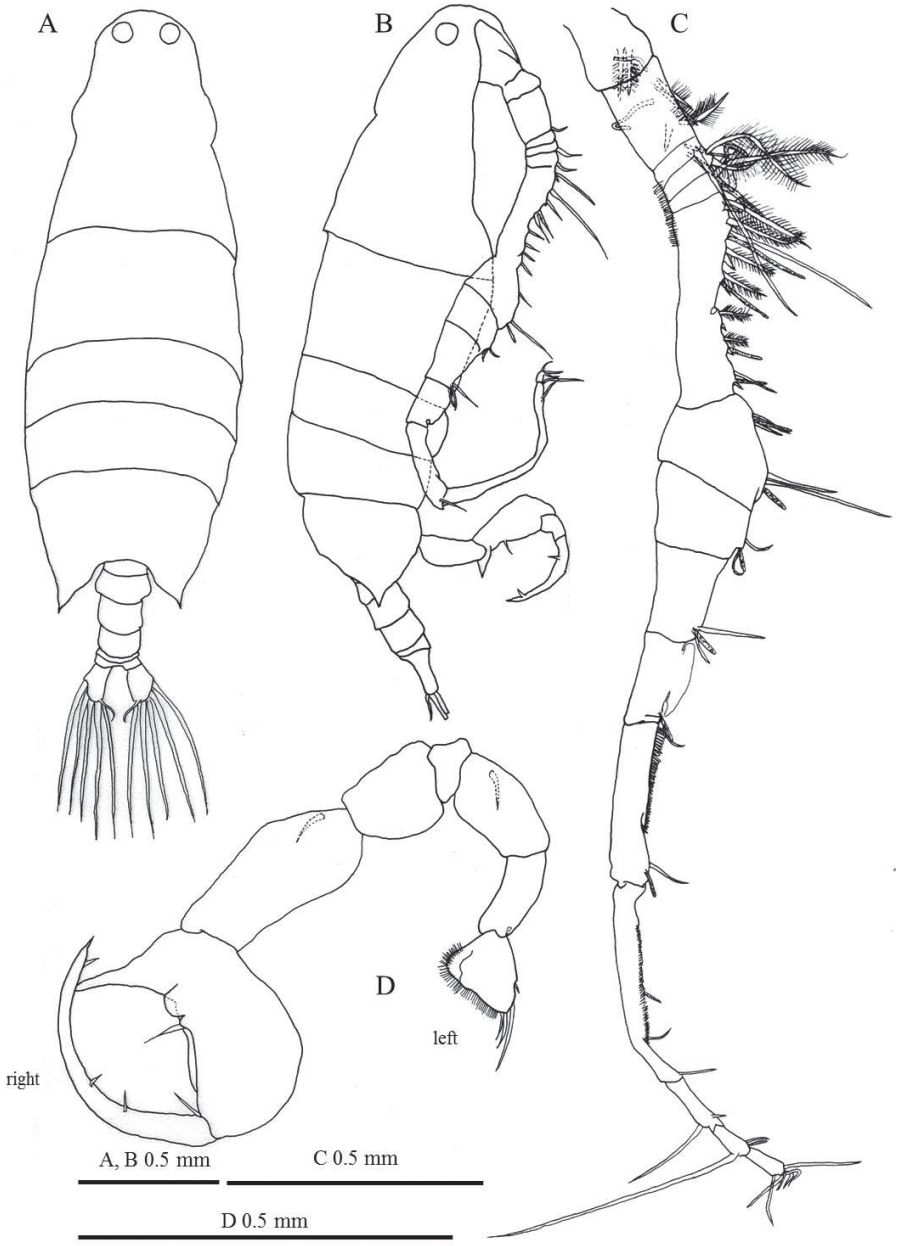

Figure 4. *Labidocera churaumi* sp. n., male (Paratype). **A** habitus, dorsal view **B** habitus, lateral view **C** right antennule **D** leg 5.

furcated tip on both sides; (3) the inner margin of the terminal segment of the male left leg 5 has a protrusion at mid-length.

Etymology. The new specific name "*churaumi*" is from an Okinawan dialect, meaning the beautiful seas around the type locality Okinawa.

Discussion

Fleminger (1967) classified species of the genus *Labidocera* into four superspecies (=species complex), the *L. wilsoni* Fleminger & Tan, 1966, *L. detruncata* (Dana, 1849), *L. darwini* Lubbock, 1853, and *L. kroyeri* (Brady, 1883) species complexes, but left some species unassigned. Within the *L. detruncata* species complex he recognized nine species. Subsequently Greenwood and Othman (1979) added further three species to this species complex, and compared nine Indo-West Pacific members of the species complex, but did not consider three species: *L. orsinii* Giesbrecht, 1889, *L. gangetica* Sewell, 1934 and *L. nerii* (Krøyer, 1849) that Fleminger (1967) originally assigned to this species complex. Subsequently Greenwood and Othman (1979) and Othman (1986) added new species: *L. farrani* Greenwood & Othman, 1979 and *L. jaafari* Othman, 1986 to the species complex. Mulyadi (2002) was the first to define the Indo-West Pacific species group within the *L. detruncata* species complex which he referred to as *L. detruncata* species group, in which were accommodated the following ten species: *L. detruncata*, *L. pavo* Giesbrecht, 1889, *L. bataviae* Scott, 1909, *L. madurae* Scott, 1909, *L. cervi* Krämer, 1895, *L. caudata* Nicholls, 1944, *L. sinilobata* Shen & Lee, 1963, *L. tasmanica* Taw, 1974, *L. farrani* Greenwood & Othman, 1979, and *L. jaafari*. One remaining issue is that two Atlantic species (*L. orsinii* and *L. nerii*) and the Indian species (*L. gangetica*) were not assigned to this species complex by Mulyadi (2002). Here we reinstate Fleminger's (1967) inclusion of the two Atlantic species (*L. orsinii* and *L. nerii*) and the Indian species (*L. gangetica*).

Therefore Mulyadi's (2002) definition of the Indo-West Pacific *L. detruncata* species group needs some emendations as follows: (1) the posterolateral prosomal corners of both sexes protrude posteriorly into a pointed tip; (2) the female urosome is slightly or distinctly asymmetrical, about 1/6 to 1/4 as long as prosome, and 2- or 3-segmented; (3) the rostrum of both sexes is widely divided; (4) the caudal rami of the female are slightly or remarkably asymmetrical, broadened, with or without one or more thickened setae; (5) the exopods of female fifth legs are asymmetrical, with each bearing 3 lateral and 2 terminal processes; (6) the endopods of female fifth legs are either simply conical (rarely bifid) distally or are totally reduced; (7) the thumb of the right leg 5 of the male is conical or spatulate; (8) the finger of the right leg 5 of the male is slender; (9) the terminal segment of the left leg 5 of the male bears 1 outer and 3 slender terminal (rarely thick in *L. caudata*) elements. Since the two Atlantic and *L. gangetica* comply with this emended diagnosis, Fleminger's (1967) original *L. detruncata* species complex (Mulyadi's (2002) Indo-West Pacific *L. detruncata* species group plus *L. orsinii*, *L. nerii* and *L. gangetica*) is well defined by this amended diagnosis.

Although Mulyadi (2002) defined the Indo-West Pacific *L. detruncata* species group (the ten species listed above), it can be further subdivided into the following five newly proposed species groups on the basis of variation in the differing expressions of sexual dimorphism. *Labidocera sinilobata*, *L. jaafari* and *L. gangetica* share synapomorphies in variation in the differing expressions of sexual dimorphism, viz., (1) the absence of endopods from leg 5 of the female, (2) the thumb and finger of the right leg 5 of the male slender, (3) there is a rounded process present basal to the thumb of the right male

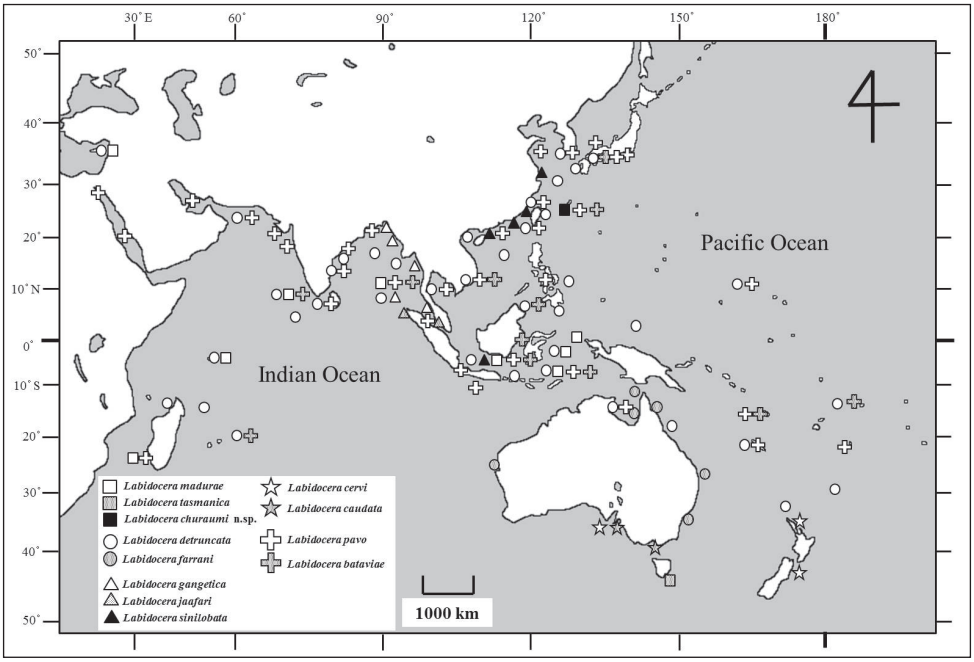

Figure 5. Distribution of *Labidocera detruncata* species complex based on previous records and present study.

leg 5, and (4) there is a protrusion on the inner surface of the terminal segment of the left male leg 5. These three species have a restricted distribution in the subtropical and tropical, coastal waters of the Indo-West Pacific (Sewell 1912, Shen and Lee 1963, Silas and Pillai 1973, Othman 1986, Mulyadi 2002, Razouls et al. 2014), and are referred to here as *L. gangetica* species group (Fig. 5).

Two species, *L. cervi* and *L. caudata* from Oceania are unusual in both having a triangular process distally on the terminal segment of the male left leg 5. The first exopodal segment of male leg 5 bears an outer subterminal process in both species, although it is not certain whether these are homologous. In the female the exopod of leg 5 bears 3 distinct lateral and 2 terminal prominences, while the endopod is simply spiniform. The posterolateral prosomal corners of *L. cervi* are remarkably large compared to those of *L. caudata*. These two species are considered here as the *L. cervi* species group. McKinnon and Kimmerer (1984) pointed out the similarity in the fifth legs of both sexes of *L. caudata* and *L. madurae*, but we regard the unique structure of the terminal exopodal segment of the male left leg 5 as a robust synapomorphy to define the species group.

Labidocera detruncata is most closely related to *L. farrani* in sharing the following synapomorphies: (1) the complex, dorsal swelling on the genital compound somite of the female; (2) the anal somite of the female protruded mid-posteriorly; (3) the caudal rami of the female are widely separated, and the right ramus is larger than the left; (4) the basis of the female leg 5 is swollen; (5) the male right leg 5 has a spatulate thumb; (6) the terminal segment of the male left leg 5 has 4 elements, the second outermost of which is the longest. These two species belong to *L. detruncata* species group *sensu stricto*. *Labidocera detruncata* is widely distributed in oceanic waters of the Indo-Pacific

and West Atlantic regions, while *L. farrani* has a distribution in coastal waters of Indo-West Pacific (Silas and Pillai 1973, Greenwood and Othman 1979, Mulyadi 2002, Jeong et al. 2009, Razouls et al. 2014) (Fig. 5).

Labidocera pavo and *L. bataviae* share the following features in the female: (1) the female caudal rami are broadly separated and posterolaterally expanded; (2) the exopod of the female leg 5 is slender, with 3 lateral and 2 terminal distinct prominences; (3) the endopod of the female leg 5 is short, at most 1/3 to 1/4 as long as the exopod; (4) the thumb of the first exopodal segment of the male right leg 5 is bifid; (5) the terminal exopodal segment of the male left leg 5 is slender, and carries 3 fine elements. These two species belong to the *L. pavo* species group and they are broadly distributed in coastal waters of the temperate to tropical Indo-Pacific regions (Silas and Pillai 1973, Razouls et al. 2014) (Fig. 5).

As already mentioned in "Remarks", *L. madurae*, *L. tasmanica* and *L. churaumi* sp. n. together belong to the *L. madurae* species group. This species group has a restricted distribution in tropical to temperate waters of the Indo-Pacific (Scott 1909, Silas and Pillai 1973, Taw 1974, Razouls et al. 2014, present study) (Fig. 5). *Labidocera detruncata* is widely distributed in the Indo-West Pacific, while *L. pavo* has a narrow coastal distribution in the region. In addition *L. sinilobata* is restricted to the West Pacific, whereas *L. gangetica* occurs in the Indian Ocean. Such restricted distributions within this species complex suggest us the possibility of parallel speciation due to the isolation mechanism by the existence of Sundaland during the glacial periods (cf. Fleminger 1986).

Key to Indo-West Pacific species groups in *Labidocera detruncata* species complex

1 Endopods of female leg 5 absent; thumb and finger of male leg 5 slender ..... ***L. gangetica* species group**

– Endopods of female leg 5 present; thumb and finger of male leg 5 not slender **2**

2 Female genital compound somite with complex swelling dorsally; apical segment of male left leg 5 with 4 terminal elements, second outermost the longest ..... ***L. detruncata* species group**

– Female genital compound somite lacking dorsal swelling; apical segment of male left leg 5 with 4 or fewer elements terminally **3**

3 Female caudal rami asymmetrical, widely separated, perpendicular to anal somite; thumb of first exopodal segment of male right leg 5 bifid ..... ***L. pavo* species group**

– Female caudal rami symmetrical, neiwther widely separated nor perpendicular to anal somite; thumb of first exopodal segment of male right leg 5 not bifid **4**

4 Posterolateral prosomal corners of female asymmetrical with right longer than left; terminal exopodal segment of male left leg 5 with distal triangular process ..... ***L. cervi* species group**

– Posterolateral prosomal corners of female symmetrical; terminal exopodal segment of male leg left 5 lacking of distal triangular process ..... ***L. madurae* species group**

Key to species of *Labidocera madurae* species group

Female

1 Genital compound somite with right postero-lateral and left antero-lateral processes ..... ***L. churaumi* sp. n.**
– Genital compound somite without right postero-lateral and left antero-lateral processes **2**
2 Genital compound somite more than twice as long as wide, furnished with anterior triangular small process on each side..... ***L. tasmanica***
– Genital compound somite as long as wide, and produced mid-laterally .... ***L. madurae***

Male

1 Inner margin of terminal segment of left leg 5 with protrusion at mid-length ..... ***L. churaumi* sp. n.**
– Inner margin of terminal segment of left leg 5 without protrusion..... **2**
2 Terminal segment of right leg 5 with expanded basal region with serrated margin ..... ***L. tasmanica***
– Terminal segment of right leg 5 without expanded basal region.... ***L. madurae***

Acknowledgements

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RESEARCH ARTICLE

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Three new rotundabaloghid mites (Acari, Uropodina) from Sabah (Malaysia)

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Abstract

Three new species of the family Rotundabaloghiidae are discovered and described from Sabah, Malaysia. The unusual *Angulobaloghia rutra* **sp. n.** differs from the other known *Angulobaloghia* Hirschmann, 1979 species in the long anterior process of the female's genital shield. *Rotundabaloghia* (*Circobaloghia*) *tobiasi* **sp. n.** has very long and apically pilose dorsal setae and two pairs of bulbiform setae, which are unique in the subgenus *Rotundabaloghia* (*Circobaloghia*) Hirschmann, 1975. The long, serrate and curved setae in the big ventral cavity of *Depressorotunda* (*Depressorotunda*) *serrata* **sp. n.** is a so far unknown character in the subgenus *Depressorotunda* (*Depressorotunda*) Kontschán, 2010.

Keywords

East Asia, taxonomy, turtle-mites

Introduction

Mites of the family Rotundabaloghiidae distinctive within the Uropodina mites, having bodies that are small and rounded, ventral setae that are reduced and the marginal shield completely fused with the dorsal shield. The members of this family can be found in soil, leaf litter and moss in all tropical areas (Kontschán 2010a). Three

groups of the family [the genus *Angulobaloghia* Hirschmann, 1979 and the subgenera *Rotundabaloghia* (*Rotundabaloghia*) Hirschmann, 1975 and *Depressorotunda* (*Depressorotunda*) Kontschán, 2010] are distributed only in the South-East Asian and Austral-Asian regions, one subgenus *Depressorotunda* (*Amerorotunda*) Kontschán, 2010 occurs only in South-America and the most species rich subgenus [*Rotundabaloghia* (*Circobaloghia*) Hirschmann, 1975] can be found in all tropical regions (Kontschán 2010b, 2011, Kontschán and Starý 2011, 2012). Currently four species are listed from Borneo (Kontschán 2010a) (where three countries, namely Malaysia, Indonesia and Brunie can be found), but so far no species are reported from Sabah (Malaysia). Searching the Arachnida collection of the Natural History Museum in Geneva revealed three new rotundabaloghid species in samples from Sabah, which are described in this paper.

Material and methods

Specimens were cleared in lactic acid and drawings were made with the aid of a drawing tube. The system of nomenclature for the ventral chaetotaxy follow Kontschán's (2010a). All specimens are stored in ethanol and deposited in the Natural History Museum in Geneva (MHNG). Abbreviations: h = hypostomal setae, St = sternal setae, im = internal malae, ad = adgenital setae, V = ventral setae. All measurements and the scales in the figures are given in micrometres (μm).

Descriptions of new species

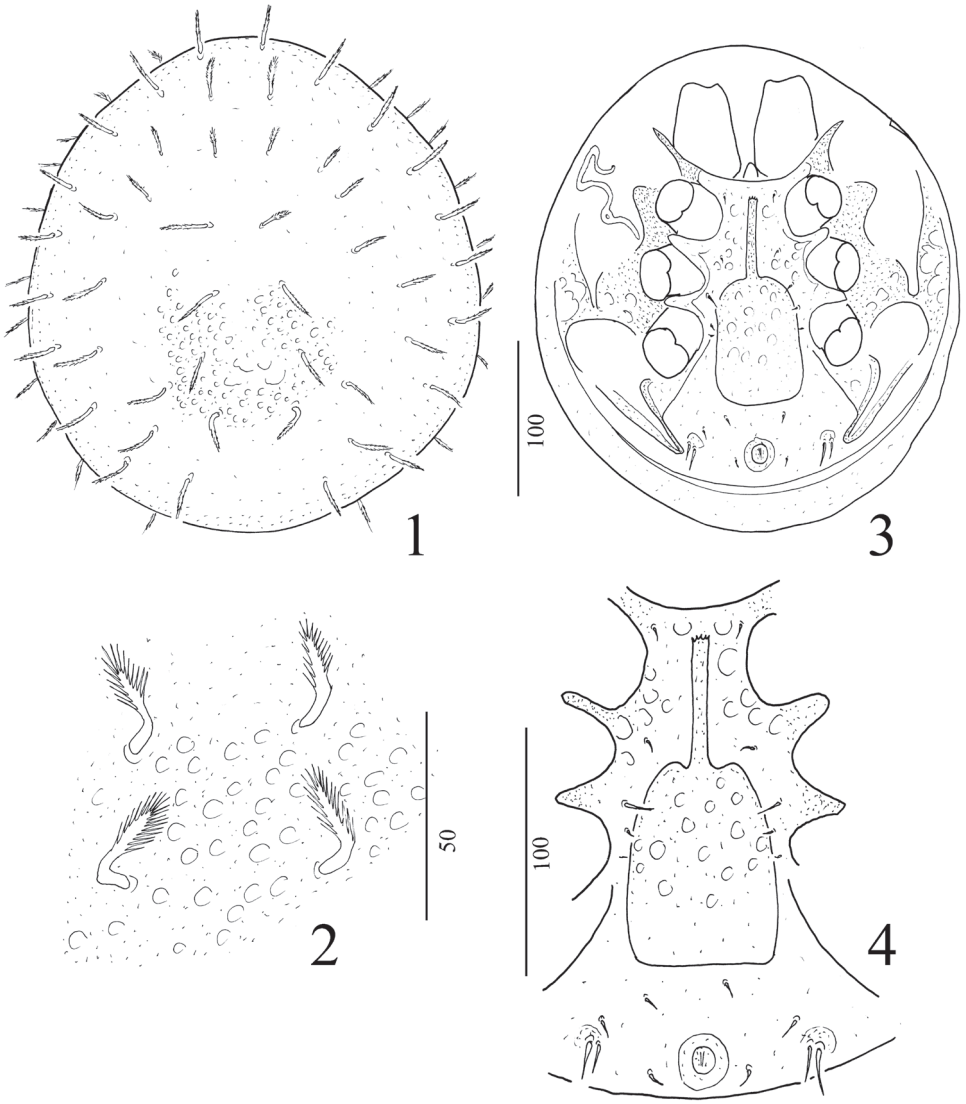
***Angulobaloghia rutra* sp. n.**
http://zoobank.org/187F29BC-A971-4115-AC7D-D7BF52284382
Figs 1–10

Material examined. Holotype: female. Sab-82/7. Malaysia: Sabah (Sandakan Residency): 15 milles (24 km) W de Sandakan: Sepilok: "Kabili-Sepilok Forest Reserve", forêt près du "Pond" (étang formant la réserve d'eau pour Sepilok), tamisage de feuilles mortes et de bois pourri, Secondary Lowland Forest; 23.IV.1982; leg. B.Hauser (appareil Winkler-Moczarski à Sepilok). Paratypes: four females. Locality and date same as in holotype.

Diagnosis. Genital shield of female with a long apical process and its surface covered by oval pits. Setae V7 and V8 smooth and needle-like, situated near end of pedofossae IV on small platelets. Setae on dorsal side of body pilose.

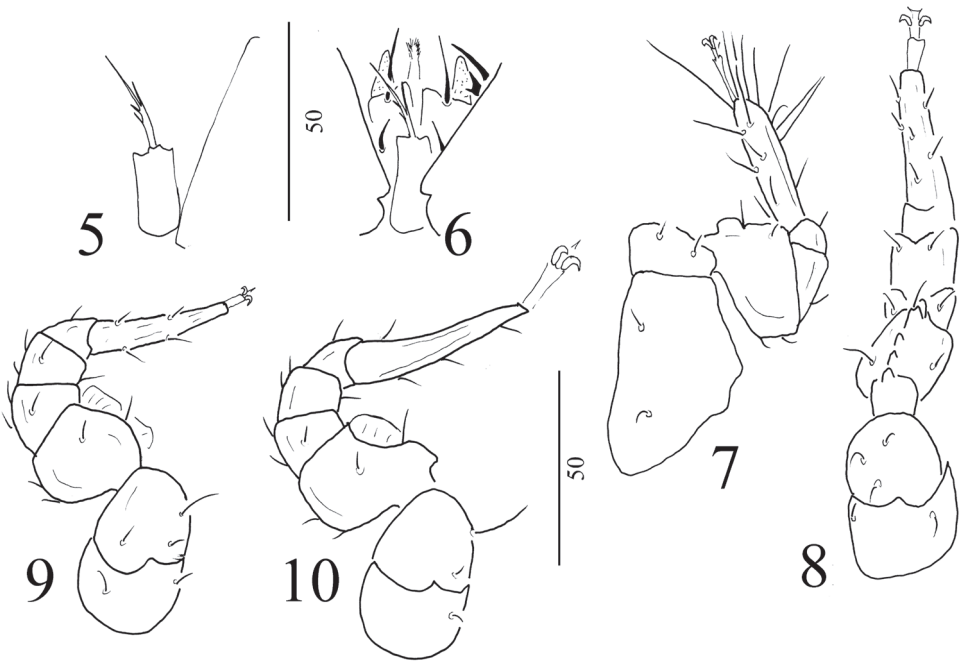
Description of female. Length of idiosoma 290–320 μm, width 280–290 μm (n = 5). Shape circular, posterior margin rounded, color reddish-brown.

Dorsal idiosoma (Figure 1). Marginal and dorsal shields fused. Dorsal setae basally curved, margins pilose (ca 22–26 μm long) (Figure 2). Surface of dorsal body covered by small oval pits (Figure 2).



Figures 1–4. *Angulobaloghia rutra* sp. n., female, holotype: **1** body in dorsal view **2** setae and ornamentation in dorsal shield **3** body in ventral view **4** intercoxal area of female.

Ventral idiosoma (Figure 3). Sternal shield ornamented by oval pits (Figure 4). Sternal setae smooth, needle-like, three pairs (St1, St2 and St4) short (ca 4–5 μm) and one pair long (ca 9–10 μm). St1 situated at level of anterior margin of coxae II, St2 at level of central area of coxae II, St3 at level of posterior margin of coxae III, St4 at level of central area of coxae IV. One pair of lyriform fissures situated near St4. Ventral shield without sculptural pattern. Ventral setae smooth and needle-like. V2 (ca 5–6 μm long) situated near basal line of genital shield. V6 shorter (ca 6–7 μm), V7 (ca 10–11 μm) and V8 (ca 13–14 μm) longer and they situated near end of pedofossae



Figures 5–10. *Angulobaloghia rutra* sp. n., female, holotype: **5** tritosternum **6** ventral view of gnathosoma, tritosternum and part of coxae I **7** ventral view of leg I **8** ventral view of leg II **9** ventral view of leg III **10** ventral view of leg IV.

IV. A small platelets bearing setae V7 and V8. Setae *ad* similar in shape and length to V2 setae, situated laterally to anal opening. Stigmata situated between coxae II and III. Peritremes hook-shaped. Genital shield linguliform with long apical process. Anterior margin of apical process serrate (Figure 4). Surface of genital shield covered by oval pits. Pedofossae deep, their surface smooth, separated furrows for tarsi IV present. Base of tritosternum narrow, vase-like, tritosternal laciniae smooth, subdivided into four smooth branches in its distal half (Figure 5).

Gnathosoma (Figure 6). Corniculi horn-like, internal malae smooth and short. Visible hypostomal setae as follows: h1 long (about 17–18 μm), smooth and needle-like, h2 short (about 8–9 μm), smooth and needle-like, h3 and h4 not visible (covered by coxae I). Apical part of epistome marginally pilose. Ventral side of palp trochanter with one needle-like and one robust and bifurcated setae, other setae on palp smooth and needle-like. Fixed digit of chelicerae longer than movable digit, internal sclerotized node present.

Legs (Figures 7–10). All legs with ambulacral claws and smooth and needle-like setae, femora II-Iv with flap-like ventral process.

Larva and nymphs, male unknown.

Etymology. The name of the new species refers to the shape of the female's genital shield. The linguliform genital shield with the long apical process resembles a shovel (= *rutrum* in Latin).

Remarks. The new species differs from the other known *Angulobaloghia* species by the apical process and pit-like ornamentation of the genital shield in females. Most other known *Angulobaloghia* species have female genital shields that are triangular, semicircular or bottle-like . Only one species [*A. vietnamensis* (Kontschán, 2008)] has a linguliform genital shield, but the apical process is short and spine-like. In contrast, females of the new species have a long and apically serrate genial process.

***Rotundabaloghia* (*Circobaloghia*) *tobiasi* sp. n.**
http://zoobank.org/5F0276EC-A10C-4DB8-9ABD-56C039A909FD
Figs 12–20

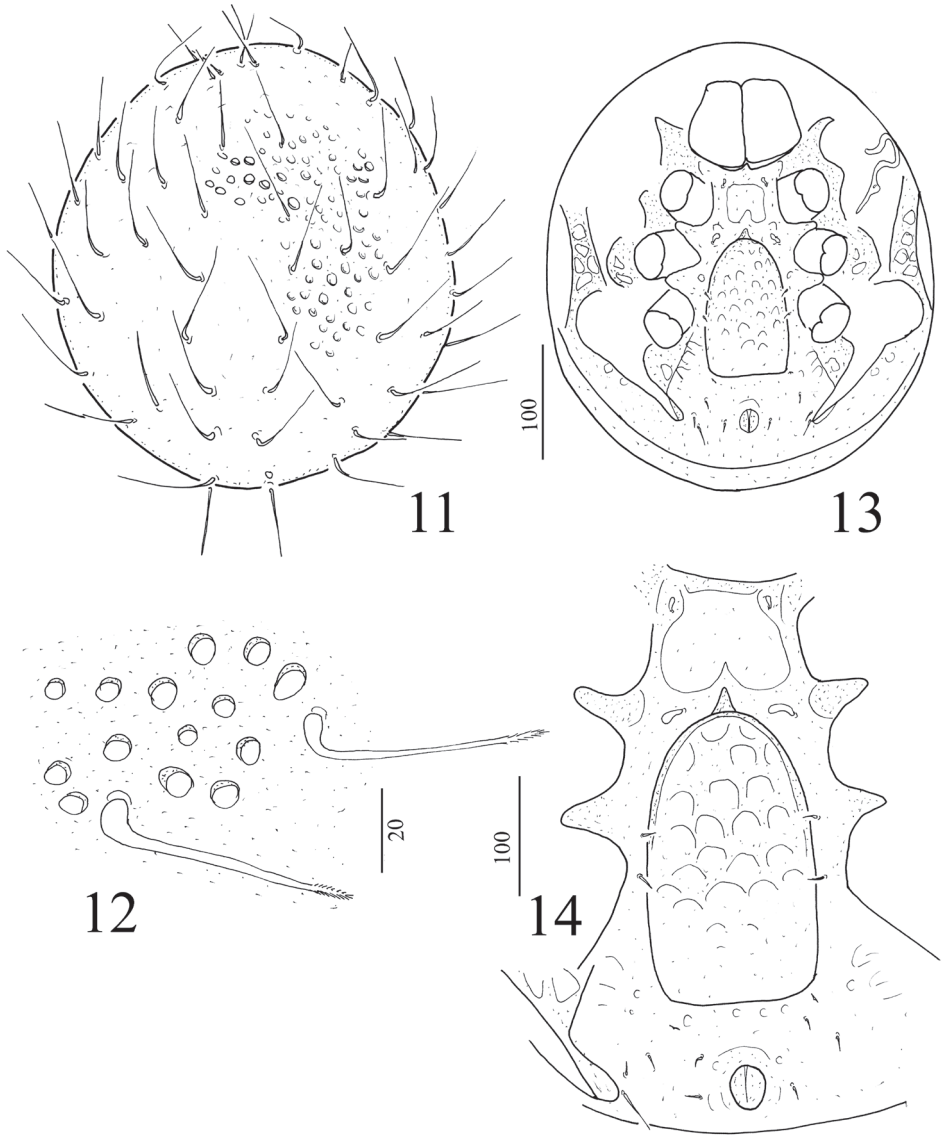
Material examined. Holotype: female. Sab-82/15. Malaysia: Sabah (West Coast Residency): Mt Kinabalu: "Bukit Ular Trail" (sentier reliant "Kambarangan Road" à "Power Station"), tamisage de feuilles mortes et de bois pourri, forêt de *Lithocarpus-Castanopsis*, 1790m; 28.IV.1982; leg. B.Hauser (appareil Winkler-Moczarski à Sepilok). Paratypes: one female and one male. Locality and date same as in holotype.

Diagnosis. Genital shield linguliform, its surface with irregular pits and bearing a small spine-like process on anterior margin. Setae St1 and St2 bulbiform in females. Ventral setae V2, V6, V7 and ad short, V8 four times longer than other ventral setae. Dorsal setae long and apically pilose. Surface of dorsal shield with deep and oval pits.

Description of female. Length of idiosoma 370–380 μm, width 300–340 μm (n = 2). Shape circular, posterior margin rounded, color reddish brown.

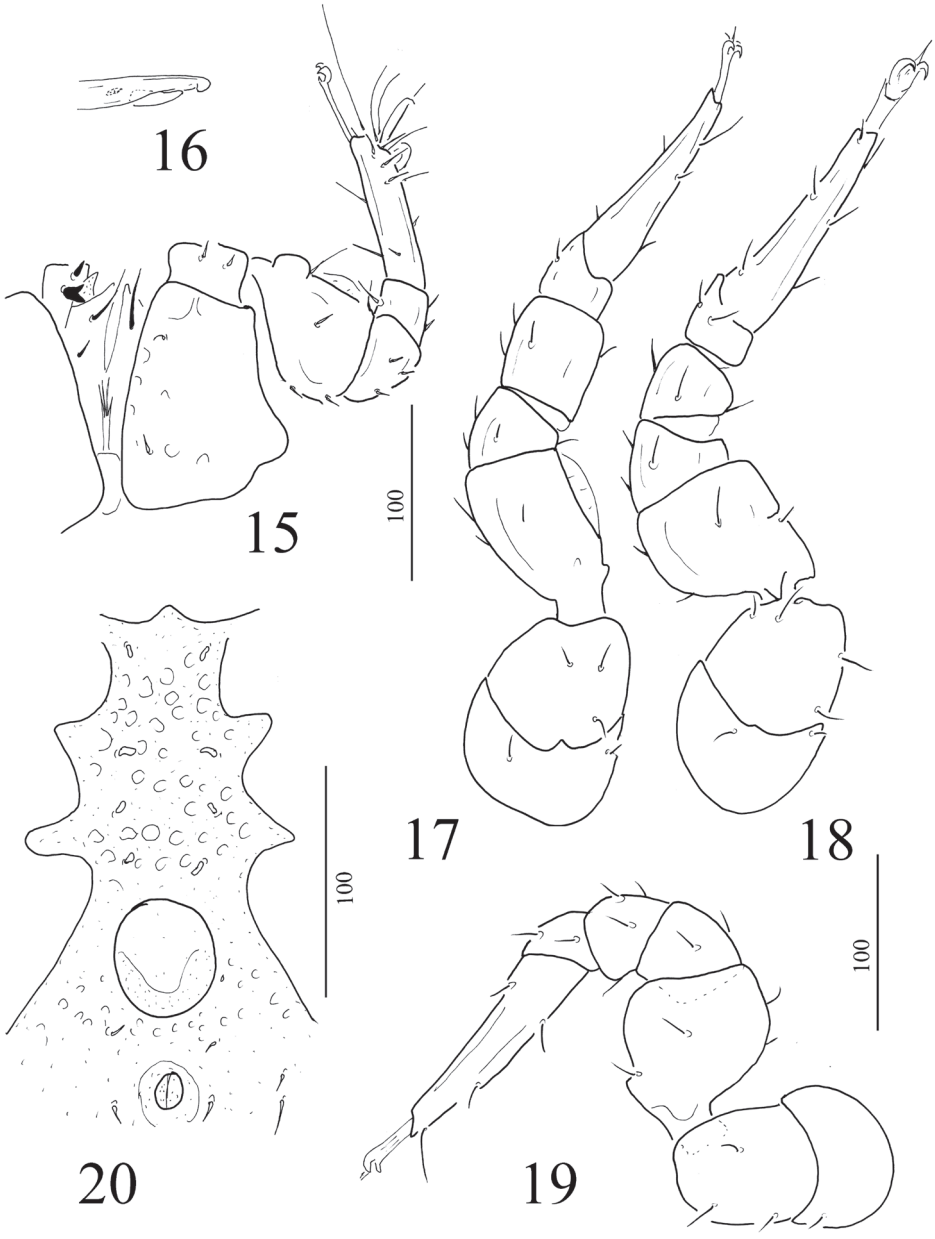
Dorsal idiosoma (Figure 11): Marginal and dorsal shields fused. All dorsal setae very long (ca 75–80 μm), basally curved and apically pilose (Figure 12). Dorsal idiosoma covered by deep and oval pits (Figure 12).

Ventral idiosoma (Figure 13). Surface of sterna shield without sculptural pattern, only a large pit situated between coxae II. Setae St1 smooth, short (ca 4–5 μm) and bulbiform, situated near anterior margin of sternal shield, St2 smooth and bulbiform, but longer than St1 (ca 9–10 μm), situated at level of anterior margin of coxae III, St3 and St4 smooth and short (ca 6–7 μm), St3 at level of anterior margin of coxae IV, St4 at level of central area of coxae IV. St5 absent. Ventral setae smooth and needle-like. V2 (ca 7–8 μm) situated near posterior margin of genital shield (in a paratype one of V6 setae situated near to setae ad (Figure 14)). V6 short (ca 6–7 μm) and situated between V2 and V7. V7 short (ca 9–10 μm) and situated near end of pedofossae IV. V8 long (ca 15–17 μm) and situated near V7. Setae *ad* similar in shape and length to V6, lateral to anal opening. One pair of lyriform fissures placed near basal edges of genital shield. Stigmata situated between coxae II and III. Peritremes hook-shaped. Genital shield linguliform, surface with large irregular pits and its apical margin rounded and bearing a spine-like process. Pedofossae deep, their surface smooth, separated furrows for tarsi IV present. Base of tritosternum narrow, tritosternal laciniae smooth, subdivided into four smooth branches (Figure 15).



Figures 11–14. *Rotundabaloghia* (*Circobaloghia*) *tobiasi* sp. n., female holotype: **11** body in dorsal view **12** dorsal setae and ornamentation **13** ventral view of body **14** intercoxal area of a female paratype.

Gnathosoma (Figure 15). Corniculi horn-like, internal malae smooth and very short. Visible hypostomal setae as follows: h1 long (about 28–30 μm), smooth and needle-like, h2 short (about 11–13 μm), smooth and needle-like, h3 and h4 not visible (covered by coxae I). Apical part of epistome marginally pilose. Ventral side of palp trochanter with one needle-like and one robust and bifurcated setae, other setae on palp smooth and needle-like. Fixed digit of chelicerae longer than movable digit, internal sclerotized node present (Figure 16).



Figures 15–20. *Rotundabaloghia* (*Circobaloghia*) *tobiasi* sp. n., female holotype: **15** ventral view of gnathosoma, tritosternum and leg I **16** chelicera **17** ventral view of leg II **18** ventral view of leg III **19** ventral view of leg IV **20** intercoxal area of a male paratype.

Legs (Figures 17–20). All legs with ambulacral claws and smooth and needle-like setae.
Description of male. Length of idiosoma 370–410 μm, width 340–370 μm (n = 5).
Dorsal idiosoma. Ornamentation and chaetotaxy of dorsal shield as for female.

Ventral idiosoma (Figures 16). Four pairs of sternal setae bulbiform (ca. 7–8 μm) and situated anterior to genital shield. St1 situated near anterior margin of sternal shield, St2 situated at level of anterior margin of coxae III, St3 at level of posterior margin of coxae III, St 4 at level of central area of coxae IV. Surface of sternal shield with numerous oval pits. Surface of ventral shield and shape and size of ventral setae as in female. Genital shield circular and situated between coxae IV.

Larva and nymphs unknown.

Etymology. I dedicate the new species to my colleague and dear friend Dr. István Tóbiás, plant virologist.

Remarks. The short apical spines on the genital shield, long dorsal setae and the bulbiform sternal setae in *Rotundabaloghia* (*Circobaloghia*) *tobiasi* sp. n. is an unknown character combination within the subgenus *Rotundabaloghia* (*Circobaloghia*) Hirschmann, 1975.

***Depressorotunda* (*Depressorotunda*) *serrata* sp. n.**

http://zoobank.org/7F4F93C8-F905-42BF-BC68-2B1EE3A8D569

Figs 21–31

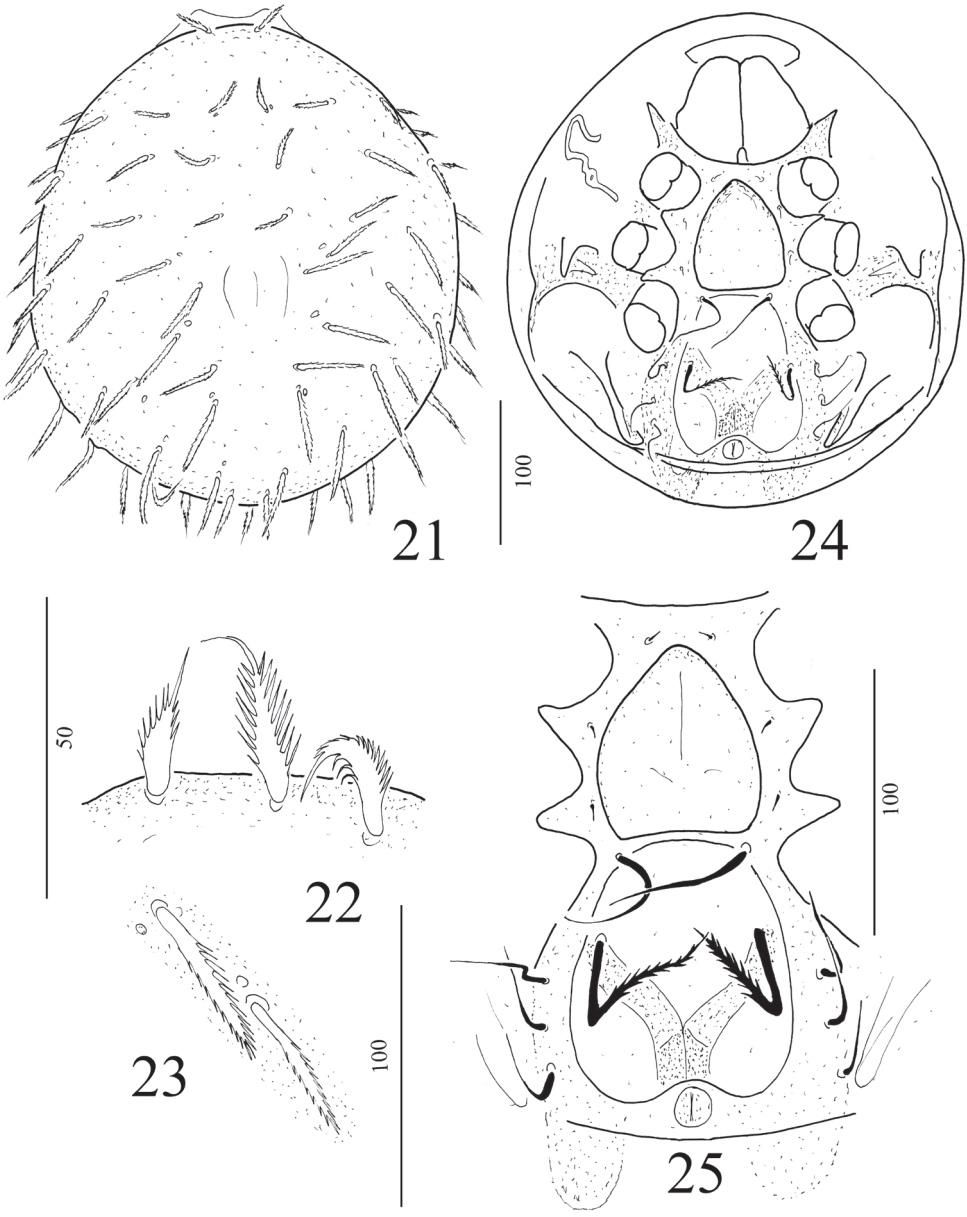
Material examined. Holotype: female. Sab-82/7. Malaysia: Sabah (Sandakan Residency): 15 milles (24 km) W de Sandakan: Sepilok: "Kabili-Sepilok Forest Reserve", forêt près du "Pond" (étang formant la réserve d'eau pour Sepilok), tamisage de feuilles mortes et de bois pourri, Secondary Lowland Forest; 23.IV.1982; leg. B.Hauser (appareil Winkler-Moczarski à Sepilok). Paratypes: six females and three males, locality and date same as in holotype.

Diagnosis. Ventral cavity oval, with one pair of long, robust, marginally serrate and curved setae. Genital shield scutiform, its surface smooth. Three pairs of short ventral setae situated near lateral margins of ventral cavity. Setae St4 very long and needle-like.

Description of female. Length of idiosoma 310–330 μm, width 270–290 μm (n = 7). Shape circular, posterior margin rounded, color reddish brown.

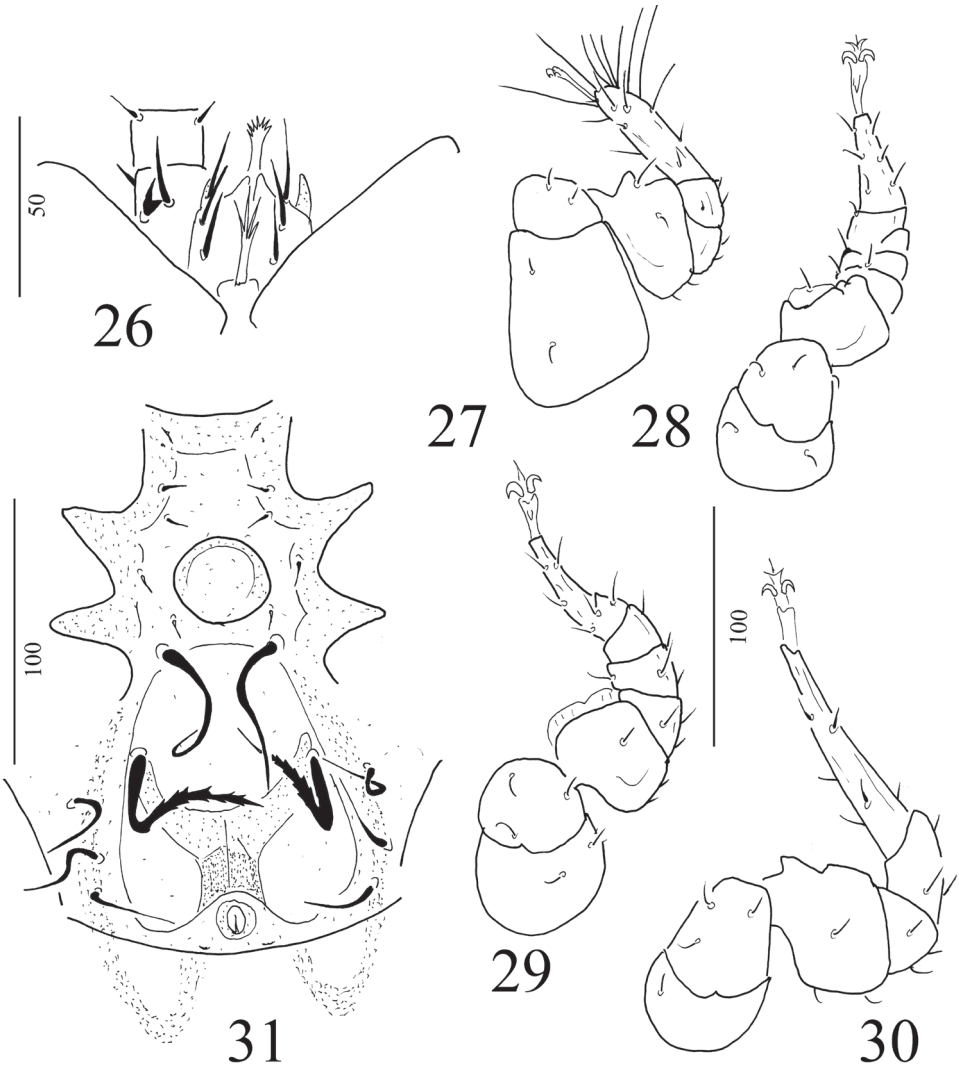
Dorsal idiosoma (Figure 21). Marginal and dorsal shields fused. Dorsal setae long (ca 42–47 μm long) and marginally pilose (Figures 23), apical setae wider than other dorsal setae (Figure 22), dorsal idiosoma without sculptural pattern.

Ventral idiosoma (Figure 24). Sternal and ventral shields without sculptural pattern. All sternal setae smooth, needle-like. Setae St1-St3 short (ca 4–6 μm), St4 robust and long (ca 58–60 μm). St1 situated at level of anterior margin of genital shield, St2 at level of posterior margin of coxae II, St3 at level of posterior margin of coxae III, St4 near basal edges of genital shield. Dorsal cavity large, oval, longer (ca 94–97 μm) than wide (ca 83–85 μm) bearing a pair of long (ca 59–62 μm) and serrate setae. Ventral setae smooth, needle-like (cat 32–35 μm) and placed in a row near margins of ventral cavity (Figure 25). Adanal setae absent. One pairs lyriform fissures situated near anterior margin of sternal shield. Stigmata situated between coxae II and III.



Figures 21–25. *Depressorotunda* (*Depressorotunda*) *serrata* sp. n. female holotype: **21** body in dorsal view **22** anterior dorsal setae **23** dorsal setae from central area of dorsal shield **14** ventral view of body **25** intercoxal area of holotype.

Peritremes hook-shaped. Genital shield scutiform, surface smooth and its apical margin a little peaked. Pedofossae deep, their surface smooth, separated furrows for tarsi IV present. Base of tritosternum narrow, tritosternal laciniae smooth, subdivided into four smooth branches (Figure 26).



Figures 25–31. *Depressorotunda* (*Depressorotunda*) *serrata* sp. n. female holotype: **26** ventral view of gnathosoma, tritosternum, two segments of palp and coxae I **27** ventral view of leg I **28** ventral view of leg II **29** ventral view of leg III **30** ventral view of leg IV **31** intercoxal area of a male paratype.

Gnathosoma (Figure 26). Corniculi horn-like, internal malae smooth and very short. Visible hypostomal setae as follows: h1, h2 and h3 long (about 18–21 μm), smooth and needle-like. Apical part of epistome marginally pilose. Ventral side of palp trochanter with one needle-like and one robust and bifurcated setae, other setae on palp smooth and needle-like. Fixed digit of chelicerae longer than movable digit, internal sclerotized node present.

Legs (Figures 27–30). All legs with ambulacral claws and smooth, needle-like setae.

Description of male. Length of idiosoma 330–340 μm, width 300–330 μm (n = 3).

Dorsal idiosoma. Ornamentation and chaetotaxy of dorsal shield as for female.

Ventral idiosoma (Figure 31). Four pairs of short sternal setae (St1-St4) needle-like (ca. 4-6 μm), St1 and St2 situated anterior to genital shield, St3 at level of central area of genital shield and St4 at level of posterior margin of genital shield. St5 long, robust (ca. 57–59 μm) and placed near anterior margin of ventral cavity. Dorsal cavity large, oval, longer (ca 96–99 μm) than wide (ca 82–85 μm) bearing a pair of long (ca 58–62 μm) and serrate setae. One pairs lyriform fissures situated near anterior margin of sternal shield, second one pair near posterior margin of anal opening. Surface of ventral shield and shape and size of ventral setae as in female. Genital shield circular and situated between coxae III.

Larva and nymphs unknown.

Etymology. The name of the new species refers to the serrate setae in ventral cavity.

Remarks. The long, robust, marginally serrate and curved setae on the big ventral cavity and the extreme long St4 setae in the species *Depressorotunda* (*Depressorotunda*) *serrata* sp. n. are previously not observed characters within the subgenus *Depressorotunda* (*Depressorotunda*) Kontschán, 2006.

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RESEARCH ARTICLE

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Taxonomy of the ant genus *Proceratium* Roger (Hymenoptera, Formicidae) in the Afrotropical region with a revision of the *P. arnoldi* clade and description of four new species

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Abstract

The taxonomy of the genus *Proceratium* Roger is updated for the Afrotropical region. We give an overview of the genus in the region, provide an illustrated identification key to the three clades (*P. arnoldi*, *P. stictum* and *P. toschii* clades) and revise the *P. arnoldi* clade. Four new species from the *P. arnoldi* clade are described as new: *P. sokoke* **sp. n.** from Kenya, *P. carri* **sp. n.** from Mozambique, and *P. nilo* **sp. n.** and *P. sali* **sp. n.** from Tanzania. In order to integrate the new species into the existing taxonomic system we present an illustrated identification key to distinguish the seven Afrotropical species of the *P. arnoldi* clade. In addition, we provide accounts for all members of the *P. arnoldi* clade including detailed descriptions, diagnoses, taxonomic discussions, distribution data and high quality montage images.

Keywords

Arabuko Sokoke Forest, Gorongosa National Park, Kenya, Mozambique, Nilo Forest, *Proceratium arnoldi* clade, *Proceratium stictum* clade, *Proceratium toschii* clade, Sali Forest, Tanzania, taxonomy

Introduction

The ant genus *Proceratium* Roger, 1863 contains 77 extant and 5 fossil species and is patchily distributed throughout all biogeographical regions (Baroni Urbani and de Andrade 2003; Bolton 2014). Despite this global distribution, these ants are seldom collected, likely due to their cryptobiotic lifestyle (Baroni Urbani and de Andrade 2003). In addition, the natural history of this genus is known from only a few fragmentary reports based on a minority of the known species. At present, it seems that *Proceratium*, like *Discothyrea* Roger, are specialised predators of arthropod eggs. Brown (1958a, 1974, 1980) repeatedly reported several species (*P. avium* Brown, 1974, *P. micrommatum* (Roger, 1863), *P. pergandei* (Emery, 1895) and *P. silaceum* Roger, 1863) carrying, storing and feeding on spider eggs. More recently, Fisher (2005b) also observed the same behaviour and diet in *P. avium* from Mauritius. Most species seem to nest in the soil, below leaf litter, in rotten wood, under deep-set stones, or in tree branches (Brown 1958a, 1974; Baroni Urbani and de Andrade 2003; Fisher 2005b). Colonies of *Proceratium* seem to be relatively small, mostly containing fewer than 100 workers (Brown 1958a, 1958b; Leston 1971), but can have a few hundred workers in some species (Onoyama and Yoshimura 2002; Fisher 2005b). Fisher (2005b) documented the largest colony encountered so far with ca. 350 workers for *P. avium* on Mauritius.

The taxonomy of the genus is in a relatively good condition since Baroni Urbani and de Andrade (2003) revised it on a global scale and provided a morphology-based phylogeny. However, due to the rarity of collections and specimens, there is very little information about intra- and interspecific variation. This becomes apparent from the fact that more than half of the species are known from only one or two type specimens and most of the others have never been collected as a nest series, especially in the tropics. A few species have been discovered and described since 2003 (Fisher 2005b; Xu 2006) and more species can be expected in the future. In their revision, Baroni Urbani and de Andrade (2003) recognised six Afrotropical species belonging to three clades: the *arnoldi* clade with three species (*P. arnoldi* Forel, 1913, *P. burundense* de Andrade, 2003 and *P. lunatum* Terron, 1981), the *P. stictum* clade with one species (*P. boltoni* Leston, 1971) and the *P. toschii* clade with two species (*P. terroni* Bolton, 1995 and *P. toschii* (Consani, 1951)).

In this study we describe four new species: *P. carri* sp. n. from Mozambique, *P. nilo* sp. n. and *P. sali* sp. n. from Tanzania and *P. sokoke* sp. n. from Kenya. We place these four new species in the *P. arnoldi* clade sensu Baroni Urbani and de Andrade (2003), which increases the diversity of the clade in the Afrotropical region to seven species. To separate these from the Afrotropical members of the *P. stictum* and *P. toschii* clades we provide an illustrated identification key to the three clades and we present an illustrated identification key to the seven species of the *P. arnoldi* clade. We also provide species accounts for all members of the clade with detailed descriptions, diagnoses, distribution data, taxonomic discussions and high quality montage images.

Abbreviations of depositories

The collection abbreviations mostly follow Evenhuis (2014). The material upon which this study is based is located and/or was examined at the following institutions:

AFRC AfriBugs, Pretoria, Gauteng, South Africa
BMNH The Natural History Museum, London, U.K.
CASC California Academy of Sciences, San Francisco, California, U.S.A.
CIRAD Centre de coopération Internationale en recherche agronomique pour le développement, Montpellier, France
MCZ Museum of Comparative Zoology, Cambridge, Massachusetts, U.S.A.
MHNG Muséum d'Histoire Naturelle de la Ville de Genève, Geneva, Switzerland
MNHN Muséum National d'Histoire Naturelle, Paris, France
SAMC Iziko Museums of South Africa, Cape Town, South Africa

Material and methods

The material for the new species on which this study is based was collected during several recent, still on-going ant diversity inventories in Kenya, Tanzania and Mozambique carried out independently by the three authors. The material from the new species and most of the previously known specimens can be uniquely identified with specimen-level barcodes affixed to each pin (*e.g.* MCZ-ENT00517081 or CASENT0235688). The series of stacked digital colour images were created either by a Canon 7D camera attached to a Leica MZ16 stereomicroscope and source images processed using Helicon Focus 5.3, or with a Leica DFC 425 camera in combination with the Leica Application Suite software. These images are all available online and can be seen on AntWeb (www.antweb.org) and AntWiki (www.antwiki.org).

The measurements were taken with a Leica MZ16 stereomicroscope equipped with an orthogonal pair of micrometers at a magnification of 100×. Measurements and indices are presented as minimum and maximum values and all measurements are expressed in mm to two decimal places. The measurements and indices used in this study are based on Ward (1988), Snelling and Cover (1992) and Baroni Urbani and de Andrade (2003); a few measurements have been redefined following Hita Garcia and Fisher (2011) and we define a few measurements and indices new to *Proceratium* (OI, DPeI and ASI):

EL Eye length – maximum length of eye measured in oblique lateral view
HL Head length – maximum measurable distance from the mid-point of the anterior clypeal margin to the mid-point of the posterior margin of head, measured in full-face view. Impressions on anterior clypeal margin and posterior head margin reduce head length

HLM Head length with mandibles – maximum head length in full-face view including closed mandibles

HW Head width – maximum head width directly behind the eyes, measured in full-face view

HFeL Hind femur length – maximum length of hind femur measured along its external face

HTiL Hind tibia length – maximum length of hind tibia measured on its external face

HBaL Hind basitarsus length – maximum length of hind basitarsus measured along its external face

LT3 Abdominal tergum III length – maximum length of abdominal tergum III (= length of segment III) in lateral view

LS4 Abdominal sternum IV length – maximum length of abdominal sternum IV following Ward (1988)

LT4 Abdominal tergum IV length – maximum length of abdominal tergum IV following Ward (1988)

PeL Petiolar length – maximum length of the petiole in dorsal view including its anterior prolongation

PeW Petiolar width – maximum width of petiole measured in dorsal view

SL Scape length – maximum length of scape shaft excluding basal condyle

TL Total body length – combined length of HLM + WL + PeL + LT3 + LT4

WL Weber's length – diagonal length of mesosoma in lateral view from the anterior-most point of pronotal slope (excluding neck) to posteroventral margin of propodeal lamella or lobe.

CI Cephalic index – HW / HL × 100

OI Ocular index – EL / HW × 100

SI Scape index – SL / HL × 100

DPeI Dorsal petiole index – PeW / PeL × 100

ASI Abdominal segment index – LT4 /LT3 × 100

IGR Gastral reflexion index – LS4 / LT4

The morphological terminology used in this study follows Snelling and Cover (1992) and Baroni Urbani and de Andrade (2003) with few exceptions. The use of postpetiole, gastral segments and abdominal segments in Baroni Urbani and de Andrade (2003) is confusing at times. To avoid this we do not use the terms postpetiole and gaster and instead use abdominal segment III for the postpetiole following Fisher (2005b) and abdominal segment IV for the gastral segment I. Also, instead of "spur of foretibia", as in Baroni Urbani and de Andrade (2003), we use the term "calcar of strigil" following Keller (2011). Furthermore, in order to adequately describe pubescence and pilosity we follow Wilson (1955) and use the terms "erect", "suberect", "subdecumbent", "decumbent" and "appressed". The terminology for the description of surface sculpturing is based on Harris (1979).

We have not been able to examine the palp formula of most species treated in this study. Due to the lack of material we did not want to risk damaging the few specimens

(most of them unique types) by moving heads or dissecting mouthparts. Baroni Urbani and de Andrade (2003) provided the palp formula 3.2 for *P. arnoldi*, *P. burundense* and *P. lunatum*, and we were able to confirm this for *P. lunatum*.

Notes on diagnostic characters

In addition to the Afrotropical material treated here we examined a larger number of species from other regions in order to assess general variation within *Proceratium*. Of special importance was the examination of the interspecific and intraspecific variation in general dimensions, the shape of the petiolar node, especially its ventral process, pilosity/pubescence and surface sculpturing. For this purpose we examined the following species, which include several undescribed species from the Malagasy region (AntWeb): *P. angulinode* de Andrade, 2003 [Malaysia]; *P. austronesicum* de Andrade, 2003 [Papua New Guinea]; *P. avium* Brown, 1974 [Mauritius]; *P. banjaranense* de Andrade, 2003 [Malaysia]; *P. crassicorne* Emery, 1895 [U.S.A.]; *P. croceum* (Roger, 1860) [U.S.A.]; *P. deelemani* Perrault, 1981 [Malaysia, Thailand]; *P. diplopyx* Brown, 1980 [Madagascar]; *P.* fhg-alob [Madagascar]; *P.* fhg-beta [Madagascar]; *P.* fhg-elia [Madagascar]; *P.* fhg-mala [Madagascar]; *P.* fhg-seyc [Seychelles]; *P. google* Fisher, 2005b [Madagascar]; *P. papuanum* Emery, 1897 [Papua New Guinea]; *P. sulawense* de Andrade, 2003 [Indonesia]; *P. terraealtae* de Andrade, 2003 [Malaysia]. On the basis of the examination of the above species and despite the paucity of Afrotropical material, we are very confident in using character sets that appear to be stable within other *Proceratium* species from other regions. Furthermore, the species *P. arnoldi*, *P. carri* and especially *P. lunatum* are known from at least two localities that are often several hundreds or even thousands of km apart. Despite these distances, there is little to no observable intraspecific variation, which is suggestive of a fairly high level of conservation of morphological characteristics over relatively long distances. In contrast, *P. sokoke* and *P. nilo* differ more significantly morphologically, yet their type localities are separated by only 220 km.

Nevertheless, to our surprise, one commonly used character for species level diagnostics turned out to be relatively variable. We observed a lot of intraspecific variation in the surface sculpture of several species throughout most regions. This was already pointed out by Fisher (2005b) who found *P. avium* from Mauritius to display noticeable differences in density and depth of surface sculpture. Our study supports this and extends it to the majority of species examined. The differences are not extreme, however, which means that there are never very different types of sculpture in the same species, but the type encountered can vary from very weakly developed and almost absent to very strongly developed, dense and conspicuous. Consequently, surface sculpture is not recommendable as a primary diagnostic character for the separation of the species treated herein or *Proceratium* in general.

Characters that have proven to be comparatively stable at species level are general dimensions of the head and petiole, the shape of the ventral process of the petiole, the relationship between abdominal segments III and IV, eye size and also pilosity and pubescence.

Like in most ants, the shape of the head and petiole turned out to be very stable within species-specific ranges and are useful for diagnostics. The relationship between the lengths of abdominal segments III and IV proved to be valuable, too. The development of the eyes is normally not very important in *Proceratium* since most species have very reduced eyes consisting of one ommatidium, a tiny cluster of indistinct flat ommatidia only distinguishable at high magnifications, or no eyes at all, but a few species, such as *P. burundense* de Andrade, 2003, have slightly larger compound eyes. At first glance the use of pilosity/pubescence might seem challenging since most species of *Proceratium* are very hairy and possess different types of hairs throughout their bodies. However, despite some small variation in density, which can also be attributed to specimen processing, we could not observe any significant variability in pilosity/pubescence within species. Especially the lack or presence of abundant, longer, standing pilosity on top of the very dense mat of subdecumbent to decumbent hairs seems to be species-specific.

Synopsis of Afrotropical *Proceratium* species

***Proceratium arnoldi* clade**
Proceratium arnoldi Forel, 1913 [South Africa, Zimbabwe]
Proceratium carri Hita Garcia, Hawkes & Alpert, sp. n. [Mozambique]
Proceratium burundense de Andrade, 2003 [Burundi]
Proceratium lunatum Terron, 1981 [Cameroon, Gabon, Uganda]
Proceratium nilo Hita Garcia, Hawkes & Alpert, sp. n. [Tanzania]
Proceratium sali Hita Garcia, Hawkes & Alpert, sp. n. [Tanzania]
Proceratium sokoke Hita Garcia, Hawkes & Alpert, sp. n. [Kenya]

***Proceratium stictum* clade**
Proceratium boltoni Leston, 1971 [Ghana]

***Proceratium toschii* clade**
Proceratium terroni Bolton, 1995 [Cameroon]
Proceratium toschii (Consani, 1951) [Kenya]

Notes on the genus in the Afrotropical region

Considering the biogeography of the genus in sub-Saharan Africa and the rarity of collections, the available data about the distribution patterns of most species is very limited. This is especially true for more than half of the species that are only known from the type locality (*P. burundense*, *P. nilo*, *P. sali*, *P. sokoke*, *P. terroni* and *P. toschii*). The data for the other four species (*P. arnoldi*, *P. boltoni*, *P. carri*, and *P. lunatum*) is a

bit better, even though they are also only known from a few localities each. The widest known distribution is seen in *P. lunatum*, which occurs in Cameroon and Gabon, but is also found in Uganda. We expect that this species will also be found in the rainforests of the Democratic Republic of Congo, Congo, and Central African Republic with further sampling in these countries. Leston (1971) noted that for the three then known species (*P. arnoldi*, *P. boltoni* and *P. toschii*) it seemed as if most of the Afrotropical *Proceratium* prefer drier savannah habitats. Nonetheless, *P. lunatum* and *P. terroni* were later described from rainforests in Cameroon (Terron 1981), and the four new species presented in this study inhabit coastal, montane or sandy forest types. So, it seems as if *Proceratium* can be found in most sub-Saharan habitats with the exception of semi-deserts and deserts.

As mentioned above, due to the cryptobiotic lifestyle and small colony size, it is not easy to collect *Proceratium*, but their rarity might also be due to sampling artefacts. For example, intensive sampling in two localities in Kenya (Kakamega Forest and Mpala Research Centre, listed in Hita Garcia et al. 2013) yielded not a single *Proceratium* worker. However, each study found an unidentified male showing clearly that the genus is present in both localities. Consequently, we expect that intensive sampling in the soil stratum in a wide range of habitats throughout the Afrotropical region will very likely yield additional material of the currently known species and from new, yet unknown forms, as can be seen for the Malagasy region, where more than ten undescribed species have been collected within the last decade due to very intensive sampling efforts to collect subterranean ants in general (Fisher 2005a; Yoshimura and Fisher 2014; FHG, unpublished data).

The knowledge on natural history or behaviour for the ten Afrotropical species is extremely limited. Leston (1971) provided the only available data on any of them. He collected a relatively small colony (one queen with 42 workers and a few larvae and pupae) of *P. boltoni* in a piece of rotten wood in the ground and he was also able to collect the same species around 600 m away in the topsoil at the base of a tree. He did not mention more on its natural history except that one greenish dipterous egg and one live nematode were with the colony.

Identification key to Afrotropical *Proceratium* clades

The following key is derived from Baroni Urbani and de Andrade (2003). It should be noted however, that we exclude the Malagasy species (Madagascar plus the surrounding islands of the Southwest Indian Ocean) from this key. We consider the Malagasy region as a distinct biogeographical region of its own following Bolton (1994).

1 Clypeus well developed, clearly protruding anteriorly, surrounding the antennal sockets and medially impressed; vertex in full face view weakly concave; calcar of strigil with a basal spine (Fig. 1A, B) ..... ***P. stictum* clade**

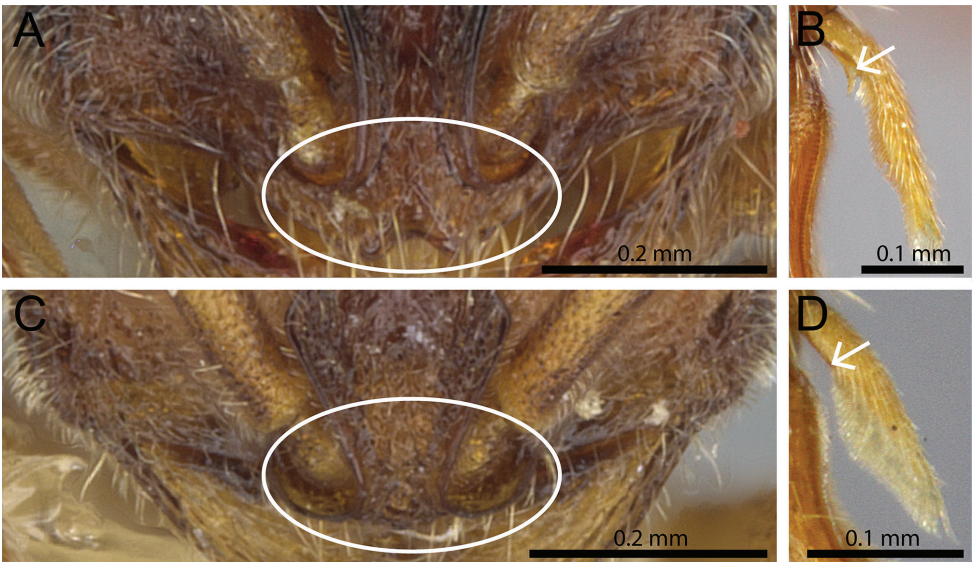

Figure 1. Anterior part of cephalic dorsum in full-face view showing clypeus (within white ellipse) and calcar of strigil (white arrows indicate position of calcar). **A** *P. boltoni* (CASENT0902424) (Will Ericson 2013) **B** *P. diplopyx* (Malagasy member of *P. stictum* clade) **C** *P. burundense* (CASENT0902427) (Will Ericson 2013) **D** *P. sokoke* (MCZ-ENT00520482).

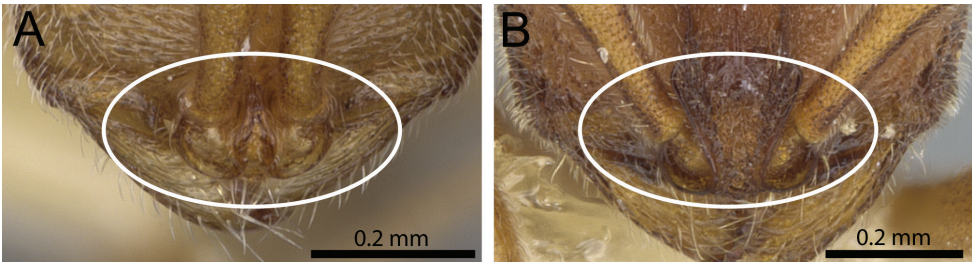

Figure 2. Anterior part of cephalic dorsum in full-face view showing frontal carinae (within white ellipse). **A** *P. terroni* (CASENT0914223) (Michele Esposito 2014) **B** *P. burundense* (CASENT0902427) (Will Ericson 2013).

– Clypeus reduced, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed; vertex in full face view not concave, usually weakly to moderately convex; calcar of strigil without basal spine (Fig. 1C, D).....**2**

2 Frontal carinae relatively close to each other, either converging and posteriorly fused (Fig. 2A) or approaching each other medially, almost fusing, but narrowly diverging posteriorly; lower mesopleura flat .....***P. toschii* clade**

– Frontal carinae relatively far from each other, never approaching medially and widely diverging posteriorly; lower mesopleura posteriorly inflated (Fig. 2B) .....***P. arnoldi* clade**

The *Proceratium arnoldi* clade

Diagnosis. The following diagnosis is based on Baroni Urbani and de Andrade (2003): clypeus reduced, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed; frontal carinae widely separated, not approaching each other closely and strongly diverging posteriorly; pair of transparent maculae on vertexal angles present in all but one species; calcar of strigil without basal spine; bulla usually located medially at the posterior end of the third abdominal segment; lower mesopleura posteriorly inflated.

Notes. Baroni Urbani and de Andrade (2003) gave the presence of transparent maculae on the vertexal angles and a bulla located medially at the posterior end of the third abdominal segment as characteristic of the clade. Nevertheless, the maculae are not present in all five species. Actually, in the new species *P. carri* there is not a trace of maculae on the vertexal angles, whereas all other clade members (including the eighth species of the clade *P. galilaeum* de Andrade from Israel) possess very conspicuous maculae. The holotype of *P. arnoldi* seemed to lack the maculae at first sight, but closer examination under higher magnifications and different light settings revealed them later. The other clade-specific character, the bulla on the third abdominal segment, is indeed present in all species of the *P. arnoldi* clade, even though it is much less developed in *P. arnoldi* and *P. carri* than in the remainder of the clade. Nevertheless, even though these characters are not always fully developed, the seven Afrotropical species of the *P. arnoldi* clade can be easily distinguished from the single Afrotropical species of the *P. stictum* clade and the two species of the *P. toschii* clade with the diagnosis given above.

Identification key to Afrotropical species of *P. arnoldi* clade

1 No maculae present on vertexal angles of head (Fig. 3A); abdominal segment IV relatively long, around 1.6 times longer than abdominal segment III (ASI 156–159) (Fig. 3D) [Mozambique] ..... ***P. carri***

– Maculae on vertexal angles of head present and usually very conspicuous, but sometimes difficult to see (Fig. 3B, 3C); abdominal segment IV always conspicuously shorter than above, between 1.0 to 1.3 times longer than abdominal segment III (ASI 102–132) (Fig. 3E, F) **2**

2 Eyes absent (OI 0) (Fig. 4A) [Tanzania] ..... ***P. nilo***

– Eyes variable in size, but always present (OI 3–8) (Fig. 4B, C)..... **3**

3 Eyes larger (OI 8) (Fig. 5A); ventral process of petiole with posteroventral corner conspicuously projecting ventrally, almost spiniform (Fig. 5D) [Burundi] ..... ***P. burundense***

– Eyes always smaller (OI 3–5) (Fig. 5B, C); ventral process of petiole usually more or less rectangular without posteroventral corner conspicuously project-

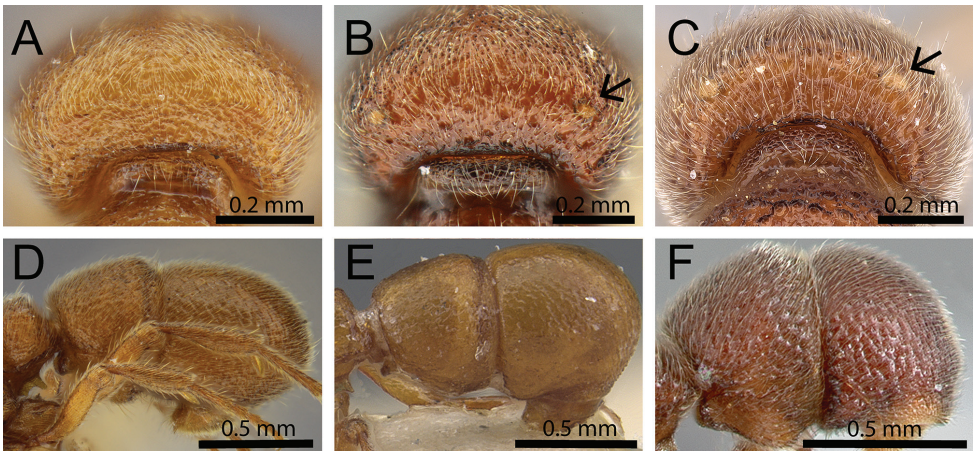

Figure 3. Vertex in posterodorsal view (black arrows indicate maculae) and abdominal segments III and IV in profile. **A, D** *P. carri* (MCZ-ENT00517081) **B** *P. sokoke* (MCZ-ENT00520482) **C** *P. sali* (CASENT0235689) (Will Ericson 2011) **E** *P. arnoldi* (CASENT0907203) (Will Ericson 2013) **F** *P. lunatum* (CASENT0005926).

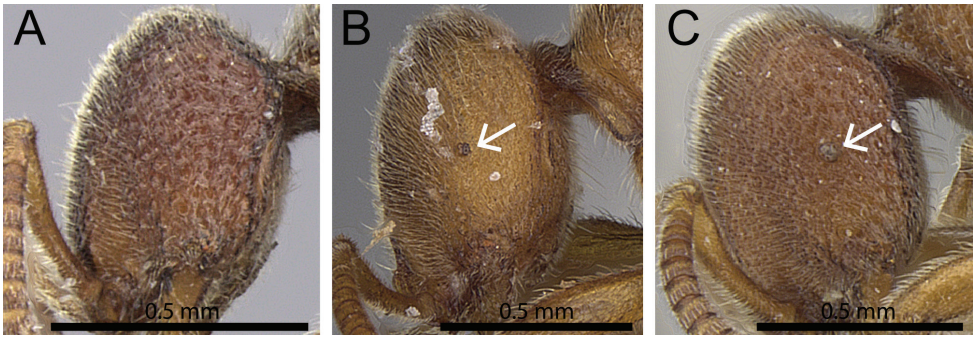

Figure 4. Head in profile showing eye (white arrows indicate location of eye, if present). **A** *P. nilo* (CASENT0235688) (Will Ericson 2011) **B** *P. arnoldi* (CASENT0914281) (Michele Esposito 2014) **C** *P. burundense* (CASENT0902427) (Will Ericson 2013).

ing ventrally, rarely posteroventral corner weakly pointing posteroventrally, but distinctly less conspicuously than above (Fig. 5E, F) **4**

4 Head, mesosoma and petiole with numerous long, fine, suberect to erect hairs on top of dense mat of much shorter decumbent to subdecumbent pubescence (Fig. 6A, B) **5**

– Head, mesosoma and petiole with mat of short decumbent to subdecumbent pubescence only, without numerous longer, fine suberect to erect hairs (Fig. 6C), sometimes parts of pubescence on mesosoma suberect to erect (Fig. 6D) **6**

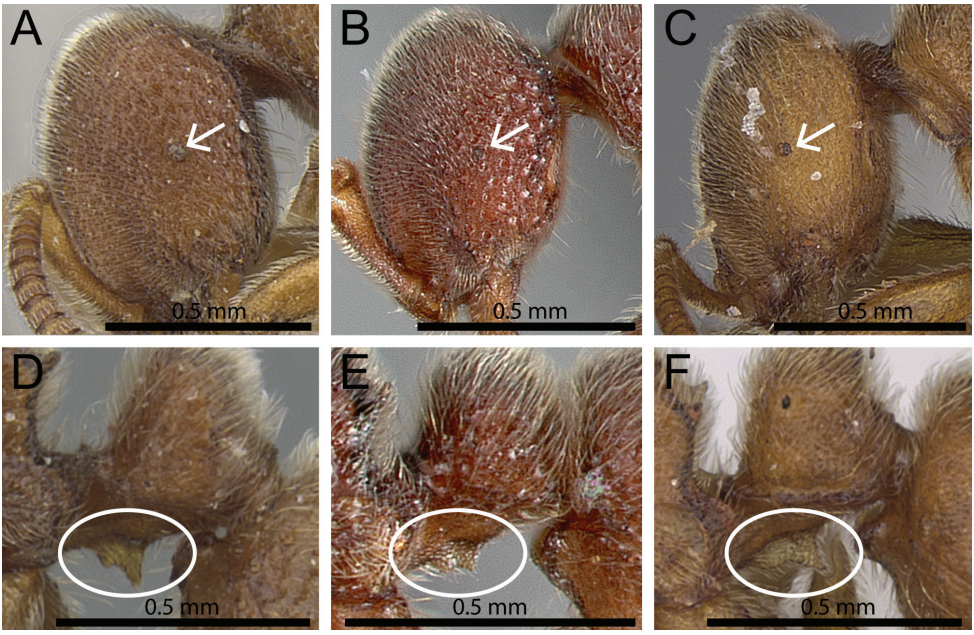

Figure 5. Head in profile showing eye (white arrows indicate location of eye) and petiole with ventral process in profile (within white ellipse). **A, D** *P. burundense* (CASENT0902427) (Will Ericson 2013) **B, E** *P. lunatum* (CASENT0005926) **C, F** *P. arnoldi* (CASENT0914281) (Michele Esposito 2014).

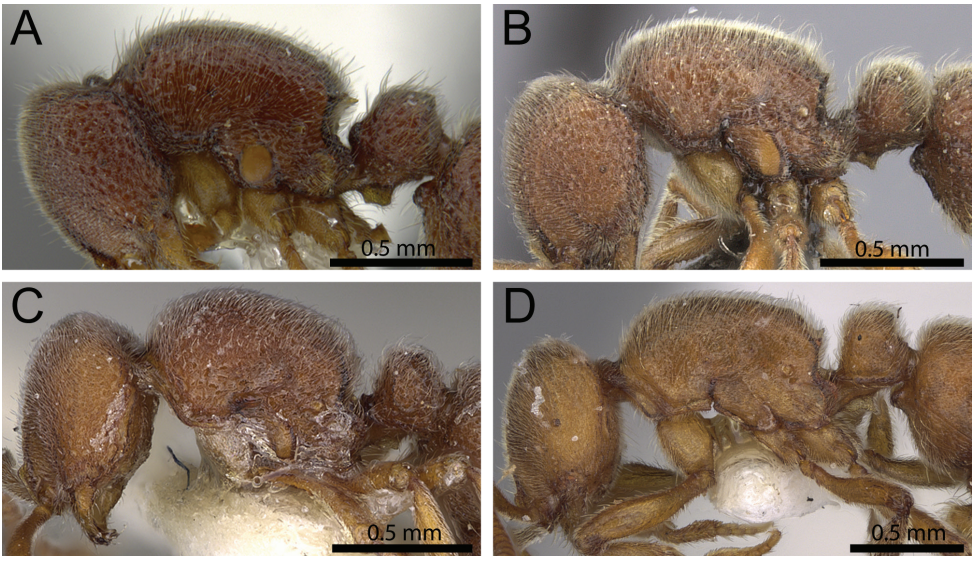

Figure 6. Head, mesosoma and petiole in profile. **A** *P. sokoke* (MCZ-ENT00520482) **B** *P. sali* (CASENT0235689) (Will Ericson 2011) **C** *P. lunatum* (CASENT0914221) (Michele Esposito 2014) **D** *P. arnoldi* (CASENT0914281).

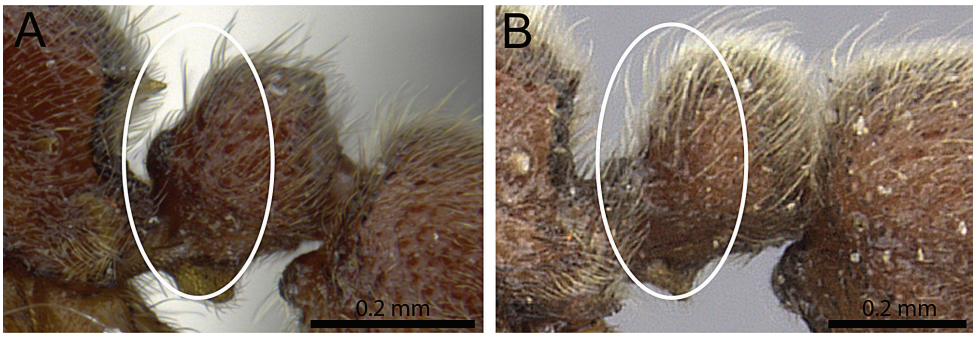

Figure 7. Petiole in profile (anterior face within white ellipse). **A** *P. sokoke* (MCZ-ENT00520482) **B** *P. sali* (CASENT0235689) (Will Ericson 2011).

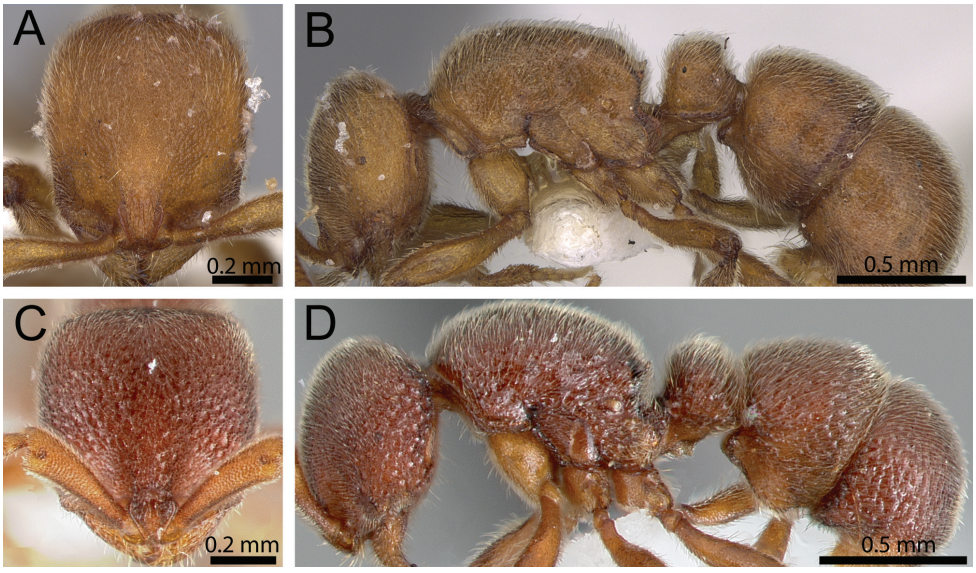

Figure 8. Head in full-face view and body in profile. **A, B** *P. arnoldi* (CASENT0914281) (Michele Esposito 2014) **C, D** *P. lunatum* (CASENT0005926).

5 Petiolar node in profile appearing thicker and stouter, with lower third of anterior face strongly produced anteriorly (Fig. 7A) [Kenya]..... ***P. sokoke***

– Petiolar node higher and thinner than above, more strongly anteroposteriorly compressed, with anterior face relatively straight (Fig. 7B) [Tanzania]... ***P. sali***

6 Head relatively longer (CI 85–87) (Fig. 8A); surface sculpture weak and superficial; body colouration yellow to very light brown (Fig. 8B) [South Africa, Zimbabwe] ..... ***P. arnoldi***

– Head relatively shorter (CI 92–95) (Fig. 8C); surface sculpture better developed, usually deeply foveolate; body colouration of darker brown than above (Fig. 8D) [Cameroon, Gabon and Uganda]..... ***P. lunatum***

Review of species

***Proceratium arnoldi* Forel, 1913**
Figs 3E, 4B, 5C, 5F, 6D, 8A, 8B, 9A, 9B, 9C, 18

Proceratium (*Sysphincta*) *arnoldi* Forel, 1913: 210. [Combination in *Sysphincta*: Arnold 1915: 35; in *Proceratium*: Brown 1958b: 247; see also: Baroni Urbani and de Andrade 2003: 297]

Type material. Holotype, pinned worker, ZIMBABWE, Bulawayo, (MHNG: CASENT0907203).

[Note: There are two known "type" specimens of *P. arnoldi*, and there is some confusion about their labels and type status. De Andrade (in Baroni Urbani and de Andrade 2003) stated that the specimen from BMNH (CASENT0902425) labelled as syntype with the collection data "Bulawayo, S. Rhodesia, 29.III.1913, (*G. Arnold*)" is likely the specimen on which Arnold (1915) based his re-description and was probably never examined by Forel, even though it seems that both specimens belong to the same collection. We agree with de Andrade that this is not a type specimen].

Non-type material. SOUTH AFRICA: Natal, N of Richard's Bay, 28.40S, 32.14E, 26.I.–11.II.1991 (*A. de Kock & J.D. Majer*) (BMNH: CASENT0914281); ZIMBABWE: Bulawayo, S. Rhodesia, 29.III.1913, (*G. Arnold*) (BMNH: CASENT0902425).

Diagnosis. The following character combination distinguishes *P. arnoldi* from the other Afrotropical members of the *P. arnoldi* clade: eyes very small, consisting of a single dark ommatidium (OI 3–5); head clearly longer than broad (CI 85–87); maculae on vertexal angles of head well developed and conspicuous; mesopleurae weakly to moderately inflated posteriorly; petiolar node high nodiform, anteroposteriorly compressed, with anterior face relatively straight; petiole in dorsal view between 1.0 and 1.2 times wider than long (DPeI 106–114); ventral process of petiole lamelliform, subrectangular, anteroventral corner blunt and posteroventral corner conspicuously projecting posteroventrally; abdominal segment IV around 1.2 to 1.3 times longer than abdominal segment III (ASI 116–132); head, mesosoma and petiole with mat of short decumbent to subdecumbent pubescence only, without any longer, fine suberect to erect hairs.

Worker measurements (N=5). TL 3.27–3.56; EL 0.02–0.03; SL 0.49–0.52; HL 0.79–0.84; HLM 0.94–1.02; HW 0.69–0.71; WL 0.91–1.03; HFeL 0.59–0.67; HTiL 0.48–0.51; HBaL 0.38–0.46; PeL 0.33–0.34; PeW 0.35–0.38; DPeI 106–114; LT3 0.47–0.54; LS4 0.24–0.25; LT4 0.62–0.64; OI 3–5; CI 85–87; SI 60–63; IGR 0.38–0.41; ASI 116–132.

Worker description. In full-face view head clearly longer than broad (CI 85–87), sides weakly convex, gently broadening posteriorly, vertex flat to weakly convex. Clypeus medially reduced, its anterior margin subconvex to slightly triangular, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed,

antennal socket with broad torulus. Frontal carinae relatively very short and widely separated, not converging medially and strongly diverging posteriorly, partially covering antennal insertions; frontal carinae conspicuously raised anteriorly, much less so posteriorly. Eyes very small, consisting of one to four weak ommatidia (OI 5) and located on mid line of head. Mandibles elongate-triangular; masticatory margin of mandibles with one well developed apical tooth and a series of four denticles decreasing in size towards basal-most denticle. Mesosoma weakly to moderately convex in profile and approximately as long as the maximum head length including mandibles. Lower mesopleurae with well impressed sutures, no other sutures developed on lateral or dorsal mesosoma, mesopleurae weakly to moderately inflated posteriorly; propodeum in profile armed with very small, pointed or blunt teeth, propodeal lobes weakly to moderately developed, lamellate, subtriangular and blunt; declivitous face of propodeum between teeth and lobes concave; in posterodorsal view sides of propodeum separated from declivitous face by margin connecting propodeal lobes and propodeal teeth. Legs slender and elongate; pro- and mesotibiae with pectinate spurs; calcar of strigil without basal spine. Petiolar node in profile high, blocky nodiform, anterior face of petiole relatively straight, anterior and posterior faces approximately parallel, dorsum of node flat to very weakly convex; petiole in dorsal view between 1.0 and 1.2 times wider than long (DPeI 106–114), petiolar node in dorsal view clearly much broader than long; ventral process of petiole lamelliform, subrectangular, anteroventral corner blunt and posteroventral corner conspicuously projecting posteroventrally. In dorsal view abdominal segment III anteriorly broader than petiole; its sides diverging posteriorly; dorsum of abdominal tergum III with posteromedial, weakly developed, semitransparent, flat bulla below the integument; abdominal sternite III anteromedially with a marked subtriangular projection. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV strongly recurved (IGR 0.38–0.41), conspicuously rounded on its curvature, especially posteriorly, abdominal tergum IV around 1.2 to 1.3 times longer than abdominal segment III (ASI 116–132); small, faint and semitransparent bulla situated posteromedially on abdominal tergum IV; remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. Whole body covered with dense mat of relatively short, decumbent to suberect pubescence without any abundant, much longer, suberect to erect, long, fine, standing hairs. Mandibles longitudinally rugose; most of body irregularly foveolate and/or punctate, sculpture best developed on cephalic dorsum, much weaker on remainder of body, especially weak, almost smooth on abdominal segments III and IV. Body colour uniformly yellowish to light brown.

Distribution and ecology. At present, *P. arnoldi* is only known from two localities in Zimbabwe and South Africa (Fig. 18). These localities are relatively far apart, but we expect that the species is more widespread and will be collected in the area between. Despite that it was described more than 100 years ago, there is no information available about its natural history.

Taxonomic notes. *Proceratium arnoldi* is well recognisable within the clade. Its relatively thin head in full-face view (CI 85–87) groups it close to *P. carri* (CI 85–86) and separates both from the other five species that have thicker heads (CI 91–95).

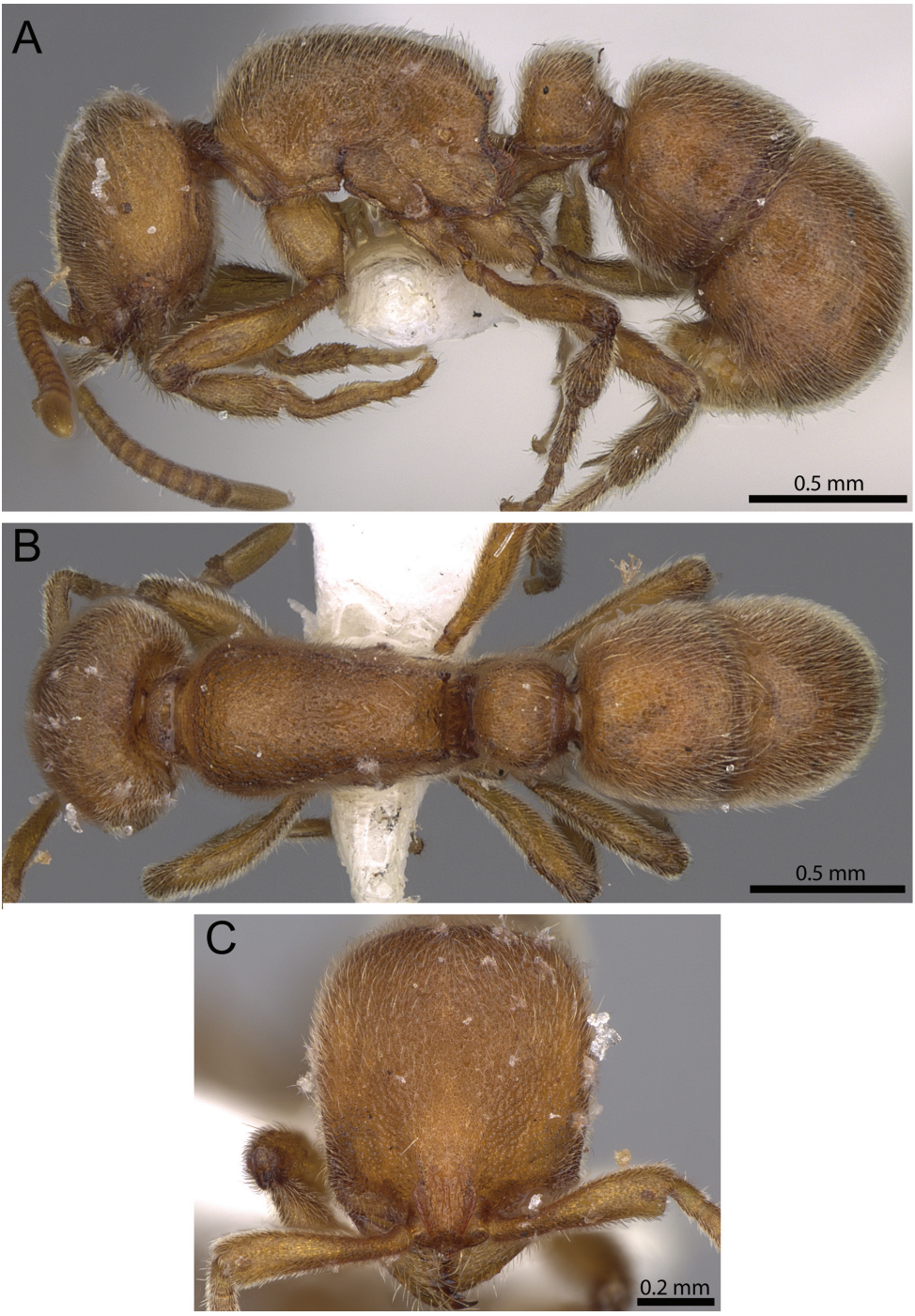

Figure 9. *Proceratium arnoldi* worker (CASENT0914281) (Michele Esposito 2014). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

However, *P. carri* is not likely to be confused with *P. arnoldi*. The latter possesses a mat of short decumbent to subdecumbent pubescence but without numerous much longer, fine standing hairs. These hairs are present in *P. carri*, which also has a much longer abdominal segment IV in relation to abdominal segment III (ASI 156–159) than *P. arnoldi* (ASI 116–132).

Variation. We only observed some minor, very normal variation in body size in the known material of *P. arnoldi* with the specimens from South Africa being somewhat larger (WL 0.98–1.03) than the ones from Zimbabwe (WL 0.91–0.92). Otherwise, there is no observable intraspecific variation.

Proceratium burundense de Andrade, 2003

Figs 1C, 2B, 4C, 5A, 5D, 10A, 10B, 10C, 18

Proceratium burundense de Andrade, in Baroni Urbani and de Andrade 2003: 294.

Type material. Holotype, pinned worker, BURUNDI, Bujumbura, 4.III.77, (*A. Dejean*) (BMNH: CASENT0902427).

Diagnosis. *Proceratium burundense* is easily distinguishable from the other Afrotropical species of the *P. arnoldi* clade by the following character combination: eyes larger, consisting of nine well developed ommatidia (OI 8); head slightly longer than broad (CI 91); maculae on vertexal angles of head well developed and conspicuous; mesopleurae moderately inflated posteriorly; petiolar node high nodiform, anteroposteriorly compressed, with anterior face relatively straight; petiole around 1.2 times wider than long (DPeI 121); ventral process of petiole lamelliform and subrectangular with posteroventral corner strongly pointing ventrally, almost spiniform; abdominal segment IV less than 1.1 times longer than abdominal segment III (ASI 106); head, mesosoma and petiole with mat of short decumbent to subdecumbent pubescence only, without any longer, fine suberect to erect hairs.

Worker measurements (N=1). TL 3.44; EL 0.06; SL 0.54; HL 0.79; HLM 0.90; HW 0.72; WL 1.02; HFeL 0.59; HTiL 0.51; HBaL 0.39; PeL 0.32; PeW 0.39; DPeI 121; LT3 0.58; LS4 0.24; LT4 0.61; OI 8; CI 91; SI 0.68; IGR 0.39; ASI 106.

[Note: the singleton holotype was examined in BMNH, but not measured. The measurements presented above are the ones given by Baroni Urbani and de Andrade (2003) except for HLM, PeL, PeW and LT3, which were measured from the montage images of the specimen]

Worker description. In full-face view head slightly longer than broad (CI 91), sides weakly convex, not broadening posteriorly, vertex flat to weakly convex. Clypeus medially reduced, its anterior margin subconvex to slightly triangular, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed, antennal socket with broad torulus. Frontal carinae relatively short and widely separated, not converging medially and strongly diverging posteriorly, partially covering antennal insertions; frontal carinae conspicuously raised on their anterior half,

much less posteriorly. Eyes small (but larger than in remainder of group), consisting of nine well developed ommatidia (OI 8) and located on mid line of head. Mandibles elongate-triangular; masticatory margin of mandibles with four to five relatively small teeth/denticles, decreasing in size from larger apical tooth to very small basal denticle. Mesosoma clearly convex in profile and slightly longer than maximum head length including mandibles. Lower mesopleurae with well impressed sutures, no other sutures developed on lateral or dorsal mesosoma; mesopleurae moderately inflated posteriorly; propodeum in profile armed with small, pointed teeth, propodeal lobes well developed, lamellate, subtriangular and blunt; declivitous face of propodeum between teeth and lobes noticeably concave; in posterodorsal view sides of propodeum separated from declivitous face by margin connecting propodeal lobes and propodeal teeth. Legs slender and elongate; pro- and mesotibiae with pectinate spurs; calcar of strigil without basal spine. Petiolar node in profile high, blocky nodiform, anterior face of petiole relatively straight, anterior and posterior faces approximately parallel, dorsum of node flat to weakly convex; petiole in dorsal view around 1.2 times wider than long (DPeI 121), petiolar node in dorsal view clearly much broader than long; ventral process of petiole lamelliform and subrectangular with posteroventral corner strongly pointing ventrally, almost spiniform. In dorsal view abdominal segment III anteriorly broader than petiole; its sides diverging posteriorly; dorsum of abdominal tergum III with posteromedial, very conspicuous, semitransparent, flat bulla below the integument; abdominal sternite III anteromedially with a marked subtriangular projection. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV strongly recurved (IGR 0.39), conspicuously rounded on its curvature, especially posteriorly, abdominal tergum IV only slightly longer than abdominal segment III (ASI 106); semitransparent bulla situated posteromedially on abdominal tergum IV; remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. Whole body covered with dense mat of relatively short, decumbent to suberect pubescence without any abundant, much longer, suberect to erect, long, fine, standing hairs. Mandibles longitudinally rugose; most of body irregularly foveolate and/or granulate, sculpture best developed on cephalic and mesosomal dorsum, less so remainder of body and especially weak on most of relatively shining abdominal tergum IV, abdominal tergum IV posteroventrally (shortly before abdominal tergum V) with irregularly rugose area; inflated, posterior part of mesopleura and declivitous face of propodeum also mostly unsculptured and relatively smooth and shining. Head, mesosoma, petiole and remaining abdominal segments brown; mandibles, antennae, and legs of lighter brown.

Distribution and ecology. The species is only known from the type locality in Burundi (Fig. 18). Unfortunately, the label provides very little locality data. Bujumbura is the capital of Burundi, but it is unclear if *P. burundense* was collected in an urban habitat or in the area surrounding of the city. Also, there is no natural history data available.

Taxonomic notes. As noted above, the presence of a larger compound eye that consists of nine well developed ommatidia in the worker caste distinguishes *P. burundense*

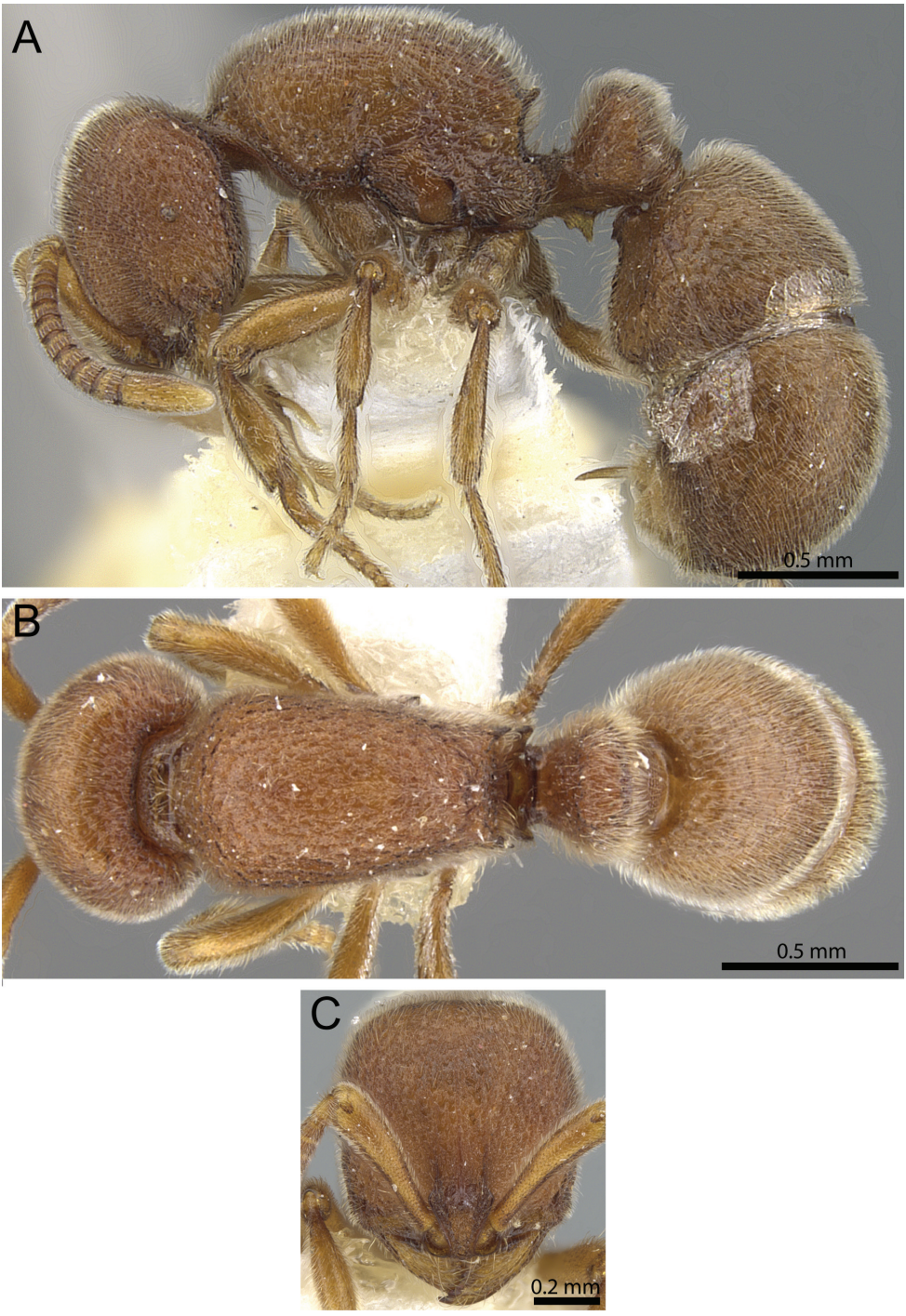

Figure 10. *Proceratium burundense* holotype worker (CASENT0902427) (Will Ericson 2013). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

(OI 8) from the other six species of the clade (OI 0–5), but also from most other known *Proceratium* species that have either no eyes, just one ommatidium or a few very weak, almost indistinguishable ommatidia only visible under higher magnifications (Baroni Urbani and de Andrade 2003). Baroni Urbani and de Andrade (2003) pointed out that they consider the eye of *P. burundense* as the only real compound eye found in workers. It should be mentioned that the known subergatoid intercastes have much larger compound eyes, as is the case in *P. toschii*, but the presence of ocelli separates these immediately from normal workers, which lack ocelli. Not considering eye size, *P. burundense* shares a thicker head (CI 91) in full-face view with *P. nilo*, *P. sali*, *P. lunatum* and *P. sokoke* (CI 91–95), which contrasts with the thinner head seen in *P. arnoldi* and *P. carri* (CI 85–87). In addition, *P. burundense*, as well as *P. arnoldi* and *P. lunatum*, lack numerous long, fine standing hairs on top of a mat of short decumbent to subdecumbent pubescence while these hairs are present in *P. nilo*, *P. sali*, *P. carri* and *P. sokoke*. Furthermore, the ventral process of the petiole, which is subrectangular with the posteroventral corner strongly pointing ventrally, almost spiniform, in *P. burundense* separates it clearly from *P. nilo*, *P. sali*, *P. lunatum* and *P. sokoke* that have a process without a posteroventral corner that is strongly projected ventrally. The shape of the ventral process in *P. arnoldi* and *P. carri* is closest to the one seen in *P. burundense* but the latter species cannot be misidentified with *P. arnoldi* and *P. carri* based on the characters presented above (e.g. head shape, eye size, pilosity). *Proceratium lunatum* is likely the species morphologically closest to *P. burundense* since they share most characters except for eye size, the shape of the ventral process of the petiole, and the propodeal of the propodeal teeth (very small and blunt in *P. lunatum* vs. small but longer and clearly pointed in *P. burundense*.

Variation. Since *P. burundense* is only known from the holotype, there is no information about intraspecific variation.

***Proceratium carri* sp. n.**
http://zoobank.org/8DF4FD29-A215-4FF7-AA15-F8C11376A7FD
Figs 3A, 3D, 11A, 11B, 11C, 12A, 12B, 12C, 13, 18

Type material. Holotype, pinned worker, MOZAMBIQUE, Sofala, Gorongosa National Park, 4 km NW of Chitengo, 18°57'34.1"S, 34°20'30.7"E, 41 m, sandy forest on road #2, dry soil-leaf litter, collected three bags of dry soil, misc. ants, WP113, 28.IV.2013 (*G.D. Alpert*) (MCZ: MCZ-ENT00517081).

Non-type material. MOZAMBIQUE: Tete, Moatize, Haul Road 6, 30 km, 15.97644S, 33.8557E, 336 m, closed undifferentiated woodland 13.IV.2014 (*P. Hawkes & R. Mulaudzi*) (AFRC: CASENT0250381), Tete, Moatize, Haul Road 6, 6 km, 15.78187 S, 33.81614 E, 303 m, closed undifferentiated woodland 14.IV.2014 (*P. Hawkes & R. Mulaudzi*) (AFRC: CASENT0250382).

Diagnosis. *Proceratium carri* differs from the other Afrotropical members of the *P. arnoldi* clade by the following character combination: eyes strongly reduced, consisting of a

single ommatidium (OI 5); head clearly longer than broad (CI 85–86); maculae on vertexal angles of head absent; mesopleurae weakly to moderately inflated posteriorly; petiolar node high nodiform, anteroposteriorly compressed, with anterior face relatively straight; petiole in dorsal view between 1.1 to 1.2 times wider than long DPeI 111–119; ventral process of petiole lamelliform, subrectangular, lamella weakly pointed anteriorly and strongly pointed posteriorly; abdominal segment IV around 1.6 times longer than abdominal segment III (ASI 156–159); head, mesosoma and petiole with numerous long, fine, suberect to erect hairs on top of dense mat of much shorter decumbent to subdecumbent pubescence.

Worker measurements (N=2). TL 2.96–3.07; EL 0.03; SL 0.48–0.51; HL 0.75–0.77; HLM 0.88–0.92; HW 0.63–0.66; WL 0.81–0.82; HFeL 0.55–0.59; HTiL 0.46–0.50; HBaL 0.34–0.35; PeL 0.26–0.29; PeW 0.31–0.32; DPeI 111–119; LT3 0.39–0.41; LS4 0.16–0.18; LT4 0.62–0.64; OI 5; CI 85–86; SI 64–66; IGR 0.25–0.29; ASI 156–159.

Worker description. In full-face view head clearly longer than broad (CI 85–86), sides weakly convex, gently broadening posteriorly, vertex shallowly concave. Clypeus medially reduced, its anterior margin convex to slightly triangular, only slightly protruding anteriorly, not surrounding antennal sockets and not medially impressed, antennal socket with broad torulus. Frontal carinae relatively short and widely separated, not converging medially and strongly diverging posteriorly, partially covering antennal insertions; frontal carinae conspicuously raised on their anterior two thirds, much less posteriorly. Eyes small, consisting of a single ommatidium and located on mid line of head. Antennae 12-segmented, scapes short (SI 64–66), not reaching vertexal margin and noticeably thickening apically, first and last funicular segments longer than broad, remaining funicular segments noticeably broader than long. Mandibles elongate-triangular; masticatory margin of mandibles with five teeth/denticles, decreasing in size from larger apical tooth to basal denticles. Mesosoma weakly to moderately convex in profile and clearly shorter than maximum head length including mandibles. Lower mesopleurae with well impressed sutures, no other sutures developed on lateral or dorsal mesosoma; mesopleurae weakly to moderately inflated posteriorly; propodeum in profile armed with small, pointed teeth, propodeal lobes moderately developed, lamellate and blunt; declivitous face of propodeum between teeth and lobes noticeably concave; in posterodorsal view sides of propodeum separated from declivitous face by margin connecting propodeal lobes and propodeal teeth. Legs slender and elongate; all tibiae with pectinate spur; calcar of strigil without basal spine; pretarsal claws simple; arolia well developed. Petiolar node in profile high, blocky nodiform, anterior face of petiole relatively straight, anterior and posterior faces approximately parallel, dorsum of node flat to weakly convex; petiole in dorsal view between 1.1 to 1.2 times wider than long (DPeI 111–119), petiolar node in dorsal view clearly much broader than long and transverse; ventral process of petiole lamelliform, subrectangular, lamella weakly pointed anteriorly and strongly pointed posteriorly. In dorsal view abdominal segment III anteriorly broader than petiole; its sides diverging posteriorly; dorsum of abdominal tergum III with posteromedial, very faint, semitransparent, flat bulla below the integument; abdominal sternite III anteromedially with a marked subtriangular projection. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV strongly recurved (IGR 0.25–0.29), conspicuously rounded on its curvature,

Figure 11. Type locality of *P. carri*. **A** Sandy Forest habitat with moderate canopy cover, little understory and thin leaf litter layer **B** Shady forest understory **C** Tree under which the holotype was collected from soil.

especially posteriorly, abdominal tergum IV relatively long, around 1.6 times longer than abdominal segment III (ASI 156–159); moderately large, semitransparent and elongate bulla situated posteromedially on abdominal tergum IV; remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. Whole body covered with dense mat of relatively short, appressed to subdecumbent pubescence; antennal scapes and legs also with moderately abundant, much longer (several times longer than pubescence), subdecumbent to erect, long, fine, standing hairs; head, mesosoma, petiole and abdominal segments with same type of long, standing pilosity, but usually more scattered than on appendages. Mandibles longitudinally rugose; most of body irregularly foveolate and/or punctate, sculpture best developed on cephalic dorsum and abdominal tergum III, less so on sides of mesosoma and especially weak on most of relatively smooth and shining abdominal tergum IV, abdominal tergum IV posteroventrally (shortly before abdominal tergum V) with small irregularly rugose area; inflated, posterior part of mesopleura and declivitous face of propodeum also only very weakly sculptured and relatively smooth and shining. Body of uniformly yellow to light orange brown colour.

Etymology. The name of the new species is a patronym dedicated to the American entrepreneur and philanthropist Gregg C. Carr. We want to honour his great accomplishments for the restoration of the Gorongosa National Park in Mozambique and his efforts in the conservation of African biodiversity.

Distribution and ecology. Gorongosa National Park is geographically divided into two sections, a higher elevation section on Gorongosa Mountain (1863 m summit) with a montane rainforest and a separate lowland elevation (39 m) section within the southern end of the Great African Rift Valley of east Africa (Fig. 18). The holotype of *P. carri* was collected at the lower elevation rift valley section within Gorongosa National Park in Sofala Province, Central Mozambique. The single specimen was collected from a dry sand forest with scattered, emergent trees including Baobab trees (Fig. 11). Several bags of sandy soil under a thin layer of leaves on the surface were collected and brought back to the lab to be hand sorted while ants were still alive. A single specimen covered in sand was collected (Fig. 13). Unfortunately, repeated trips to the same locality and microhabitat did not produce any additional specimens. The species is also known from the Tete region in northern Mozambique, where a single worker and a dealate queen were found at different localities (separated by 24 km) north of Moatize. In contrast to the holotype, both of these

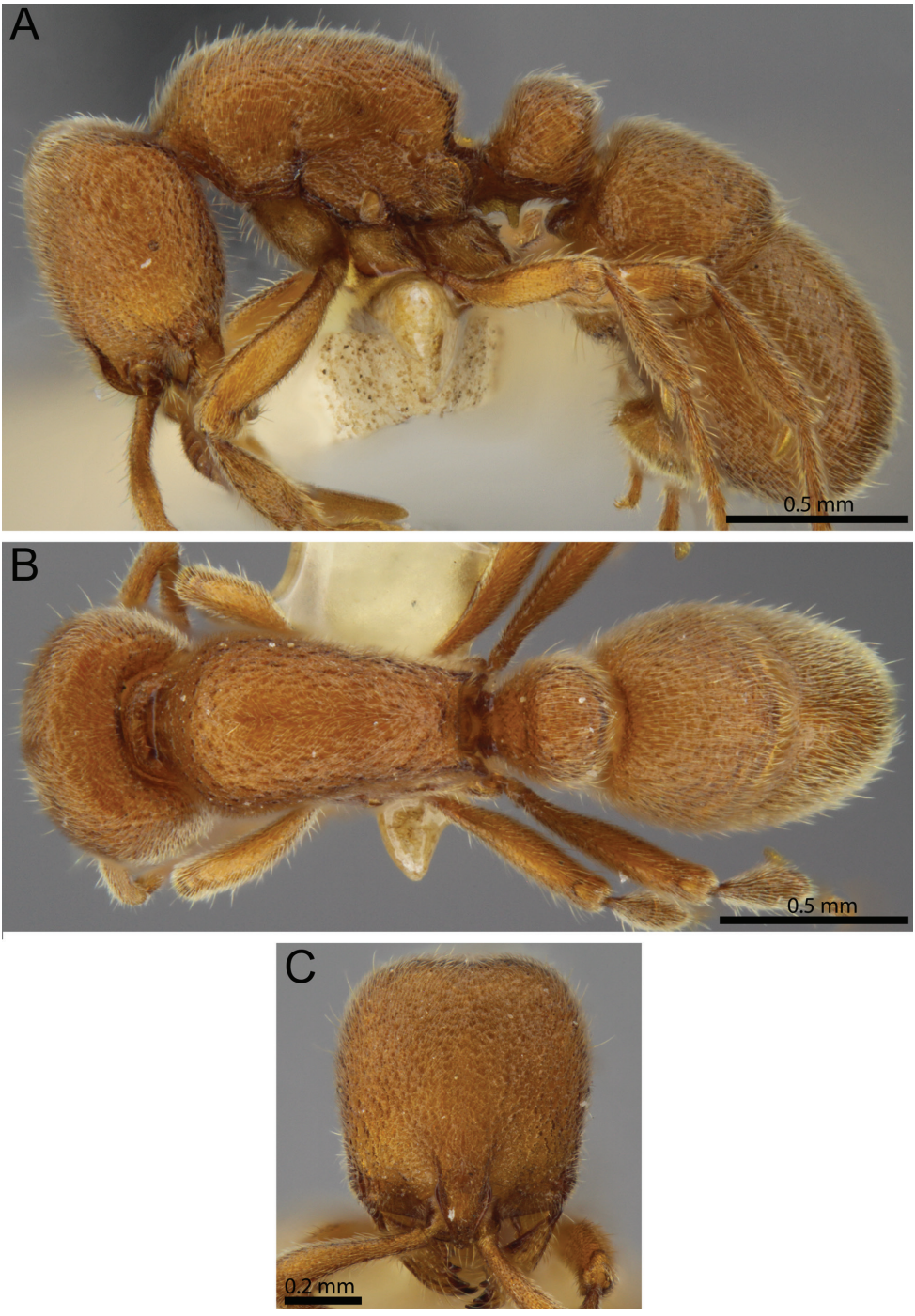

Figure 12. *Proceratium carri* sp. n. holotype worker (MCZ-ENT00517081). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

Figure 13. Photo of the living holotype of *P. carri* (MCZ-ENT00517081) taken after discovery in soil sample prior to preservation of the specimen in ethanol.

additional specimens were found under stones in rocky outcrops in open undifferentiated Zambezian woodland.

Taxonomic notes. *Proceratium carri* displays a character combination that renders it easily identifiable within the *P. arnoldi* clade. The most conspicuous difference is the lack of maculae on the vertexal margins of the head, which are present in all examined specimens of the other six species. Nonetheless, this character can be challenging to detect sometimes, especially under low magnifications or with the wrong lighting. An additional character unique to *P. carri* is the relatively long abdominal segment IV, which is around 1.6 times longer than abdominal tergite III (ASI 156–159), whereas it is much shorter in the other four species, around 1.0 to 1.3 times longer (ASI 102–132). Furthermore, *P. carri* has a comparatively thin head in full-face view (CI 85–86), which is shared by *P. arnoldi* (CI 85–87), but strongly contrasts with the head shape of the other five species (CI 91–95).

Variation. We cannot observe any significant intraspecific variation between the two known workers of this species. The only difference is that the specimen from Gorongosa is of darker colour than the one from Moatize.

Proceratium lunatum **Terron, 1981**

Figs 3F, 5B, 5E, 6C, 8C, 8D, 14A, 14B, 14C, 18

Proceratium lunatum Terron, 1981: 96. [see also Baroni Urbani and de Andrade 2003: 290]

Type material. Holotype, pinned worker, CAMEROON, Arboretum de Mbalmayo (51 km S of Yaounde), no. 1579, 17.III.1968, (*G. Terron*) (CIRAD). **Paratypes**, one pinned paratype worker from CAMEROON, Kala (18 km W Yaounde), Ve Berlese,

sp. 1, tamisage terre et terreau, 16.V.1974, (*G. Terron*) (CIRAD); two pinned paratype workers from CAMEROON, Mbalmayo, no. 1759, 17.III.1968 (*G. Terron*) (BMNH: CASENT0902426; MNHN); one pinned paratype worker from CAMEROON, UO Bikok, tamisage terre et terreau, 19.III.1974, (*G. Terron*) (MHNG: CASENT0914221).

Non-type material. CAMEROON: Sud-Ouest, Korup N. P., 6.9 km 317°NW Mundemba, 5.016 N, 8.864 E, 110 m, rainforest, 19.IV.2000 (*B.L. Fisher*) (CASC: CASENT0005926); GABON: Woleu-Ntem, 31.3 km 108°ESE Minvoul, 2.08N, 12.40667E, 600 m, rainforest, 11.II.1998 (*B.L. Fisher*) (CASC: CASENT0914280); UGANDA: Western Uganda, Kabarole, Kibale National Park, Kanyawara Biological Station, 0.56437N, 30.36059E, 1520 m, moist evergreen forest, 8.–11.VIII.2012 (*B.L. Fisher et al.*) (CASC: CASENT0355483).

Diagnosis. The following character combination distinguishes *P. lunatum* from the other Afrotropical members of the *P. arnoldi* clade: eyes strongly reduced (OI 3–5), usually consisting of a single ommatidium, rarely more; head slightly longer than broad (CI 92–95); maculae on vertexal angles of head well developed and conspicuous; mesopleurae weakly to moderately inflated posteriorly; petiolar node high nodiform, anteroposteriorly compressed, with anterior face relatively straight; petiole in dorsal view between 1.2 to 1.3 times wider than long DPeI 122–129; ventral process of petiole lamelliform and approximately rectangular, lamella not significantly pointing anteriorly nor posteriorly; abdominal segment IV between 1.0 to 1.2 times longer than abdominal segment III (ASI 104–118); head, mesosoma and petiole with mat of short decumbent to subdecumbent pubescence only, without any longer, fine suberect to erect hairs.

Worker measurements (N=8). TL 2.81–3.43; EL 0.02–0.04; SL 0.46–0.60; HL 0.73–0.84; HLM 0.86–0.96; HW 0.68–077; WL 0.84–1.00; HFeL 0.52–0.63; HTiL 0.41–0.51; HBaL 0.31–0.42; PeL 0.27–0.30; PeW 0.35–0.38; DPeI 122–129; LT3 0.40–0.57; LS4 0.14–0.23; LT4 0.43–0.60; OI 3–5; CI 92–95; SI 63–71; IGR 0.33–0.38; ASI 104–118.

Worker description. In full-face view head slightly longer than broad (CI 92–95), sides weakly convex, vertex flat to weakly convex. Clypeus medially reduced, its anterior margin subconvex to slightly triangular, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed, antennal socket with broad torulus. Frontal carinae relatively short and widely separated, not converging medially and strongly diverging posteriorly, partially covering antennal insertions; frontal carinae conspicuously raised on their anterior half, much less posteriorly. Eyes very small, consisting one to three or four weak ommatidia (OI 3–5) and located on mid line of head. Mandibles elongate-triangular; masticatory margin of mandibles with four relatively small teeth/denticles, decreasing in size from larger apical tooth to basal denticle. Mesosoma in profile convex and approximately as long as the maximum head length including mandibles. Lower mesopleurae with well impressed sutures, no other sutures developed on lateral or dorsal mesosoma; mesopleurae weakly to moderately inflated posteriorly; propodeum in profile armed with small, blunt teeth, propodeal lobes well developed, lamellate, rounded to subtriangular and blunt; declivitous face of propodeum between teeth and lobes noticeably concave; in posterodorsal

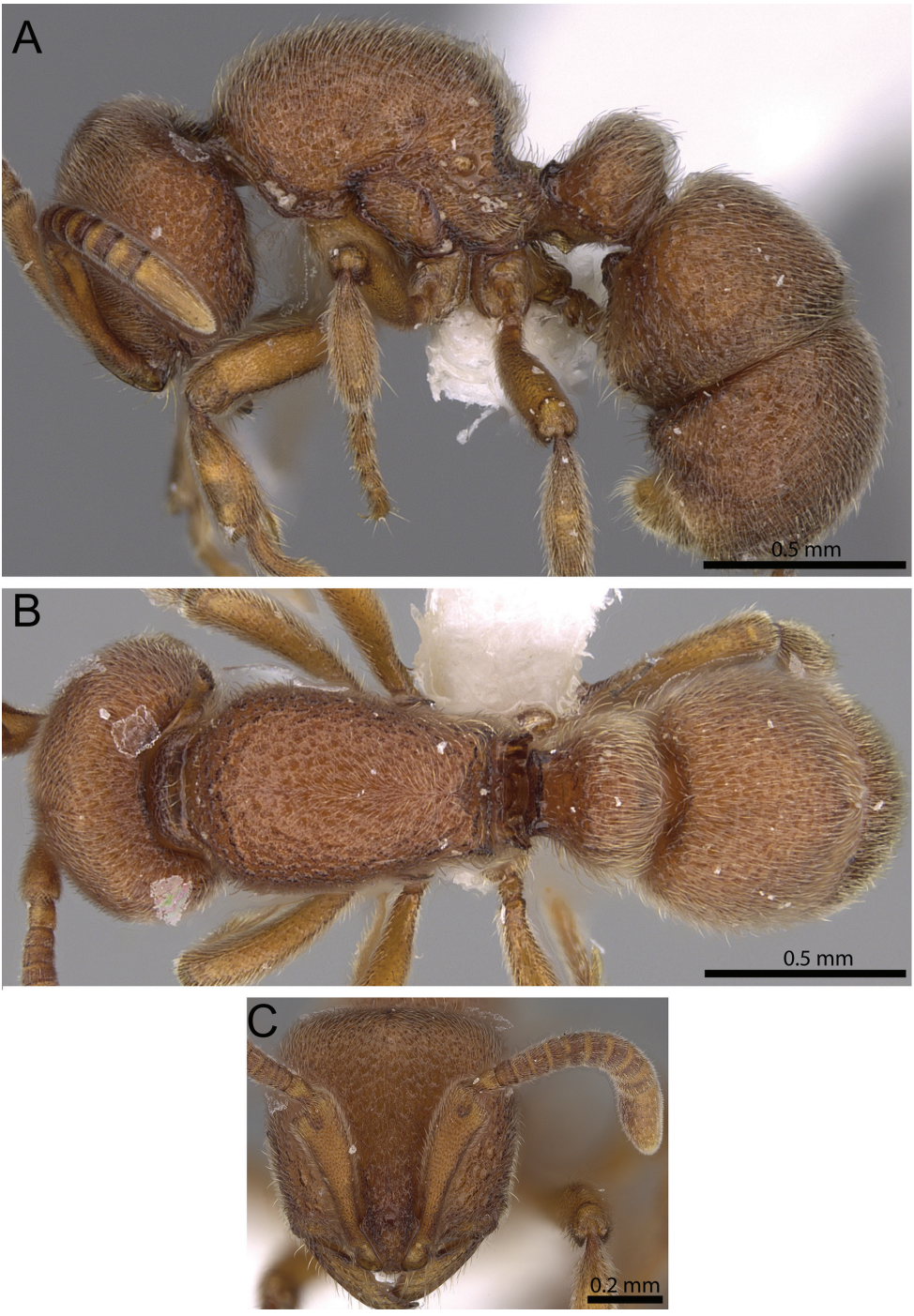

Figure 14. *Proceratium lunatum* worker (CASENT0914280) (Michele Esposito 2014). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

view sides of propodeum separated from declivitous face by margin connecting propodeal lobes and propodeal teeth. Legs slender and elongate; pro- and mesotibiae with pectinate spurs; calcar of strigil without basal spine. Petiolar node in profile high, blocky nodiform, anterior face of petiole relatively straight, anterior and posterior faces approximately parallel, dorsum of node flat to weakly convex; petiole in dorsal view between 1.2 and 1.3 times wider than long (DPeI 122–129), petiolar node in dorsal view clearly much broader than long; ventral process of petiole lamelliform and approximately rectangular, lamella not significantly pointing anteriorly nor posteriorly. In dorsal view abdominal segment III anteriorly broader than petiole; its sides diverging posteriorly; dorsum of abdominal tergum III with posteromedial, very conspicuous, semitransparent, raised bulla below the integument; abdominal sternite III anteromedially with a marked subtriangular projection. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV strongly recurved (IGR 0.33–0.38), conspicuously rounded on its curvature, especially posteriorly, abdominal tergum IV between 1.0 and 1.2 times longer than abdominal segment III (ASI 104–118); large, semitransparent and circular bulla situated posteromedially on abdominal tergum IV; remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. Whole body covered with dense mat of relatively short, decumbent to subdecumbent pubescence without abundant, much longer, suberect to erect, long, fine, standing hairs. Mandibles longitudinally rugose; most of body irregularly foveolate and/or granulate, sometimes more weakly developed on cephalic dorsum and anterior part of abdominal tergum IV, posteroventral part of abdominal tergum IV with conspicuous irregular rugosity; inflated, posterior part of mesopleura and declivitous face of propodeum unsculptured, smooth and shining. Head, mesosoma (excluding posteriorly inflated part of mesopleurae), postpetiole and remaining abdominal segments of light brown to brown colour, mandibles, inflated part of mesopleurae and legs always of lighter brown colour.

Distribution and ecology. *Proceratium lunatum* is known to occur in Cameroon, Gabon and Uganda (Fig. 18) where it was collected in rainforests at elevations ranging from 110 to 1520 m. The known specimens were either collected from within the soil or sifted litter suggesting that *P. lunatum* is a predominantly hypogaeic species.

Taxonomic notes. The recognition of *P. lunatum* within the *P. arnoldi* clade is fairly easy and straightforward. The relatively broad head in full-face view (CI 92–95) groups it together with *P. burundense*, *P. nilo*, *P. sali* and *P. sokoke* (CI 91–95) while it separates it from *P. arnoldi* and *P. carri* that have thinner heads (CI 85–87). The lack of long, standing pilosity on top of a dense mat of much shorter pubescence distinguishes *P. lunatum* from *P. carri*, *P. nilo*, *P. sali* and *P. sokoke*. The species closest to *P. lunatum* seems to be *P. burundense*. However, both differ in eye size, ventral process of the petiole, and propodeal armament. *Proceratium lunatum* has smaller eyes (OI 3–5) and shorter propodeal teeth than *P. burundense* (OI 8). In addition, the ventral process of the petiole has a very distinct posteroventral corner that strongly projects ventrally, whereas the process of *P. lunatum* is more or less rectangular without a projecting posteroventral corner.

Variation. The *P. lunatum* material from Cameroon and Gabon shows no observable intraspecific variation. The specimen from Uganda, however, displays some noticeable differences. It possesses longer antennal scapes (SI 71 vs. SI 63–66) and is generally

larger than the western specimens (TL 3.43 vs. TL 2.81–2.94). Nevertheless, we consider these differences as intraspecific variation. The difference in body size is well within the range of other species, thus not significant, and the longer antennal scape alone is not sufficient to warrant species status. This assessment might change with further material from the eastern parts of the equatorial forest belt, such as Uganda, Rwanda and Kenya, but for the moment we keep all the material listed here as *P. lunatum* as one species.

***Proceratium nilo* sp. n.**
http://zoobank.org/6D9A7B7F-46EC-40D1-A34E-27362E42D23D
Figs 4A, 15A, 15B, 15C, 18

Type material. Holotype, pinned worker, TANZANIA, Tanga, Korogwe, Nilo Forest Reserve, 4.91456S, 38.67712E, 1006 m, primary forest, collection code CEPF-TZ-4.1, 1.–4.IX.2005 (*P. Hawkes, J. Makwati & R. Mtana*) (SAMC: CASENT0235688).

Diagnosis. *Proceratium nilo* can be distinguished from the other Afrotropical members of the *P. arnoldi* clade by the following combination of characters: eyes absent; head slightly longer than broad (CI 91); maculae on vertexal angles of head well developed and conspicuous; mesopleurae extremely inflated posteriorly; petiolar node in profile relatively low, bluntly rounded nodiform, anterior face of petiole strongly produced anteriorly on lower third and not straight; petiole in dorsal view between 1.1 and 1.2 times wider than long (DPeI 115); ventral process of petiole well developed, lamelliform and rectangular, lamella not pointed anteriorly nor posteriorly; abdominal segment IV around as long as abdominal segment III (ASI 102); head, mesosoma and petiole with numerous long, fine, suberect to erect hairs on top of dense mat of much shorter decumbent to subdecumbent pubescence.

Worker measurements (N=1). TL 3.31; EL n.a. (eyes absent); SL 0.56; HL 0.82; HLM 0.99; HW 0.75; WL 0.97; HFeL 0.60; HTiL 0.51; HBaL 0.40; PeL 0.34; PeW 0.39; DPeI 115; LT3 0.50; LS4 0.20; LT4 0.51; OI 0; CI 91; SI 68; IGR 0.39; ASI 102.

Worker description. In full-face view head slightly longer than broad (CI 91), sides weakly convex, head not gently diverging posteriorly, vertex weakly convex. Clypeus medially reduced, its anterior margin convex to slightly triangular, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed, antennal socket with broad torulus. Frontal carinae relatively short and widely separated, not converging medially and strongly diverging posteriorly, partially covering antennal insertions; frontal carinae conspicuously raised on their anterior half, much less posteriorly. Eyes absent (OI 0). Mandibles elongate-triangular; masticatory margin of mandibles with four relatively small teeth/denticles, decreasing in size from larger apical tooth to basal denticle. Mesosoma weakly to moderately convex in profile and approximately as long as the maximum head length including mandibles. Lower mesopleurae with well impressed sutures, no other sutures developed on lateral or dorsal mesosoma; mesopleurae extremely inflated posteriorly; propodeum in profile armed with small, pointed teeth, propodeal lobes well developed, lamellate, rounded and blunt; declivi-

tous face of propodeum between teeth and lobes noticeably concave; in posterodorsal view sides of propodeum separated from declivitous face by margin connecting propodeal lobes and propodeal teeth. Legs slender and elongate; pro- and mesotibiae with pectinate spurs; calcar of strigil without basal spine. Petiolar node in profile relatively low, bluntly rounded nodiform, anterior face of petiole strongly produced anteriorly on lower third and not straight, posterior face approximately straight, anterior and posterior faces not parallel, dorsum of node weakly rounded; petiole in dorsal view between 1.1 and 1.2 times wider than long (DPeI 115), petiolar node in dorsal view clearly much broader than long; ventral process of petiole well developed, lamelliform and rectangular, lamella not pointed anteriorly nor posteriorly. In dorsal view abdominal segment III anteriorly broader than petiole; its sides diverging posteriorly; dorsum of abdominal tergum III with posteromedial, very conspicuous, semitransparent, flat bulla below the integument; abdominal sternite III anteromedially with a marked subtriangular projection. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV strongly recurved (IGR 0.39), conspicuously rounded on its curvature, especially posteriorly, abdominal tergum IV approximately as long as abdominal segment III (ASI 102); large, semitransparent and semicircular bulla situated posteromedially on abdominal tergum IV; remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. Whole body covered with dense mat of relatively short, decumbent to subdecumbent pubescence, and most of body with moderately abundant, much longer (several times longer than pubescence), suberect to erect, fine, standing hairs. Mandibles longitudinally rugose; most of body irregularly foveolate and/or granulate, sculpture best developed on cephalic dorsum, moderately so on mesosoma and petiole, especially weak, almost smooth, on most on anterior third of abdominal tergum IV, posterior third of abdominal tergum IV with conspicuous, longitudinal, irregular rugosity; inflated, posterior part of mesopleura and declivitous face of propodeum unsculptured, smooth and shining. Head, mesosoma (excluding posteriorly inflated part of mesopleurae), postpetiole and remaining abdominal segments of brown colour, mandibles, inflated part of mesopleurae and legs yellowish to light brown.

Etymology. The name of the new species is derived from the type locality, the Nilo Forest Reserve in Tanzania. The species epithet is a noun in apposition and thus invariant.

Distribution and ecology. Like several other species of the clade, *P. nilo* is only known from a singleton holotype collected in the Nilo Forest Reserve in the Tanga region of northeast Tanzania (Fig. 18). Nilo covers an area of 5366 ha and, although the 9048 ha Amani Nature Reserve is significantly larger, Nilo is the largest of the 14 forest reserves in the East Usambara mountain range. The forest is largely undisturbed with a dense canopy cover (estimated at 90–95%) and little evidence of logging. Altitude within the reserve ranges from approximately 340 to 1500 m; the area surveyed was near the middle of this range at approximately 1000 m. The soil along the 230 m transect sampled varied from moist loamy sand to sandy clay loam (hand soil texture classification) and roughly 80% covered by an approximately 1 cm thick layer of leaf litter, with deeper accumulations in places. The single *P. nilo* specimen was collected in pitfall trap 18 of 24 placed along the transect, and no further details of its microhabitat preferences can be determined.

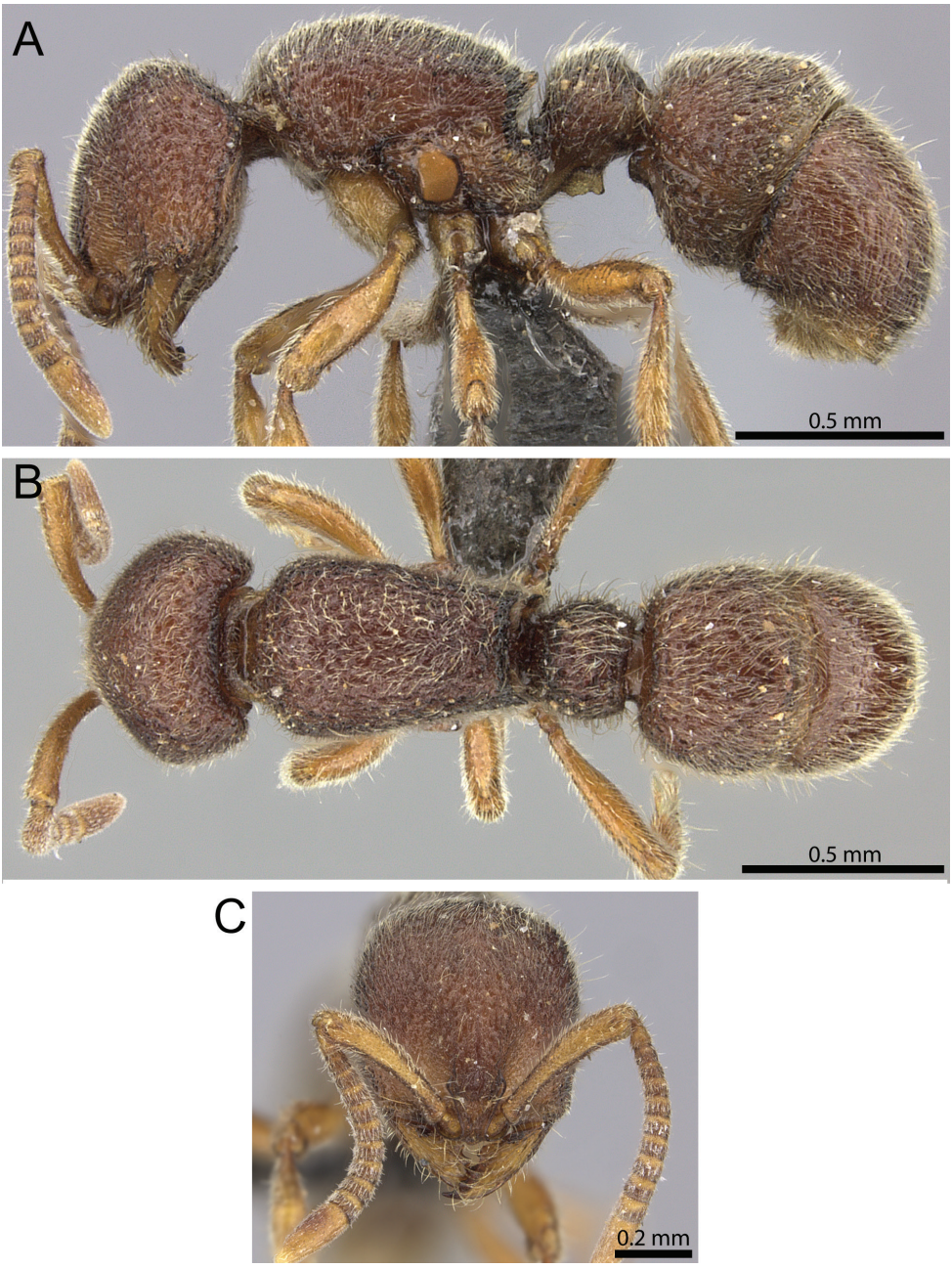

Figure 15. *Proceratium nilo* sp. n. holotype worker (CASENT0235688) (Will Ericson 2011). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

Taxonomic notes. *Proceratium nilo* is a fairly conspicuous member of the clade, and possesses a unique character combination allowing an easy identification. The most noticeable difference is the total lack of eyes, which are present in all the other species of the clade. Not considering the eyes, the shape of the petiolar node groups *P. nilo* with *P.*

sokoke while it separates it from *P. arnoldi*, *P. burundense*, *P. carri*, *P. lunatum* and *P. sali*. In the latter five the node is high nodiform, anteroposteriorly compressed and with the anterior face relatively straight, whereas the node shape of *P. nilo* and *P. sokoke* is relatively low, bluntly rounded nodiform with the anterior face strongly produced anteriorly on lower third. Despite the clear separation based on the presence/absence of the eyes, *P. nilo* is morphologically very close to *P. sokoke*. Indeed, the only significant difference is eye development, and for a short while we considered to lump them both under the same species name. However, the examination of many more species of *Proceratium* led us to refrain from doing so. As it seems, the presence or absence of eyes, as well as their specific development, is species-specific in the genus, which supports the separation into two species. Also, there are a few more differences. *Proceratium sokoke* has a longer abdominal tergum IV in relation to abdominal segment III (ASI 125) compared to *P. nilo* (ASI 102). In addition, the head of *P. nilo* does not significantly broaden posteriorly while the head of *P. sokoke* does so. However, based on the very limited material this could just be within a normal species-specific range. The two-species hypothesis is also supported by different habitat preferences (littoral, mixed dry forest at a very low elevation vs. submontane, primary rainforest at a medium elevation). Future sampling in East Africa might provide additional evidence for their heterospecificity or not (if eye development turns out to be variable within species), but for the moment we prefer to describe *P. nilo* and *P. sokoke* as easily identifiable species and make them both available to the taxonomic community.

Variation. Since this species is known only from the holotype there is no available information about intraspecific variation.

***Proceratium sali* sp. n.**
http://zoobank.org/F9D11EEE-59A5-44E9-9837-0081F4860F68
Figs 3C, 6B, 7B, 16A, 16B, 16C, 18

Type material. Holotype, pinned worker, TANZANIA, Morogoro, Ulanga, Sali Forest Reserve, 8.94497S, 36.67261E, 1150 m, primary forest, collection code CEPF-TZ-9.1, 17.–20.X.2007 (*P. Hawkes, M. Bhoke & U. Richard*) (SAMC: CASENT0235689).

Diagnosis. The following character combination separates *Proceratium sali* from the other Afrotropical members of the *P. arnoldi* clade by the following combination of characters: eyes very small, consisting of three to four weak ommatidia (OI 5); CI 94; maculae on vertexal angles of head well developed and conspicuous; petiolar node high nodiform, anteroposteriorly compressed, with anterior face relatively straight; petiole in dorsal view between 1.1 and 1.2 times wider than long (DPeI 116); ventral process of petiole well developed, lamelliform and rectangular, lamella not pointed anteriorly nor posteriorly; abdominal segment IV around 1.1 times longer than abdominal segment III (ASI 108); head, mesosoma and petiole with numerous long, fine, suberect to erect hairs on top of dense mat of much shorter decumbent to subdecumbent pubescence.

Worker measurements (N=1). TL 3.35; EL 0.04; SL 0.55; HL 0.81; HLM 0.94; HW 0.76; WL 1.00; HFeL 0.62; HTiL 0.53; HBaL 0.41; PeL 0.31; PeW 0.36; DPeI 116; LT3 0.53; LS4 0.19; LT4 0.57; OI 5; CI 94; SI 68; IGR 0.33; ASI 108.

Worker description. In full-face view head slightly longer than broad (CI 94), sides and vertex moderately convex. Clypeus medially reduced, its anterior margin convex to slightly triangular, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed, antennal socket with broad torulus. Frontal carinae relatively short and widely separated, not converging medially and strongly diverging posteriorly, partially covering antennal insertions; frontal carinae conspicuously raised on their anterior half, much less posteriorly. Eyes very small, consisting of three to four faint ommatidia (OI 5) and located on mid line of head. Mandibles elongate-triangular; masticatory margin of mandibles with four relatively small teeth/denticles, decreasing in size from larger apical tooth to basal denticle. Mesosoma weakly to moderately convex in profile and weakly longer than maximum head length including mandibles. Lower mesopleurae with well impressed sutures, no other sutures developed on lateral or dorsal mesosoma; mesopleurae extremely inflated posteriorly; propodeum in profile armed with very small, pointed teeth, propodeal lobes well developed, triangular and blunt; declivitous face of propodeum between teeth and lobes noticeably concave; in posterodorsal view sides of propodeum separated from declivitous face by margin connecting propodeal lobes and propodeal teeth. Legs slender and elongate; pro- and mesotibiae with pectinate spurs; calcar of strigil without basal spine. Petiolar node in profile high, blocky nodiform, anterior face of petiole relatively straight, anterior and posterior faces approximately parallel, dorsum of node flat to weakly convex; petiole in dorsal view between 1.1 and 1.2 times wider than long (DPeI 116), petiolar node in dorsal view clearly much broader than long; ventral process of petiole well developed, lamelliform and rectangular, lamella not pointed anteriorly nor posteriorly. In dorsal view abdominal segment III anteriorly broader than petiole; its sides diverging posteriorly; dorsum of abdominal tergum III with posteromedial, very conspicuous, semitransparent, flat bulla below the integument; abdominal sternite III anteromedially with a marked subtriangular projection. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV strongly recurved (IGR 0.33), conspicuously rounded on its curvature, especially posteriorly, abdominal tergum IV only less than 1.2 times longer than abdominal segment III (ASI 116); large, semitransparent and semicircular bulla situated posteromedially on abdominal tergum IV; remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. Whole body covered with dense mat of relatively short, decumbent to subdecumbent pubescence; most of body with moderately abundant, much longer (several times longer than pubescence), suberect to erect, fine, standing hairs. Mandibles longitudinally rugose; most of body irregularly foveolate and/or granulate, sculpture best developed on cephalic and mesosomal dorsum, less so on mesosoma and especially weak on most of relatively smooth and shining abdominal tergum IV; inflated, posterior part of mesopleura and declivitous face of propodeum unsculptured, relatively smooth and shining. Head, mesosoma (excluding posteriorly inflated part of mesopleurae), postpetiole and remaining

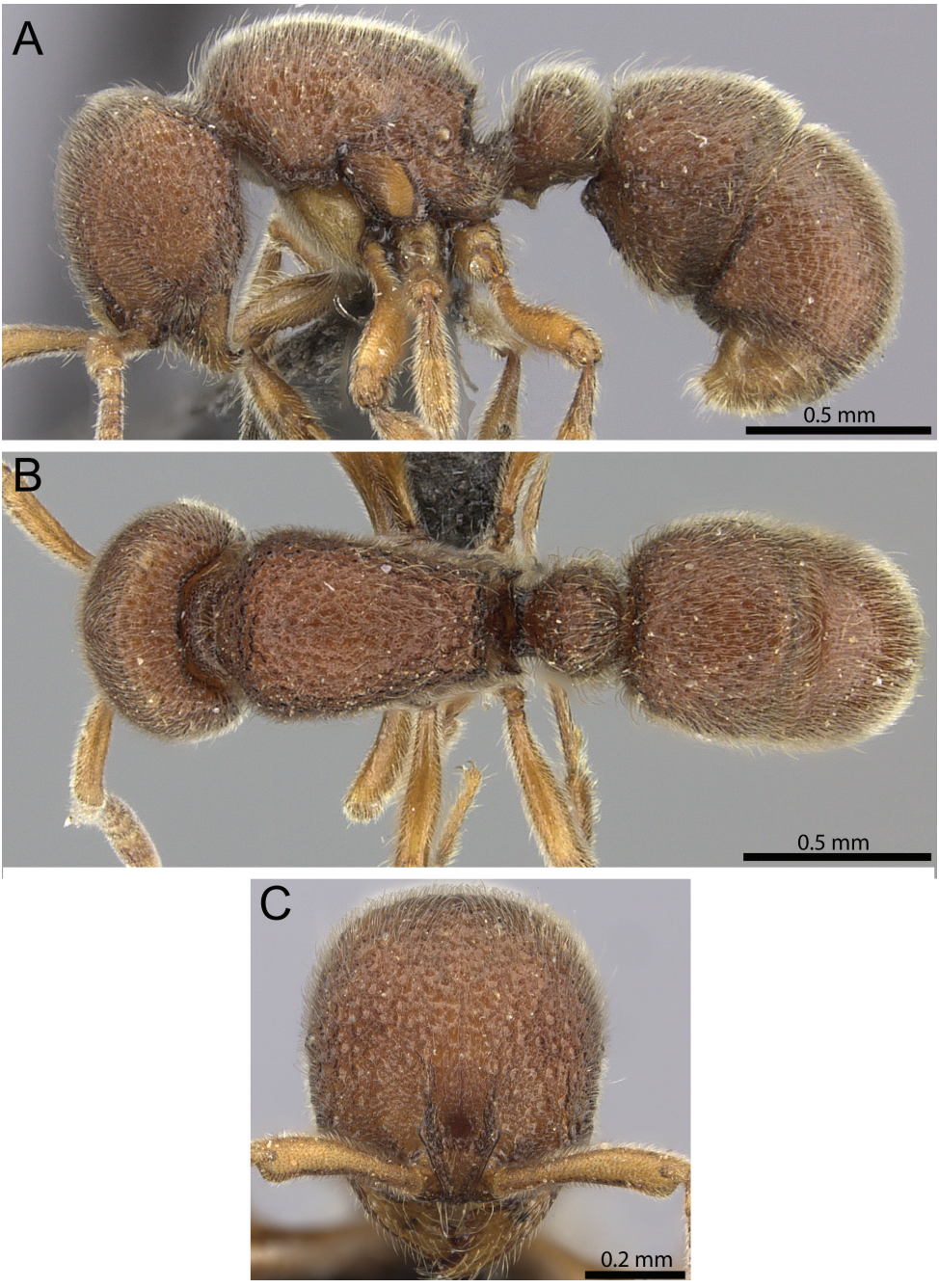

Figure 16. *Proceratium sali* sp. n. holotype worker (CASENT0235689) (Will Ericson 2011). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

abdominal segments of brown colour, mandibles, inflated part of mesopleurae and legs yellowish to light brown.

Etymology. The name of the new species is derived from the type locality, the Sali Forest Reserve in Tanzania. The species epithet is a noun in apposition and thus invariant.

Distribution and ecology. *Proceratium sali* is only known from the Sali Forest Reserve in the Morogoro region of south-central Tanzania (Fig. 18). Sali covers an area of 1072 ha and is the largest of the seven reserves in the Mahenge mountain range. The forest is largely undisturbed with little evidence of logging and a fairly dense canopy cover (estimated at 80–90%). Altitude within the reserve ranges from approximately 1150 to 1480 m and the area surveyed was at the lower end of this range. The soil along the 230 m transect surveyed was moist sandy clay loam (hand soil texture classification) and approximately 90% covered by a 2–3 cm thick layer of leaf litter. The single *P. sali* specimen was collected in pitfall trap 16 of 24 placed along the transect, and no further details of its microhabitat preferences can be determined.

Taxonomic notes. *Proceratium sali* shares a thicker head in full-face view (CI 94) with *P. burundense*, *P. lunatum*, *P. nilo* and *P. sokoke* (CI 91–95), which contrasts with the thinner head of *P. arnoldi* and *P. carri* (85–87). In addition, *P. sali* (as well as *P. carri*, *P. nilo*, *P. sali* and *P. sokoke*) possesses numerous long, fine, standing hairs on top of a mat of much shorter pubescence distinguishing it from *P. arnoldi*, *P. lunatum* and *P. burundense* that lack this type of pilosity. The two species most similar to *P. sali* are *P. nilo* and *P. sokoke*, but the latter two have a lower, less compressed petiolar node with the anterior face strongly produced anteriorly on lower third. This contrasts strongly with the node of *P. sali* that is high nodiform and more compressed with a straight anterior face.

Variation. As for *P. burundense*, *P. nilo* and *P. sokoke*, *P. sali* is also only known from a singleton holotype, which does not allow any conclusions on intraspecific variation.

***Proceratium sokoke* sp. n.**
http://zoobank.org/23A889EA-F16E-4142-ACC6-6AA0F6D5B382
Figs 1D, 3B, 6A, 7A, 17A, 17B, 17C, 18

Type material. Holotype, pinned worker, KENYA, Coastal Province, Arabuko Sokoke Forest, 18°51'72"S, 39°56'26.6"E, 136 m, undisturbed and protected mixed forest, Winkler leaf litter extraction, collection code FHG00206, VI.2009 (*F. Hita Garcia & G. Fischer*) (MCZ: MCZ-ENT00520482).

Diagnosis. *Proceratium sokoke* differs from the other Afrotropical members of the *P. arnoldi* clade by the following character combination: eyes strongly reduced, consisting of a single ommatidium (OI 4); CI 92; maculae on vertexal angles of head well developed and conspicuous; petiolar node in profile relatively low, bluntly rounded nodiform, anterior face of petiole strongly produced anteriorly on lower third and not straight; petiole in dorsal view between 1.1 to 1.2 times wider than long (DPeI 115); ventral process of petiole well developed, lamelliform and rectangular, lamella not pointed anteriorly nor posteriorly; abdominal segment IV around 1.25 times longer than abdominal segment III (ASI 125); head, mesosoma and petiole with numerous long, fine, suberect to erect hairs on top of dense matt of much shorter decumbent to subdecumbent pubescence.

Worker measurements (N=1). TL 2.47; EL 0.03; SL n.a.; HL 0.72; HLM 0.87; HW 0.66; WL 0.86; HFeL n.a.; HTiL n.a.; HBaL n.a.; PeL 0.30; PeW 0.35; DPeI 115; LT3 0.44; LS4 0.14; LT4 0.55; OI 4; CI 92; SI n.a.; IGR 0.25; ASI 125.

Worker description. [Note: the holotype is partly damaged: antennae, one foreleg, one midleg and one hindleg missing, remaining hindleg broken at level of tibia].

Head longer than broad (CI 92), sides weakly convex, cephalic dorsum broader posteriorly than anteriorly; vertex in full-face view flat to weakly convex. Clypeus medially reduced, its anterior margin convex to slightly triangular, only slightly protruding anteriorly, not surrounding the antennal sockets and not medially impressed, antennal socket with broad torulus. Frontal carinae relatively short and widely separated, not converging medially and strongly diverging posteriorly, partially covering antennal insertions; frontal carinae conspicuously raised on their anterior two thirds, much less posteriorly. Eyes very small (OI 4), consisting only of one ommatidium and located on mid line of head. Mandibles elongate-triangular; masticatory margin of mandibles with four relatively small teeth/denticles, decreasing in size from larger apical tooth to basal denticle. Mesosoma weakly to moderately convex in profile and approximately as long as the maximum head length including mandibles. Lower mesopleurae with well impressed sutures, no other sutures developed on lateral or dorsal mesosoma; mesopleurae extremely inflated posteriorly; propodeum in profile armed with small, pointed teeth, propodeal lobes well developed, lamellate, rounded and blunt; declivitous face of propodeum between teeth and lobes noticeably concave; in posterodorsal view sides of propodeum separated from declivitous face by margin connecting propodeal lobes and propodeal teeth. Legs slender and elongate; pro- and mesotibiae with pectinate spurs; calcar of strigil without basal spine. Petiolar node in profile relatively low, bluntly rounded nodiform, anterior face of petiole strongly produced anteriorly on lower third and not straight, posterior face approximately straight, anterior and posterior faces not parallel, dorsum of node weakly rounded; petiole in dorsal view between 1.1 to 1.2 times wider than long (DPeI 115), petiolar node in dorsal view clearly much broader than long; ventral process of petiole well developed, lamelliform and rectangular, lamella not pointed anteriorly nor posteriorly. In dorsal view abdominal segment III anteriorly broader than petiole; its sides diverging posteriorly; dorsum of abdominal tergum III with posteromedial, very conspicuous, semitransparent, flat bulla below the integument; abdominal sternite III anteromedially with a marked subtriangular projection. Constriction between abdominal segment III and IV conspicuously impressed. Abdominal segment IV strongly recurved (IGR 0.25), conspicuously rounded on its curvature, especially posteriorly, abdominal tergum IV around 1.25 times longer than abdominal segment III (ASI 125); large, semitransparent and semicircular bulla situated posteromedially on abdominal tergum IV; remaining abdominal tergites and sternites relatively inconspicuous and curved ventrally. Whole body covered with dense matt of relatively short, decumbent to subdecumbent pubescence; most of body with moderately abundant, much longer (several times longer than pubescence), suberect to erect, long, fine, standing hairs. Mandibles longitudinally ru-

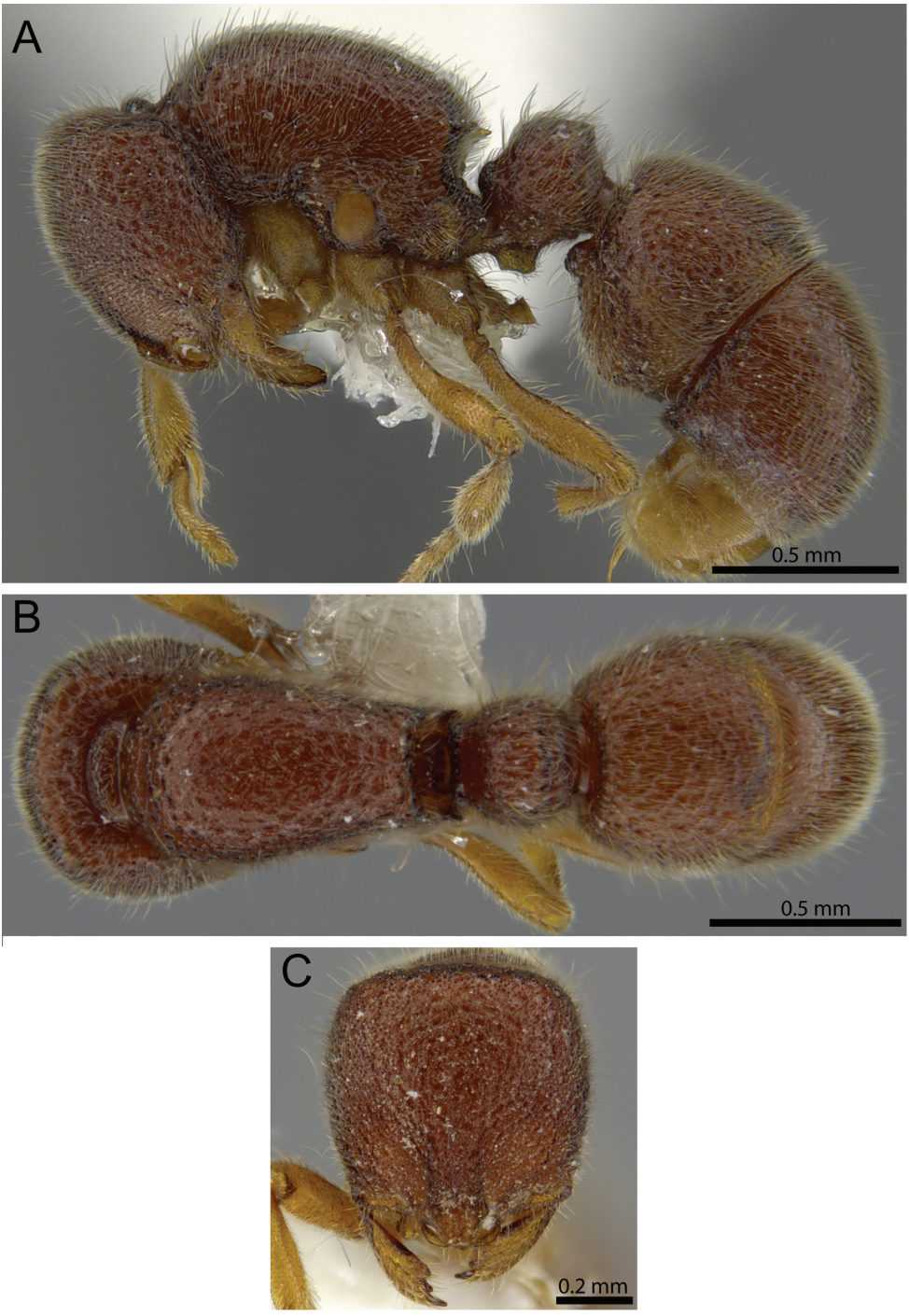

Figure 17. *Proceratium sokoke* sp. n. holotype worker (MCZ-ENT00520482). **A** Body in profile **B** Body in dorsal view **C** head in full-face view.

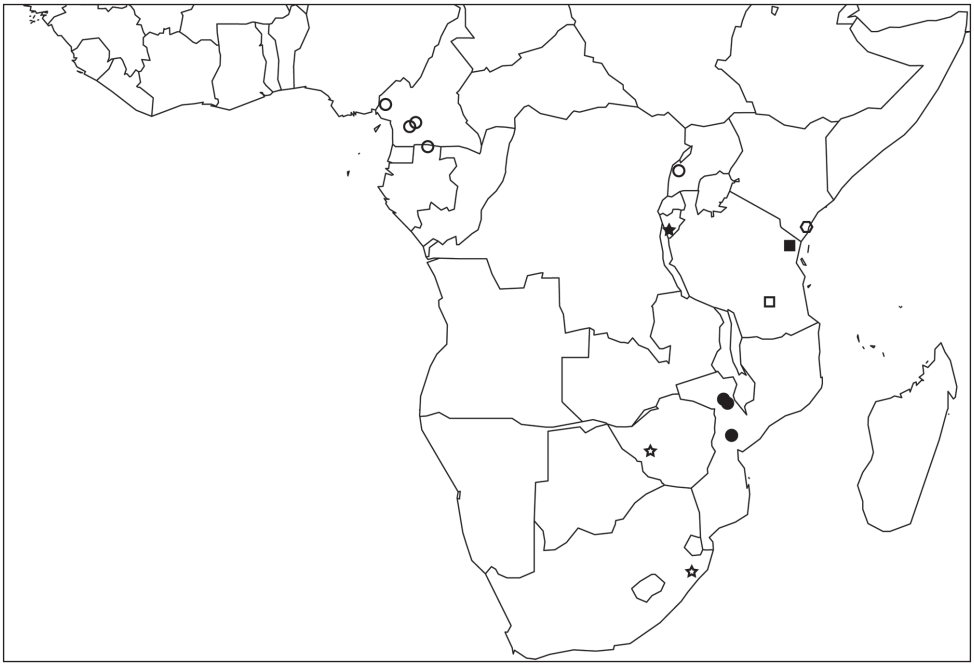

Figure 18. Map of sub-Saharan Africa showing the known distribution ranges of the seven Afrotropical members of the *P. arnoldi* clade: *P. arnoldi* (empty star), *P. burundense* (filled star), *P. carri* (filled circle), *P. lunatum* (empty circle), *P. nilo* (filled square), *P. sali* (empty square), *P. sokoke* (empty hexagon).

gose; most of body irregularly foveolate and/or punctate, sculpture best developed on cephalic dorsum, less so on mesosoma and especially weak on most of relatively smooth and shining abdominal tergum IV; inflated, posterior part of mesopleura and declivitous face of propodeum also only very weakly sculptured and relatively smooth and shining. Head, mesosoma (excluding posteriorly inflated part of mesopleurae), postpetiole and remaining abdominal segments of brown colour, mandibles, inflated part of mesopleurae and legs yellowish to light brown.

Etymology. The name of the new species is inspired by the type locality, the Arabuko Sokoke Forest in Coastal Kenya. The forest is the last larger remnant of the Coastal Forests of Eastern Africa in Kenya and hosts a unique fauna and flora. The species epithet is a noun in apposition and thus invariant.

Distribution and ecology. *Proceratium sokoke* is only known from the type locality, the Arabuko Sokoke Forest in Kenya, which is a tropical dry forest adjacent to the Indian Ocean coast (Fig. 18). As for most of its congeners, the natural history of this species is completely unknown. The holotype was collected from a leaf litter sample in a mixed forest habitat. Unfortunately, *P. sokoke* was only found in that one leaf litter sample and could not be recollected in the remaining 180 litter samples from Arabuko Sokoke, which means that it is either very rare or lives deep in the soil. With the background of the biology of the genus in general, we consider the latter most likely.

Taxonomic notes. The identification of *P. sokoke* is straightforward within the *P. arnoldi* clade. *Proceratium nilo* and *P. sokoke* are the only species of the *P. arnoldi* clade in which the petiolar node in profile does not have a straight anterior face; instead the lower third is produced anteriorly. In the other five species the anterior face is conspicuously straight. *Proceratium nilo* is relatively similar to *P. sokoke*, but the latter has eyes that are absent in the first. Not considering presence/absence of eyes, both species could be seen as conspecific. As discussed in detail in the taxonomic notes section for *P. nilo*, we prefer to treat them as heterospecific in this study since eye development appears to be relatively stable within species of *Proceratium*. In addition to petiolar node shape, *P. sokoke* (CI 92) has a thicker head than *P. arnoldi* and *P. carri* (CI 85–87), and its smaller eyes (O 4) and the rectangular ventral process of the petiole distinguish it from *P. burundense* with its larger eyes (OI 8) and ventral process with an almost spiniform posteroventral corner. Furthermore, the presence of numerous long, fine, suberect to erect hairs on top of a dense mat of much shorter decumbent to subdecumbent pubescence is an additional character that separates *P. sokoke* from *P. arnoldi*, *P. burundense* and *P. lunatum*.

In general it is not recommendable to describe a new species based on a damaged singleton holotype. However, after detailed examination of all the material collected from Arabuko Sokoke, there was no other specimen to be found. In addition, we think that *P. sokoke* is a fairly distinct member of the *P. arnoldi* clade and even without antennae and the missing three and half legs, it can be easily separated from the remainder of the group. Consequently, we prefer to make the species available to science now than to await the discovery of additional material.

Variation. Since the species is only known from the holotype, no information about intraspecific variation exists.

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collaboration in collecting and curating Kenya ants from Arabuko Sokoke and other localities. FHG also wants to thank Marcell Peters (University of Würzburg, Germany), the BIOTA East Africa project funded by the German Ministry of Education and Research (BMBF), the National Museums of Kenya and the Kenya Wildlife Service for organising the study in Arabuko Sokoke, as well as for granting collecting and export permits. FHG was granted two Ernst Mayr Travel Grants in Animal Systematics from the MCZ to visit the collections at BMNH and MCZ. The surveys during which the *P. nilo* and *P. sali* specimens were collected formed part of a project run by PGH investigating ground-living ant and beetle diversity in Tanzania, funded by the Critical Ecosystem Partnership Fund (CEPF), which is a joint initiative of l'Agence Française de Développement, Conservation International, the Global Environment Facility, the Government of Japan, the MacArthur Foundation and the World Bank. A fundamental goal of CEPF is to ensure civil society is engaged in biodiversity conservation. Funding from the CEPF is gratefully acknowledged. Thanks are also due to Joas Makwati, Renald Mtana, Upendo Richard and Munanka Bhoke, whose assistance with the fieldwork in Tanzania was invaluable, as well as Dr Bruno Nyundo of the University of Dar es Salaam for logistical assistance. Sample collection in Tanzania was carried out under COSTECH permit numbers 2005-269-NA-2005-57 and 2007-101-ER-2005-57 and the specimens exported under Tanzanian Ministry of Wildlife trophy export certificate numbers 48157 and 53211. PGH would also like to thank the staff of Baobab Resources Plc for logistical support during surveys of haul road alternatives for the Tete Pig Iron & Ferro-Vanadium Project in the Tete Region of Mozambique, and especially to Elisa Vicente for her very able assistance with export permits.

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Review of *Nitidotachinus* Campbell (Staphylinidae, Tachyporinae) from Mainland China

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Abstract

The genus *Nitidotachinus* Campbell of Mainland China is reviewed with descriptions of five new species: *N. anhuiensis* **sp. n.** (Anhui), *N. bini* **sp. n.** (Zhejiang), *N. brunneus* **sp. n.** (Zhejiang), *N. capillosus* **sp. n.** (Zhejiang), and *N. xiangi* **sp. n.** (Hubei). *Nitidotachinus excellens concolor* Schülke is synonymized with *N. excellens* **syn. n.** All treated species are described with their major diagnostic characters illustrated. An identification key to the species is given.

Keywords

Coleoptera, *Nitidotachinus*, review, new species, new synonym, Mainland China

Introduction

Nitidotachinus Campbell was established to hold the species formerly placed in the *T. tachyporoides* and *T. impunctatus* groups of *Tachinus* Gravenhorst (Campbell 1993) and *Tachinus excellens* Bernhauer. *Nitidotachinus tachyporoides* (Horn) was designated as the type species. Twelve species (including subspecies) are known worldwide, with four (including one species with doubtful records) from mainland China (Herman 2001, Smetana 2004, Schülke 2004).

Nitidotachinus excellens was the first Chinese species described as member of *Tachinus* by Bernhauer in 1938 from Manchuria, Hengtaohotze [now officially

spelled as 'Hengdaohezi, in Chinese: 横道河子', located in Heilongjiang, Northeast China]. Later, *Nitidotachinus dui* Li, 1999 was described from Zhejiang and *N. excellens concolor* Schülke, 2000 was described from Sichuan.

Nitidotachinus impunctatus (Sharp) was originally described from Junsai Lake and Sapporo, Japan . With more collecting data published (Watanabe and Shibata 1961, Shibata 1985), the distribution of the species is now limited in Hokkaido and Honshu of Japan except few records from Jilin of Northeast China reported by Li and Chen (1990) and Li (1992, 1993). These Chinese records were published without any description or collecting datum, and many identification mistakes of other staphylinid groups are found in their papers. Thus, the distribution of *N. impunctatus* in China is highly doubtful, and thus this species is excluded from the present paper.

In the past few years, we collected a large series of *Nitidotachinus* specimens from Anhui, Hebei, Hubei, Sichuan and Zhejiang Provinces. Among this material, we recognized seven species from Mainland China, which includes five new species.

Material and methods

Material used in this study is deposited in the Insect Collection of Shanghai Normal University, Shanghai, China (SNUC).

Habitus photos were taken using a Canon EOS 7D camera mounted with an MP-E 65 mm Macro Photo Lens. Photos of dissected parts were taken using a Canon G9 camera mounted on an Olympus CX21 microscope, and combined by the automontage software Zerene Stacker.

Total length was measured from the anterior margin of the head to the posterior margin of the abdominal tenth tergite; forebody length, from the anterior margin of the head to the posterior margin of the elytra; pronotum length, length of the pronotum along the midline; elytra length, length of the elytra along the suture; head width, width of the head across the eyes; pronotum width, maximum width of the pronotum.

Systematics

Nitidotachinus Campbell, 1993

Nitidotachinus Campbell, 1993: 522; Downie and Arnett 1996: 470; Herman 2001: 849.

Type species. *Tachinus tachyporoides* Horn, 1877.

Diagnosis. Species of the genus are similar to those of allied genera *Tachinus* and *Leucotachinus*, but differ mainly in follows (Campbell 1993).

Body flatter, strongly shining. Ocular puncture obsolete; mentum with a pair of long apical setae and frequently a pair of basal setae; submentum setae; antennae elongate,

with subapical segments at least 1.5 times as long as wide, with only first and second segments lacking dense pubescence; mandible narrowly elongate, with prostheca reduced, not extending beyond middle of mandible. Surface of pronotum almost impunctate, at most with minute fine punctures; mesocoxal cavities contiguous, with apex of mesosternal intercoxal process not reaching posteriorly to apex of metasternal intercoxal process. Abdominal tergites devoid of pruinose spots; posterior lateral corners of fouth–sixth tergites each with a long, projecting bristle. The empodial setae much longer than those of *Tachinus* and *Leucotachinus*.

Key to the species of *Nitidotachinus* from Mainland China

1 Elytra with punctures and micropunctures; sixth sternite of male narrowly depressed medially, with curved row of short peg setae near apical margin; parameres of aedeagus longer than median lobe (the median lobe and parameres fused in *N. dui*), without long protuberance near apex. Eighth tergite of female with three pairs of long setae. (Because of the similarity in female sexual characters and the variation of female sexual characters within species, the following species can be precisely identified only by male characters.) ... **2**

– Elytra with micropunctures only (Fig. 1G); sixth sternite of male even medially, without short peg setae; parameres of aedeagus shorter than median lobe, each with a long protuberance near apex (Fig. 8A, G). Eighth tergite of female with four pairs of long setae ..... ***N. excellens***

2 Median portion of seventh sternite with distinct pubescence in addition to areas of peg setae **3**

– Median portion of seventh sternite without pubescence, only with areas of peg setae in apical half **5**

3 Seventh sternite with short peg setae area reaching the apical margin of sternite **4**

– Seventh sternite with short peg setae area distinctly separated from the apical margin of sternite..... ***N. xiangi* sp. n.**

4 Median portion of seventh sternite densely pubescent, peg setae area reaching anterior half of sternite..... ***N. capillosus* sp. n.**

– Median portion of seventh sternite sparsely pubescent, peg setae area not reaching anterior half of sternite ..... ***N. anhuiensis* sp. n.**

5 Aedeagus with parameres and median lobe fused entirely, parameres asymmetrical truncated at apex..... ***N. dui***

– Aedeagus with parameres and median lobe separated, parameres symmetrical pointed at apex **6**

6 Area of short peg setae on seventh sternite (Fig. 3B) smaller, about 1/6 times as long as entire sternite, and with posterior margin distinctly concave .... ***N. brunneus* sp. n.**

– Area of short peg setae on seventh sternite (Fig. 7B) larger, about 1/3 times as long as entire sternite and with posterior margin slightly concave..... ***N. bini* sp. n.**

***Nitidotachinus capillosus* sp. n.**
http://zoobank.org/546F89C2-B07F-4165-B29F-5FF024F56DEB
Figs 1A, 2

Type specimens. Holotype: China: male, Mt. Longwang Reserve (alt. 950–1200m), Anji County, Zhejiang Prov., 25.IV.2004, Jing-Wen Zhu leg. **Paratypes: China:** 3 males, same date and locality as holotype, Li-Long Zhu leg.; 1 male, same date and locality as holotype, Jing Chen leg.; 1 male, same date and locality as holotype, Shan-Jia Shen leg.; 2 females, same date and locality as holotype, Jin-Wen Li leg.

Description. Body (Fig. 1A) medium in size, 4.2–5.2 mm (total length); 2.8–2.9 mm (length of forebody). Color dark brown with shine; head black; first and second antennal segments, mouthparts, margins of pronotum, narrow apical margins of both elytra and abdominal segments, and legs yellowish red; disc of pronotum, third to apical antennal segments dark reddish brown.

Head subtriangular, 0.49 times as wide as pronotum; surface very finely and sparsely punctate, with dense and coarse microsculpture consisting mostly of irregular meshes and transverse wave lines. Antennae long, extending backward beyond the middle of elytra; first and second segments glabrous except for a few long setae, third to 11th densely pubescent; the relative length of each segment from base to apex: 11.0 : 6.0 : 14.0 : 11.0 : 13.0 : 13.0 : 13.0 : 12.5 : 12.0 : 11.0 : 17.0; 10th segment 1.69 times as long as wide. Maxillary palpus moderately long, relative lengths of 4th and 3rd segments: 15.0 : 8.5.

Pronotum broad, transverse, 0.66 times as long as wide, widest at basal third. Surface with dense and fine microsculpture consisting of transverse wave lines; punctures similar to those on head.

Elytra in sutural length 0.67 times as long as wide; 1.09 times as long as the median length of pronotum; sides gradually widened posteriad; apical margins sinuate; apical angles sharp. Surface with punctures and microsculpture similar to those on pronotum.

Abdomen gradually narrowed from base to apex. Surface with many long bristles which are becoming denser towards anal apex, finely and sparsely punctate and pubescent, with minute microsculpture only at sides of third tergite.

Male: Fore tarsal segments I–IV dilated; the relative lengths of hind tarsal segments from base to apex: 14.0 : 5.0 : 4.0 : 4.0 : 9.0. Eighth tergite (Fig. 2C) 4-lobed; inner lobes separated from each other by a V-shaped emargination, much longer than outer lobes. Sixth sternite (Fig. 2A) slightly and arcuately emarginate at middle in apical margin, with 10–12 peg setae on each side of the emargination. Seventh sternite (Fig. 2B) subtriangularly depressed at middle in posterior part, roundly and deeply emarginate in apical margin, covered with a lot of peg setae and dense fine pubescence in the depression, densely bordered by long black spiniform setae on posterior margin. Eighth sternite (Fig. 2D) 2-lobed apically, deeply incised between the lobes, the depth 0.36 times

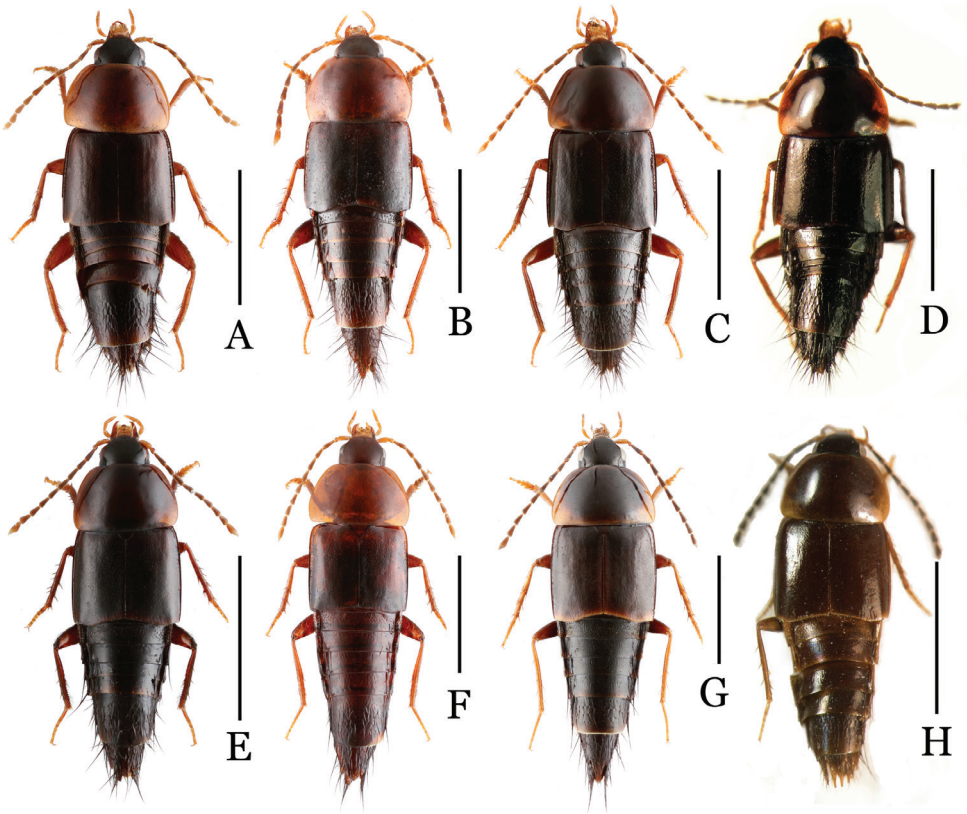

Figure 1. Habitus of *Nitidotachinus* spp. **A** *N. capillosus* sp. n. **B** *N. brunneus* sp. n. **C** *N. dui* **D** *N. xiangi* sp. n. **E** *N. anhuiensis* sp. n. **F** *N. bini* sp. n. **G** *N. excellens* **H** *N. excellens concolor* (paratype). Scale: 2 mm.

as long as the length of sternite. Aedeagus (Figs 2G–H) with parameres much longer than median lobe, narrowed apicad and slightly curved ventrad near apices.

Female: Fore tarsal segments I–IV normal. Eighth tergite (Fig. 2E) 4-lobed; inner lobes distinctly shorter than outer lobes. Eighth sternite (Fig. 2F) 6-lobed; inner lobes much broader than intermediate lobes, separated from each other by a deep subtriangulate emargination.

Distribution. China (Zhejiang Province).

Remarks. This new species is similar to *Nitidotachinus anhuiensis* and *N. xiangi* by the median portion of male seventh sternite with distinct pubescence, but can be separated from *N. anhuiensis* by median portion of seventh sternite densely pubescent. It differs from *N. xiangi* by the male seventh sternite with short peg setae area reaching the apical margin of sternite.

Etymology. The specific name is derived from a Latin word "capillosus" (= hairy), which refers to male seventh sternite with dense pubescence on disc.

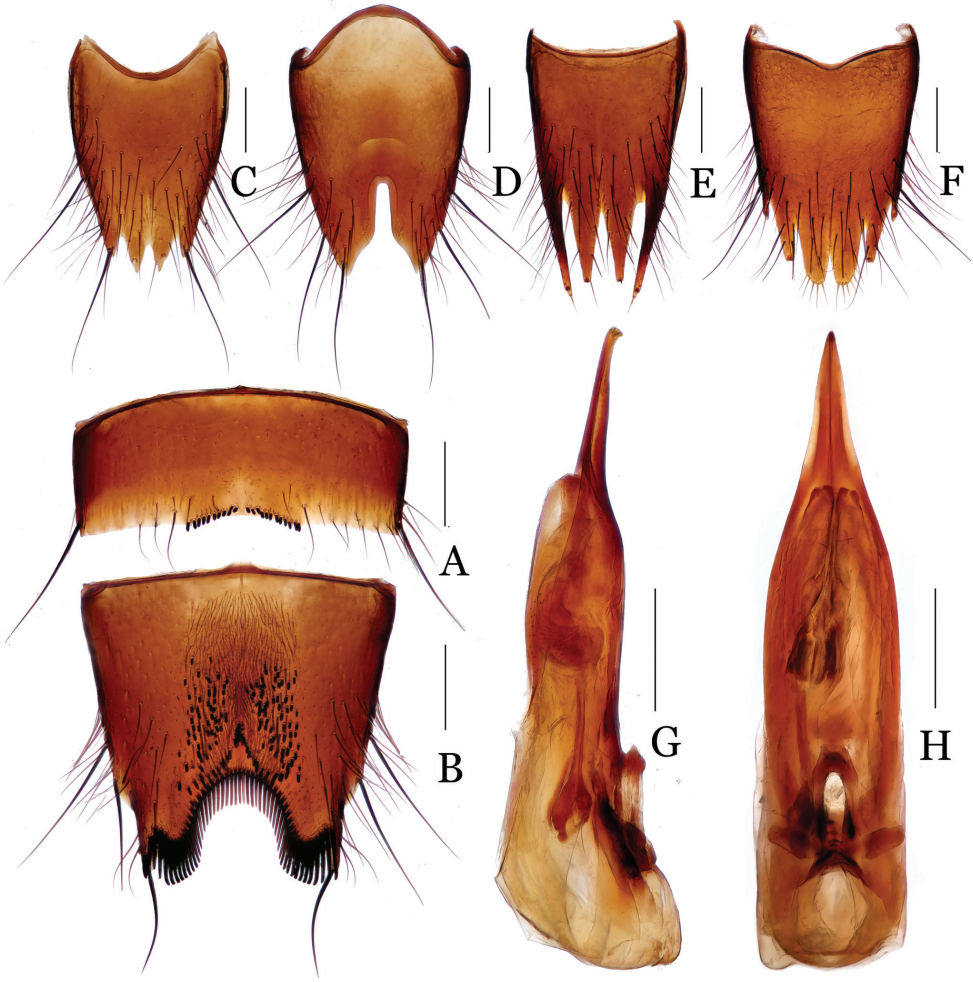

Figure 2. *Nitidotachinus capillosus* sp. n. **A** male 6th sternite **B** male 7th sternite **C** male 8th tergite **D** male 8th sternite **E** female 8th tergite **F** female 8th sternite **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale: 0.3 mm.

***Nitidotachinus brunneus* sp. n.**
http://zoobank.org/719CF9A5-E3B5-46AA-9FC2-59491B99F87A
Figs 1B, 3

Type specimens. Holotype: China: male, Mt. Longwang Reserve (alt. 950–1200m), Anji County, Zhejiang Prov., 25.IV.2004, Li-Long Zhu leg. **Paratypes: China:** 1 female, same data as holotype; 2 males, same locality as holotype, Liang Tang leg.; 1 male, 1 female, same locality as holotype, Jia-Jie Huang leg.; 1 male, same locality as holotype, Jia-Yao Hu leg.; 1 male, same locality as holotype, 25.IV.2006, Liang Tang leg.; 1 female, same locality as holotype, 25.IV.2006, Shan-Jia Shen leg.

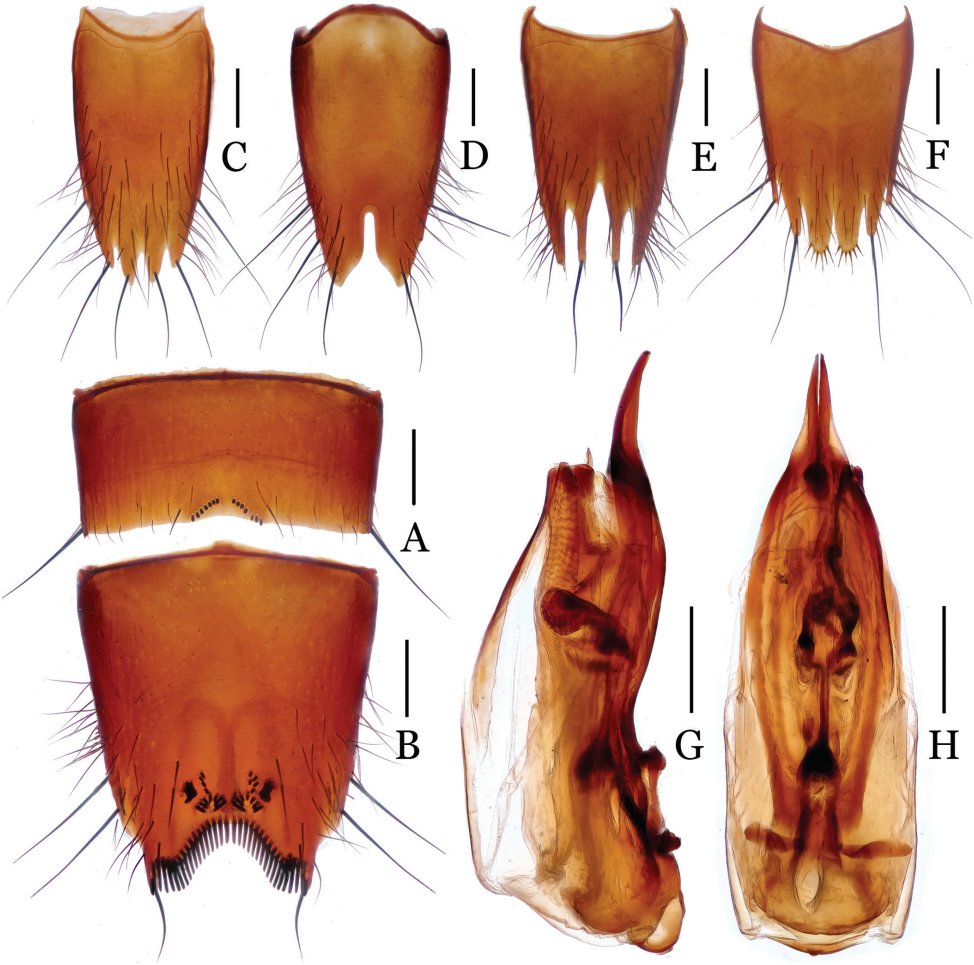

Figure 3. *Nitidotachinus brunneus* sp. n. **A** male 6th sternite **B** male 7th sternite **C** male 8th tergite **D** male 8th sternite **E** female 8th tergite **F** female 8th sternite **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale: 0.3 mm.

Description. Body (Fig. 1B) medium in size, 5.4–5.7 mm (total length); 2.9–3.2 mm (length of forebody). Color dark reddish brown with shine; first and second segments of antennae, mouthparts, sides of pronotum, and legs dark red.

Head subtriangular, 0.47 times as wide as pronotum. Surface finely and sparsely punctate, with dense and coarse microsculpture consisting mostly of irregular meshes. Antennae moderately long, reaching the apical third of elytra; 1st and 2nd segments glabrous except for a few long setae, 3rd to 11th densely pubescent; the relative length of each segment from base to apex: 13.0 : 8.0 : 16.0 : 13.0 : 14.0 : 15.0 : 14.0 : 13.0 : 13.0 : 13.0 : 17.0; the 10th segment 1.86 times as long as wide. Maxillary palpus moderately long, relative lengths of 4th and 3rd segments: 16.5 : 9.0.

Pronotum broad, transverse, 0.64 times as long as wide, widest at basal third. Surface with dense and fine microsculpture consisting of transverse wave lines, punctures slightly sparser and finer than those on head.

Elytra in sutural length 0.69 times as long as wide; 1.06 times as long as the median length of pronotum; sides gradually widened posteriad; apical margins sinuate; apical angles sharp. Surface with punctures much coarser than, and microsculpture similar to those on pronotum.

Abdomen gradually narrowed from base to apex. Surface with many long bristles which are becoming denser towards anal apex, very finely and sparsely punctate and pubescent, with minute microsculpture only at sides of third tergite.

Male: Fore tarsal segments I–IV dilated; the relative lengths of hind tarsal segments from base to apex: 13.0 : 6.0 : 4.5 : 4.0 : 10.0. Eighth tergite (Fig. 3C) 4-lobed; inner lobes separated from each other by a V-shaped emargination and much longer than outer lobes. Sixth sternite (Fig. 3A) slightly emarginate at middle in apical margin, with 7–8 granules on each side of the emargination. Seventh sternite (Fig. 3B) subtriangularly depressed at middle in posterior part, deeply and sinuately emarginated in apical margin, symmetrically covered with some short peg setae near posterior margin; densely bordered by long black spiniform setae on posterior margin. Eighth sternite (Fig. 3D) 2-lobed, deeply incised between two lobes, the depth 0.28 times as long as the median length of sternite; Aedeagus (Figs 3G–H) moderate in size; parameres longer than median lobe, strongly narrowed apicad, slightly curved ventrad in apical fourth.

Female: Fore tarsal segments I–IV normal. Eighth tergite (Fig. 3E) 4-lobed; inner lobes deeply separated with each other, much narrower and slightly shorter than outer lobes. Eighth sternite (Fig. 3F) 6-lobed; inner lobes much broader than intermediate lobes, separated from each other by a shallow, "V" shaped emargination.

Distribution. China (Zhejiang Province).

Remarks. This new species can be easily separated from the other species from Mainland China by the area of short peg setae on male seventh sternite smaller, about 1/6 times as long as entire sternite.

Etymology. The specific name is derived from a Latin word "brunneus" (= brown), which refers to the body color.

Nitidotachinus dui Li, 1999

Figs 1C, 4

Nitidotachinus dui Li, 1999: 197; Schülke 2000: 907; Herman 2001: 850; Smetana 2004: 340.

Specimens examined. China: 1 male (holotype), 1 female (paratype), Mt. West Tianmu Reserve, Lin'an City, Zhejiang Prov., 6–12.V.1998, Li-Zhen Li leg.; 1 male, 8 fe-

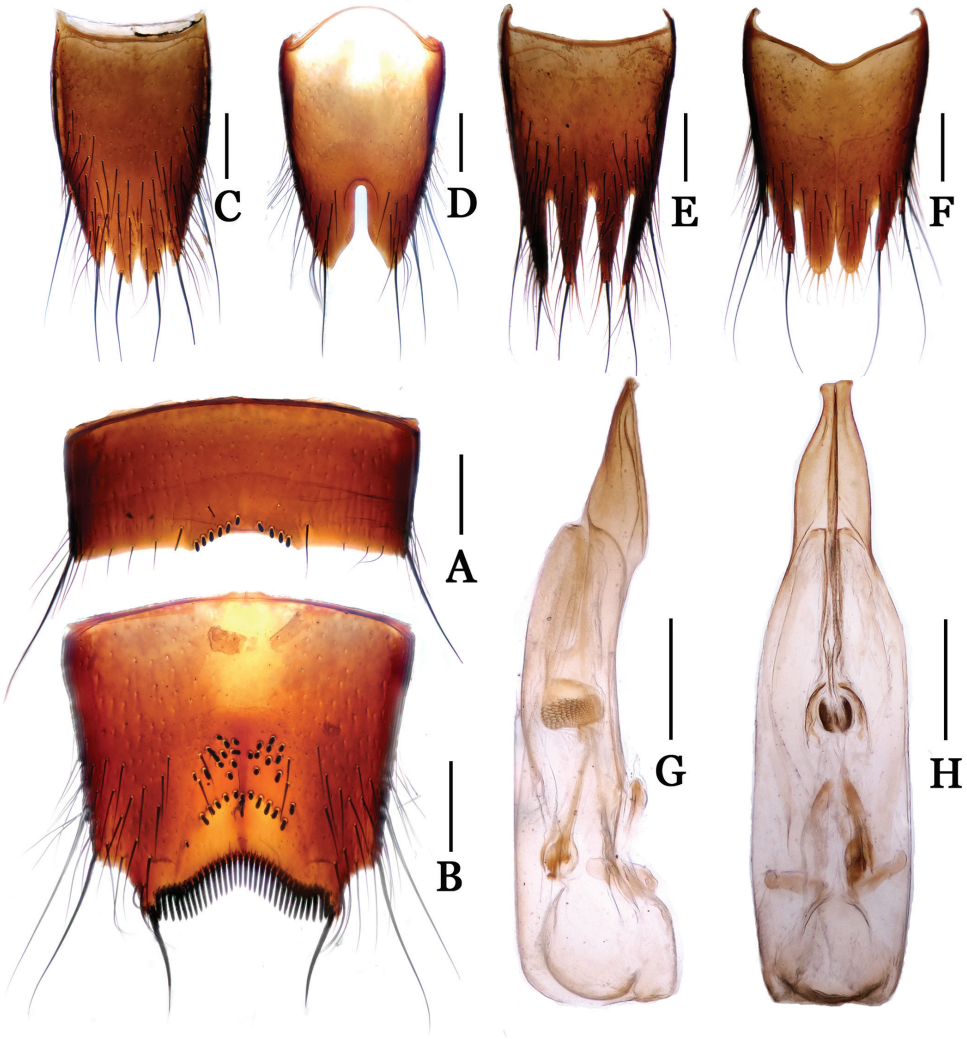

Figure 4. *Nitidotachinus dui.* **A** male 6th sternite **B** male 7th sternite **C** male 8th tergite **D** male 8th sternite **E** female 8th tergite **F** female 8th sternite **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale: 0.3 mm.

males, same locality as above, (alt. 300–400m), 11–15.VI.2006, Jia-Yao Hu and Liang Tang leg.; 1 female, Mt. Longwang Reserve (alt. 300–500m), Anji County, Zhejiang Prov., 24.IV.2004, Liang Tang leg.; 4 males, 7 females, Danzhu (alt. 450–600m), Xianju County, Zhejiang Prov., 2.VI.2006, Jin-Wen Li and Shan-Jia Shen leg.; 1 male, Mt. Dapan Reserve (alt. 550–700m), Pan'an County, Zhejiang Prov., 7.VI.2006, Jin-Wen Li and Shan-Jia Shen leg.; 3 female, same locality and collectors as above, 6.VI.2006; 1 female, Qingliangfeng (alt. 1050–1070m), Lin'an City, Zhejiang Prov., 9.V.2005, Li-Long Zhu and Li-Zhen Li leg.

Description. Body (Fig. 1C) relative small in size, 4.8–5.0 mm (total length); 2.6–2.8 mm (length of forebody). Color piceous, shining; head black; 1st and 2nd antennal segments, mouthparts, lateral margins of pronotum, narrow apical margins of abdominal segments, and tarsi light reddish brown; disc of pronotum, 3rd to 11th antennal segments, and legs except for tarsi dark reddish brown.

Head subtriangular, 0.48 times as wide as pronotum; surface finely and sparsely punctate, with dense microsculpture consisting of irregular meshes and transverse wave lines. Antennae moderately long, reaching backward to the apical third of elytra; 1st and 2nd segments glabrous except for a few long setae, 3th to 11th densely pubescent; the relative length of each segment from base to apex: 12.0 : 7.0 : 17.0 : 12.0 : 15.0 : 14.0 : 14.0 : 13.0 : 13.0 : 12.5 : 17.0; the 10th segment twice as long as wide. Maxillary palpus moderately long, relative lengths of 4th and 3rd segments: 2.0 : 1.0.

Pronotum broad, transverse, 0.63 times as long as wide, widest at basal third. Surface with dense and fine microsculpture consisting of transverse wave lines; punctures similar to those on head.

Elytra in sutural length 0.73 times as long as wide; 1.17 times as long as the median length of pronotum; sides gradually widened posteriad; apical margins sinuate. Surface with punctures courser and microsculpture somewhat finer than those on pronotum.

Abdomen gradually narrowed from base to apex. Surface sparsely and finely punctate and pubescent, with short transverse microsculpture only at sides of third tergite.

Male: Fore tarsal segments I–IV dilated; the relative lengths of hind tarsal segments from base to apex: 14.0 : 5.0 : 4.0 : 4.0 : 9.0. Eighth tergite (Fig. 4C) 4-lobed; inner lobes much longer than outer lobes. Sixth sternite (Fig. 4A) arcuately emarginate at middle in apical margin, with nine peg setae on each side of the emargination. Seventh sternite (Fig. 4B) subtriangularly depressed at middle in posterior part, deeply and sinuately emarginated in apical margin, sparsely covered with some peg setae near middle of the subtriangular depression, densely bordered by long black spiniform setae on posterior margin. Eighth sternite (Fig. 4D) 2-lobed, deeply incised between the lobes, the depth 0.33 times as long as the median length of sternite. Aedeagus (Figs 4G–H) moderate in size, with parameres and median lobe fused, asymmetrical, narrowed apicad, distinctly widened and truncated at apices in ventral view.

Female: Fore tarsal segments 1–4 normal. Eighth tergite (Fig. 4E) 4-lobed; inner lobes slightly longer than outer lobes. Eighth sternite (Fig. 4F) 6-lobed; inner lobes much broader than intermediate lobes, fimbriate apically, separated from each other by a "V" shaped emargination.

Distribution. China (Zhejiang Province).

Remarks. This species can be easily recognized from the others of the genus by parameres and median lobe of aedeagus being fused and the asymmetrical truncated apices of parameres.

***Nitidotachinus xiangi* sp. n.**
http://zoobank.org/4D76772A-2D99-4167-B374-20B6050D8E1B
Figs 1D, 5

Type specimens. Holotype: China: male, Houhe Conv., Wufeng County, Hubei Prov., 1.V.2004, Li-Zhen Li leg. **Paratypes: China:** 1 female, same locality as holotype, 30.IV.2004, Li-Zhen Li leg.

Description. Body (Fig. 1D) relative large in size, 5.7–6.0 mm (total length); 2.9–3.1 mm (length of forebody). Color dark reddish brown with shine; head black; first and second antennal segments, mouthparts, lateral margins of pronotum, narrow apical margins of both elytra and abdominal segments, and legs yellowish red; disc of pronotum, 3rd to apical segments of antennae reddish brown.

Head subtriangular, 0.48 times as wide as pronotum; surface finely and sparsely punctate, with dense microsculpture consisting mostly of transverse wave lines. Antennae long, extending backward beyond the middle of elytra; 1st and 2nd segments glabrous except for a few setae, 3rd to 11th densely pubescent; the relative length of each segment from base to apex: 11.5 : 7.0 : 16.0 : 12.0 : 14.0 : 14.0 : 13.0 : 13.0 : 13.0 : 13.0 : 16.5; the 10th segment 1.71 times as long as wide. Maxillary palpus moderately long, relative lengths of 4th and 3rd segments: 16.0 : 9.0.

Pronotum broad, transverse, 0.66 times as long as wide, widest at basal third. Surface with dense and fine microsculpture consisting of transverse wave lines; punctures similar to those on head.

Elytra in sutural length 0.62 times as long as wide; 1.02 times as long as the median length of pronotum; sides gradually widened posteriad; apical margins sinuate; apical angles sharp. Surface with punctures much courser, and microsculpture somewhat finer than those on pronotum.

Abdomen gradually narrowed from base to apex. Surface with many long bristles which are becoming denser towards apex, finely and sparsely punctate and pubescent, with minute microsculpture only at sides of third tergite.

Male: Fore tarsal segments I–IV dilated; the relative lengths of hind tarsal segments from base to apex: 14.5 : 6.0 : 4.5 : 4.0 : 16.0. Eighth tergite (Fig. 5C) 4-lobed; inner lobes separated from each other by a V-shaped emargination, much longer than outer lobes. Sixth sternite (Fig. 5A) slightly and roundly emarginate at middle in apical margin, with 9–11 peg setae on each side of the emargination. Seventh sternite (Fig. 5B) subtriangularly depressed at middle in posterior part, deeply and sinuately emarginated in apical margin, symmetrically covered with a lot of short peg setae in median part of the depression, densely pubescent in the depression before the area of peg setae, and densely bordered by long black spiniform setae on posterior margin. Eighth sternite (Fig. 5D) 2-lobed apically, deeply incised between the lobes, the depth 0.32 times as long as the median length of sternite. Aedeagus (Figs 5G–H) somewhat elongate; parameres much longer than median lobe, arrowhead-shaped at apices in ventral view, slightly curved ventrad at apical third.

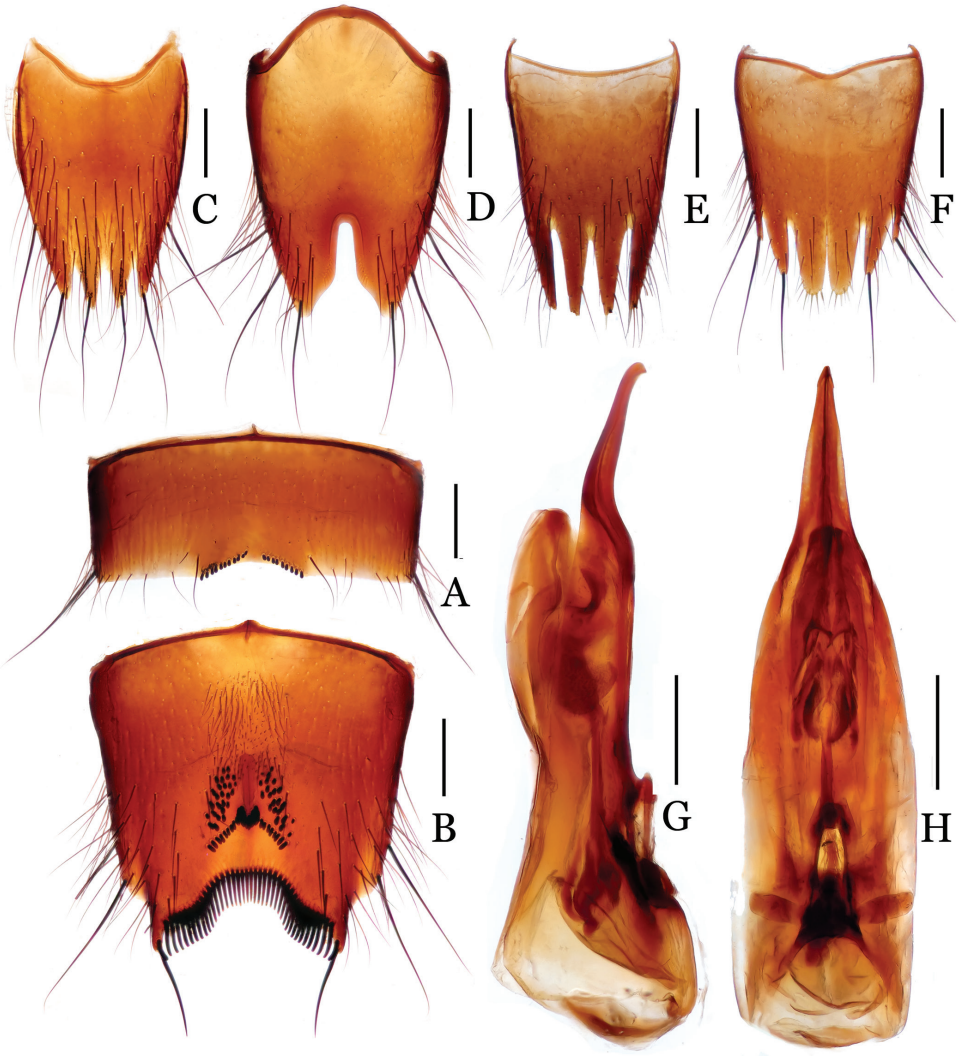

Figure 5. *Nitidotachinus xiangi* sp. n. **A** male 6th sternite **B** male 7th sternite **C** male 8th tergite **D** male 8th sternite **E** female 8th tergite **F** female 8th sternite **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale: 0.3 mm.

Female: Fore tarsal segments I–IV normal. Eighth tergite (Fig. 5E) 4-lobed; inner lobes slightly longer than outer lobes. Eighth sternite (Fig. 5F) 6-lobed; inner lobes much broader than intermediate lobes, distinctly separated from each other.

Distribution. China (Hubei Province).

Remarks. This new species is similar to *Nitidotachinus capillosus* and *N. anhuiensis*. But it can be easily separated from them by the male seventh sternite with short peg setae area distinctly separated from the apical margin of sternite.

Etymology. The specific name is derived from the name of Prof. Jia-Xiang Xiang, the vice-president of Shanghai Normal University, who helped us in many ways during our studies.

***Nitidotachinus anhuiensis* sp. n.**
http://zoobank.org/E674BDE3-3C5B-434D-984E-87D9C40957BC
Figs 1E, 6

Type specimens. Holotype: China: male, Mt. Tianzhu (alt. 960m), Anhui Prov., 23.IV.2005, Jia-Yao Hu and Liang Tang leg. **Paratypes: China:** 1 male, 4 females, same data as holotype.

Description. Body (Fig. 1E) medium in size, 4.5–5.7 mm (total length); 2.8–3.2 mm (length of forebody). Color dark brown with shine; the first and second segments of antennae and mouthparts, sides of pronotum, posterior margins of elytra, and legs reddish brown.

Head subtriangular, 0.48 times as wide as pronotum. Surface finely and sparsely punctate, with dense and coarse microsculpture consisting of irregular meshes and transverse wave lines. Antennae moderately long, reaching the apical third of elytra; 1st and seconf segments glabrous except for a few long setae, 3rd to 11th densely pubescent; the relative length of each segment from base to apex: 11.5 : 7.0 : 14.0 : 10.5 : 12.0 : 12.0 : 12.0 : 11.5 : 11.5 : 11.5 : 15.0; the 1tenth segment 1.92 times as long as wide. Maxillary palpus moderately long, relative lengths of 4th and 3rd segments: 15.5: 9.0.

Pronotum broad, transverse, 0.65 times as long as wide, widest at basal third. Surface with microsculpture finer and punctures slightly sparser and shallower than those on head.

Elytra in sutural length 0.68 times as long as wide; 1.10 times as long as the median length of pronotum; sides gradually widened posteriad; apical margins sinuate; apical angles sharp. Surface with punctures coarser than, and microsculpture similar to those on pronotum.

Abdomen gradually narrowed from base to apex. Surface with many long bristles which are becoming denser towards anal apex, very finely and sparsely punctate and pubescent, with minute microsculpture only at sides of third tergite.

Male: Fore tarsal segments I–IV dilated; the relative lengths of hind tarsal segments from base to apex: 14.0 : 5.0 : 4.5 : 3.5 : 9.0. Eighth tergite (Fig. 6C) 4-lobed; inner lobes separated from each other by a V-shaped emargination and distinctly longer than outer lobes. Sixth sternite (Fig. 6A) slightly emarginate at middle in apical margin, with seven short peg setae on each side of the emargination. Seventh sternite (Fig. 6B) subtriangularly depressed at middle in posterior part, very deeply and sinuately emarginated at the middle in apical margin, symmetrically covered with many short peg setae in apical half and fine setae in basal half of the depression respectively; densely

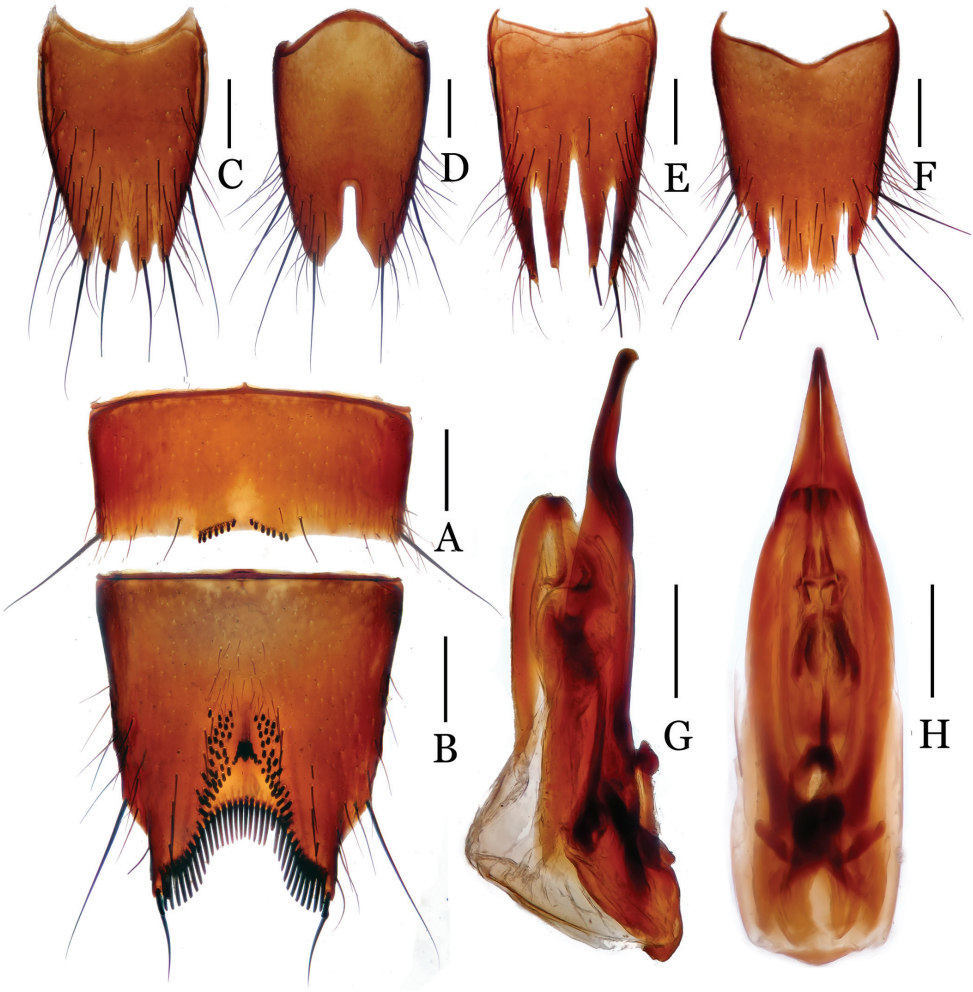

Figure 6. *Nitidotachinus anhuiensis* sp. n. **A** male 6th sternite **B** male 7th sternite **C** male 8th tergite **D** male 8th sternite **E** female 8th tergite **F** female 8th sternite **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale: 0.3 mm.

covered with long black spiniform setae on posterior margin. Eighth sternite (Fig. 6D) 2-lobed, deeply incised between two lobes, the depth 0.31 times as long as the median length of sternite. Aedeagus (Figs 6G–H) moderately long, with parameres longer than median lobe, narrowed apicad and slightly curved ventrad at apical portions.

Female: Fore tarsal segments I–IV normal. Eighth tergite (Fig. 6E) 4-lobed; inner lobes deeply separated from each other, distinctly shorter than outer lobes. Eighth sternite (Fig. 6F) 6-lobed; inner lobes much broader than intermediate lobes, separated from each other by a shallow, "V" shaped emargination.

Distribution. China (Anhui Province).

Remarks. This new species is similar to *Nitidotachinus capillosus* and *N. xiangi*. But can be easily separated from *N. capillosus* by the median portion of male seventh sternite sparsely pubescent. It differs from *N. xiangi* by the male seventh sternite with short peg setae area reaching the apical margin of sternite.

Etymology. The specific name is named after Anhui Province, where the type specimens were collected.

***Nitidotachinus bini* sp. n.**

http://zoobank.org/074B0938-76AB-4902-BC5F-59501D3FE5A7

Figs 1F, 7

Type specimens. Holotype: China: male, Qingliangfeng Reserve (alt.1080m), Zhejiang Prov., 10.V.2005, Li-Long Zhu & Li-Zhen Li leg. **Paratypes: China:** 3 males, 1 female, same data as holotype, but data from 8–10.V.2005; 1male, 2 females, Mt. Dapan Reserve (alt.550–800m), Pan'an County, Zhejiang Prov. 6–7.VI.2006, Li-Zhen Li & Shan-jia Shen leg.

Description. *Male* (Fig. 1F) : Body medium in size, 5.7–6.0 mm (total length); 2.8–2.9 mm; 2.5–2.8 mm (length of forebody). Color reddish brown with shine; head black, the 1st and 2nd segments of antennae, mouthparts, sides of pronotum, posterior margins of elytra, and legs light reddish brown.

Head 0.47 times as wide as pronotum. Surface finely and sparsely punctate, with dense and coarse microsculpture consisting of irregular meshes and transverse wave lines. Antennae long, reaching the apical third of elytra; the relative length of each segment from base to apex: 13.0 : 8.0 : 16.0 : 11.0 : 13.0 : 13.0 : 13.0 : 13.0 : 13.0 : 12.0 : 17.0; the 10th segment 1.60 times as long as wide. Maxillary palpus with relative lengths of 4th and 3rd segments: 16.5 : 9.0.

Pronotum 0.63 times as long as wide; microsculpture shallower and punctures slightly sparser than those on head.

Elytra in sutural length 0.67 times as long as wide; 1.05 times as long as the median length of pronotum; punctures coarser than, and microsculpture similar to those on pronotum.

Abdomen sparsely and finely punctate and pubescent, with minute microsculpture only at sides of third tergite.

Male: Fore tarsal segments I–IV dilated; the relative lengths of hind tarsal segments from base to apex: 15.0 : 5.0 : 4.5 : 4.0 : 9.0. Eighth tergite (Fig. 7C) 4-lobed; inner lobes separated from each other by a V-shaped emargination, much longer than outer lobes. Sixth sternite (Fig. 7A) slightly emarginate at middle in apical margin, with 6–8 short peg setae on each side of the emargination. Seventh sternite (Fig. 7B) subtriangularly depressed at middle in posterior part, roundly emarginated at middle in apical margin, symmetrically covered with some short peg setae in apical half of the depression, densely covered with long black spiniform setae on apical margin. Eighth

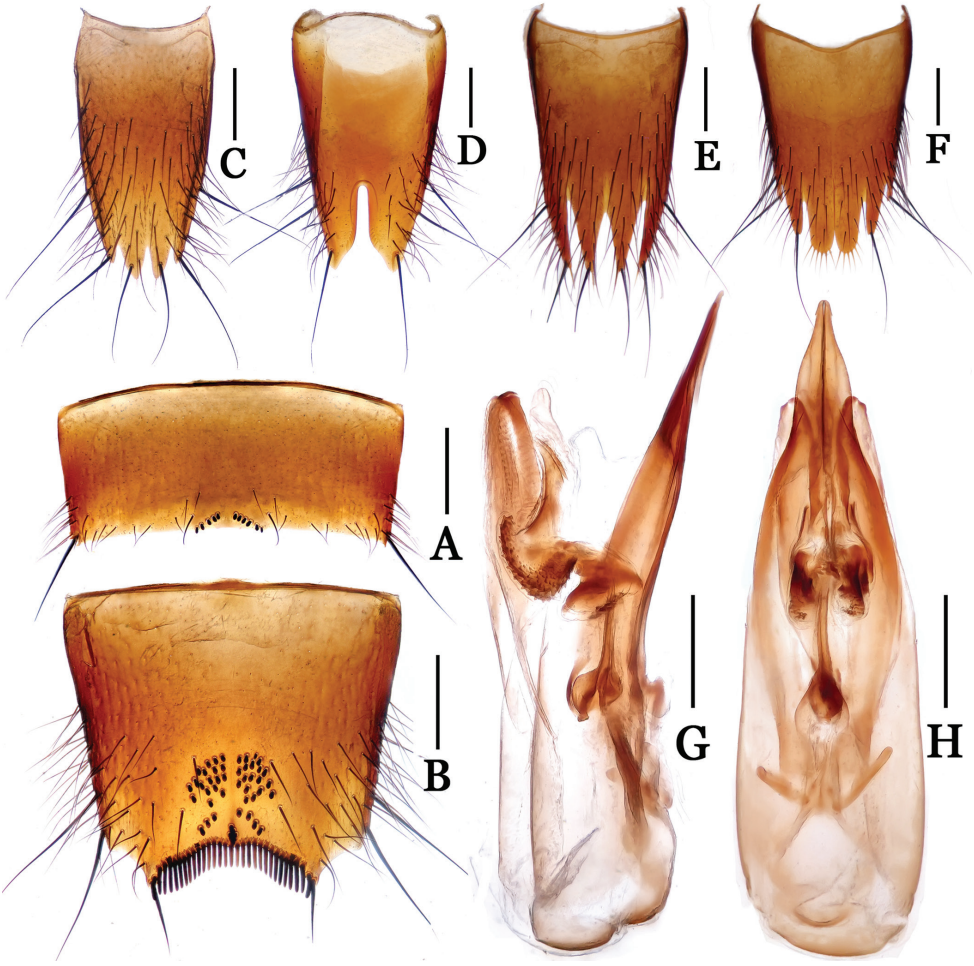

Figure 7. *Nitidotachinus bini* sp. n. **A** male 6th sternite **B** male 7th sternite **C** male 8th tergite **D** male 8th sternite **E** female 8th tergite **F** female 8th sternite **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale: 0.3 mm.

sternite (Fig. 7D) 2-lobed, deeply incised between two lobes, the depth 0.30 times as long as the median length of sternite. Aedeagus (Figs 7G–H) with parameres longer than median lobe, tapered apicad.

Female: Fore tarsal segments I–IV normal. Eighth tergite (Fig. 7E) 4-lobed; inner lobes deeply separated with each other, about as long as outer lobes. Eighth sternite (Fig. 7F) 6-lobed; inner lobes distinctly separated from each other.

Distribution. China (Zhejiang Province).

Remarks. This new species is similar to *Nitidotachinus taiwanensis*. But can be separated from it by the shape of peg setae area of male seventh sternite; female eighth tergite with emargination between the inner lobes is distinctly shallower than

those between inner and outer lobes ; and parameres of aedeagus a little narrower in apical parts.

Etymology. The specific name is named after the nick name of Xiao-bin Song.

***Nitidotachinus excellens* (Bernhauer, 1938)**
Figs 1G–H, 8, 9

Tachinus excellens Bernhauer, 1938: 23; Li and Chen 1990: 19; Li 1992: 55.
Tachinus exceliens: Li 1993: 43.
Tachinus sawadai Watanabe & Shibata, 1961: 36; Campbell 1993: 531.
Nitidotachinus excellens: Campbell 1995: 45; Herman 2001: 850; Smetana 2004: 340; Schülke 2005: 170.
Nitidotachinus excellens concolor Schülke, 2000: 907. **syn. n.**

Specimens examined. China: 5 males, 5 females Mt. Xiaowutai Reserve (alt. 1300–1600m), Wei County, Hebei Prov., 22.VIII.2005, Li-Zhen Li leg.; 1 male, 1 female, Jinhekou (alt. 1300m), Wei County, Hebei Prov., 23.VIII.2005, Li-Zhen Li leg.; 11 males, 10 females, Labahe Reserve (alt. 1900m), Tianquan County, Sichuan Prov., 29.VII.2006, Jia-Yao Hu and Liang Tang leg.; 1 male, 5 females, Labahe Reserve (alt. 2000m), Tianquan County, Sichuan Prov., 30.VII.2006, Jia-Yao Hu and Liang Tang leg.; 1 males, 1 females, Foping Conv. (alt. 1400–1800m), Shaanxi Prov., 19.VII.2004, Jia-Yao Hu, Liang Tang and Li-Long Zhu leg.; 1 male, ditto, but (alt.1250–1400m), 18.VII.2004; 1 female, Yangjiaping (alt.830m), Zhulu Couty, Hebei Prov., 4.VIII.2005, Li-Zhen Li leg.; 1 female (paratype), with labels as: CHINA: S-Sichuan 1999, Ya'an Prefecture, Shimian Co., Xiaoxiang Ling, Pass zw. Shimian u., Ganluo, 27 km SE Shimian, 29°03N, 102°31E, 2450m, Quellsumpf, Bachufer, 8. VII., leg. M/ Schülke (white) / Sammlung M. Schülke, Berlin (green) / PARATYPUS, *Nitidotachinus exellens* subspec. *concolor* n., det. M. Schülke, 2000 (red).

Description. Body (Fig. 1G–H) medium in size, 4.5–5.9 mm (total length); 3.1–3.4 mm (length of forebody). Color dark brown with shine; the first and second segments of antennae, mouthparts, sides and posterior margin of pronotum, posterior margins of elytra, and legs yellowish red.

Head 0.48 times as wide as pronotum. Surface finely and sparsely punctate, with dense and coarse microsculpture consisting of irregular meshes and transverse wave lines. Antennae moderately long, reaching the middle of elytra; the relative length of each segment from base to apex: 11.5 : 7.0 : 15.0 : 12.0 : 14.0 : 14.5 : 13.0 : 13.0 : 13.0 : 13.0 : 16.0; the tenth segment 1.73 times as long as wide. Maxillary palpus with relative lengths of 4th and 3rd segments: 15.5 : 8.0.

Pronotum 0.65 times as long as wide; microsculpture shallower and punctures much finer and sparser than those on head.

Elytra in sutural length 0.72 times as long as wide; 1.15 times as long as the median length of pronotum; punctures and microsculpture a little courser than those on pronotum.

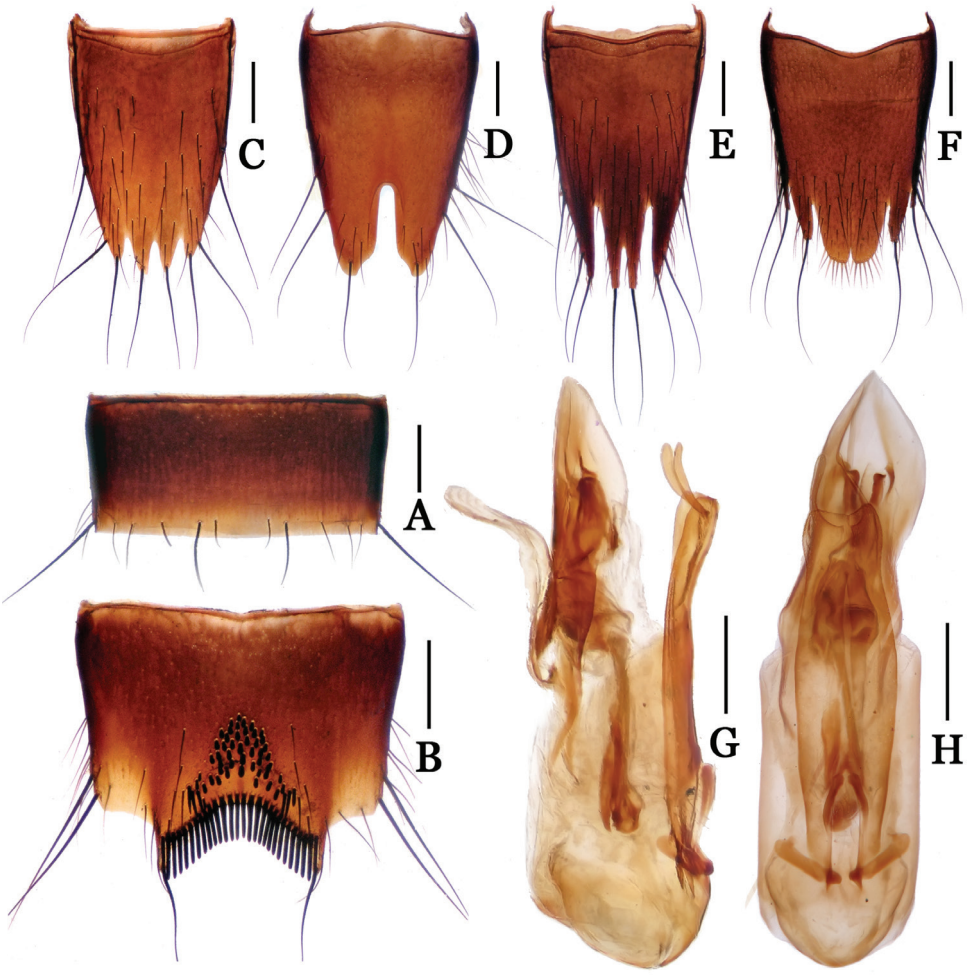

Figure 8. *Nitidotachinus excellens*. **A** male 6th sternite **B** male 7th sternite **C** male 8th tergite **D** male 8th sternite **E** female 8th tergite **F** female 8th sternite **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale: 0.3 mm.

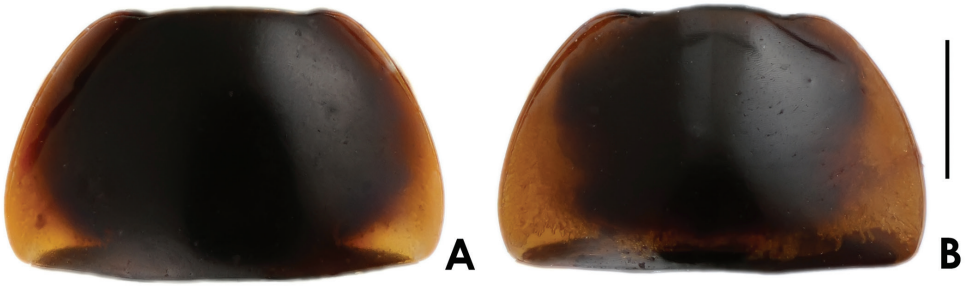

Figure 9. *Nitidotachinus excellens*. **A** Pronotum, specimen collected from Labahe, Tianquan, Ya'an, Sichuan **B** ditto. Scale: 0.5 mm.

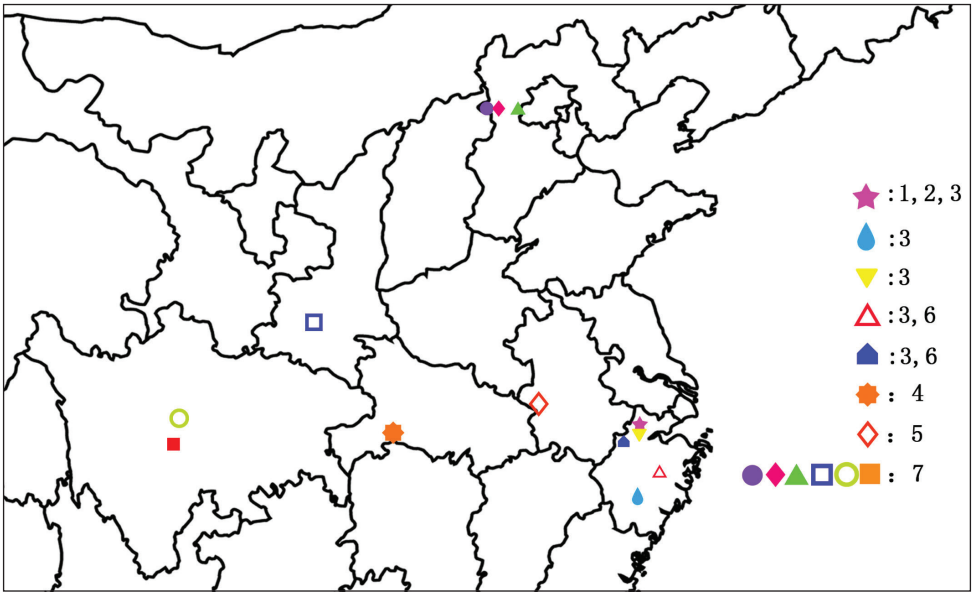

Figure 10. Distribution of *Nitidotachinus* species from Mainland China: **1** *N. capillosus* sp. n. **2** *N. brunneus* sp. n. **3** *N. dui* **4** *N. xiangi* sp. n. **5** *N. anhuiensis* sp. n. **6** *N. bini* sp. n. **7** *N. excellens*.

Abdomen sparsely and finely punctate and pubescent, with minute microsculpture only at sides of third tergite.

Male: Fore tarsal segments I–IV dilated; the relative lengths of hind tarsal segments from base to apex: 14.0 : 7.5 : 5.0 : 4.0 : 10.0. Eighth tergite (Fig. 8C) 4-lobed; inner lobes separated from each other by a V-shaped emargination and distinctly longer than outer lobes. Sixth sternite (Fig. 8A) without short peg seta. Seventh sternite (Fig. 8B) subtriangularly depressed at middle in posterior part, roundly emarginated at middle in apical margin, symmetrically covered with sparse short peg setae in the depression before posterior margin, densely covered with long black spiniform setae on posterior margin. Eighth sternite (Fig. 8D) 2-lobed, deeply incised between two lobes, the depth 0.35 times as long as the median length of sternite. Aedeagus (Figs 8G–H) medium in size; parameres shorter than median lobe, each with a spindly projection near apex.

Female (Fig. 8): Fore tarsal segments I–IV normal. Eighth tergite (Fig. 8E) 4-lobed; inner lobes relatively shallowly separated with each other, distinctly longer than outer lobes. Eighth sternite (Fig. 8F) 6-lobed; inner lobes almost fused with each other, slightly emarginate at middle in posterior margins.

Distribution. China (Hebei, Shaanxi, Sichuan, Heilongjiang, Jilin, Liaoning, Beijing); Japan; Far East Russia; Korea.

Remarks. This new species is similar to *Nitidotachinus impunctatus* and *N.japonicus*. But can be easily separated from them by the different shape of aedeagal parameres.

Comments. *Nitidotachinus excellens concolor* was described by Schülke in 2000 from Xiaoxiang Ling, Shimian, Ya'an, Sichuan Province. The characters separating

it from the nominal subspecies were mentioned to be almost total black pronotum, darker elytra and inner emargination of female eighth tergite slightly deeper and wider. Though a paratype (Fig. 1H) of it also shows the broad yellowish brown lateral margins on pronotum. With more material collected in recent years, those diagnosis characters mentioned above are now considered as variability within *Nitidotachinus excellens* and the distribution gap between two subspecies are totally filled. Thus *N. excellens concolor* has to be synonymized with *N. excellens*, which is also fully agreed by M. Schülke (personal communication).

Acknowledgments

We thank to Mr. Michael Schülke (Berlin, Germany) for offering us the paratype of *N. excellens concolor* and providing us many useful suggestions of the study, to Dr. Nobuo Ohbayashi and Dr. Masahiro Sakai (Matsuyama, Japan) for helping us in many ways, to Mr. Jia-Yao Hu and Mr. Xiao-Bin Song for offering various helps during this study, to Dr. Liang Tang and Dr. Zi-Wei Yin (Shanghai Normal University) for providing useful comments on a previous draft. The study is supported by the National Natural Science Foundation of China (No. 31101659 and No. 31172134, 31201734) and Shanghai Normal University (DZL125).

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Taxonomy of the genus *Homalota* Mannerheim in Korea (Coleoptera, Staphylinidae, Aleocharinae)

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Abstract

A taxonomic study of the genus *Homalota* Mannerheim in Korea is presented. Five species are recognized, one of which, *Homalota serrata* (Assing), **comb. n.** is transferred from *Anomognathus* Solier. *Homalota fraterna* (Sharp), *H. mikado* Likovský, *H. sauteri* Bernhauer, and *H. serrata* are newly added to the Korean fauna. A key, descriptions, and illustrations of the diagnostic characters are provided.

Keywords

Staphylinidae, Aleocharinae, *Homalota*, key to species, Korea, new combination, taxonomy

Introduction

The genus *Homalota* Mannerheim in the tribe Homalotini Heer contains 72 species worldwide, with six species recorded from the Palearctic region (Smetana 2004, Newton and Thayer 2005). In East Asia, three species have been recorded from Japan and Taiwan, and two species from China. In the Korean Peninsula, Paśnik (2001) reported *H. plana* (Gyllenhal) from North Korea. Members of *Homalota* are usually found under bark, but are often collected from decaying fruits or using flight intercept trap (FITs).

During an ongoing study of the Korean Homalotini, we recognized five *Homalota* species. We concluded that *Anomognathus serratus* Assing should be transferred to the genus *Homalota*. *Homalota fraterna* (Sharp), *H. mikado* Likovský, *H. sauteri* Bernhauer, and *H. serrata* are new to the Korean fauna. We provide a key, descriptions, and illustrations of the diagnostic characters for these five species.

Methods

The specimens were examined by scanning electron microscopy (SEM; S-4800, Hitachi High-Technologies, Tokyo, Japan). Specimens were dissected in water and mounted on sticky carbon tape. Then, the specimens dried at 60 °C on a slide warmer for 24 h, sputter-coated with Pt/Pd nanoparticles using a sputter coater (208 HR, Cressington Scientific Instruments, Watford, Hertfordshire, UK), and examined with SEM. The terminology used here follows Sawada (1972), but we followed Ashe (1984) in some cases. Ashe (1984) modified Sawada's character system, especially the mouthparts, to reduce some confusion. North Korean species were borrowed from the Institute of Systematics and Evolution of Animals (ISEA), Kracôw, Poland. All other examined specimens are deposited in the Chungnam National University Insect Collection (CNUIC), Daejeon, Korea.

Results

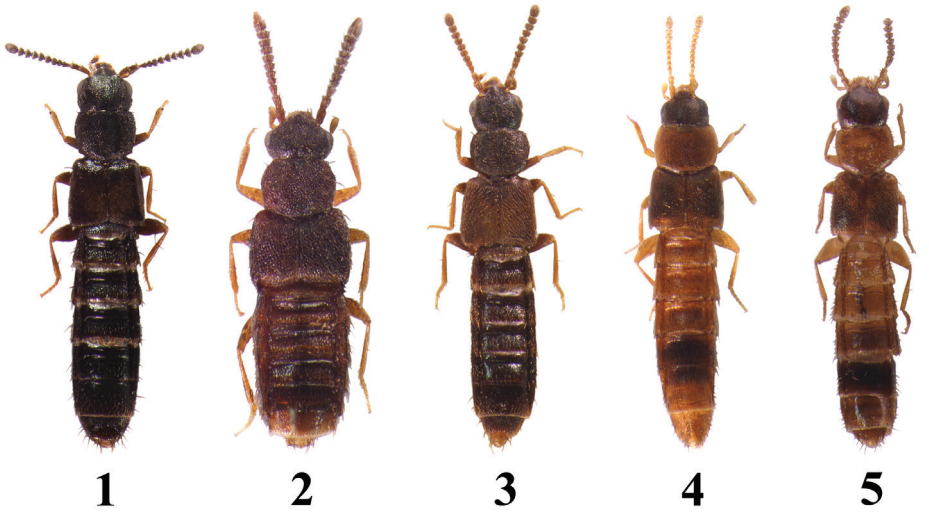
Genus *Homalota* Mannerheim

Homalota Mannerheim, 1830: 73. Type species. *Aleochara plana* Gyllenhal, 1810.

Diagnosis. Body strongly to moderately dorsoventrally flattened, parallel-sided. Head almost as wide as pronotum or slightly narrower than pronotum. Eye moderate in size, almost as long as tempora. Infraorbital carina well developed, complete. Labium with two palpomeres, ligula as long as palpomere 1, its apical half bifid. Scutellum posteromedially round. Mesocoxae narrowly separated, isthmus present, less than about half of mesocoxae length. Male tergite VIII with modified processes in males (most species) or in both sexes (some species).

Key to the species of the genus *Homalota* Mannerheim in Korea

1 Body dorsoventrally slightly flattened; mesocoxae moderately separated (Fig. 17) ..... ***H. mikado***



Figures 1–5. Habitus: **1** *Homalota fraterna*, 2.3 mm **2** *H. mikado*, 2.0 mm **3** *H. plana*, 2.9 mm **4** *H. sauteri*, 1.8 mm **5** *H. serrata*, 2.1 mm.

– Body dorsoventrally strongly flattened; mesocoxae very narrowly separated (Fig. 10) **2**

2 Body yellowish brown; size smaller, length less than 2.1 mm **3**

– Body brown to dark brown; size larger, length more than 2.1 mm **4**

3 Head narrower than pronotum; male tergite VII with 16 to 18 tubercles (Fig. 27) ..... ***H. sauteri***

– Head almost as wide as pronotum; male tergite VII without tubercles ..... ***H. serrata***

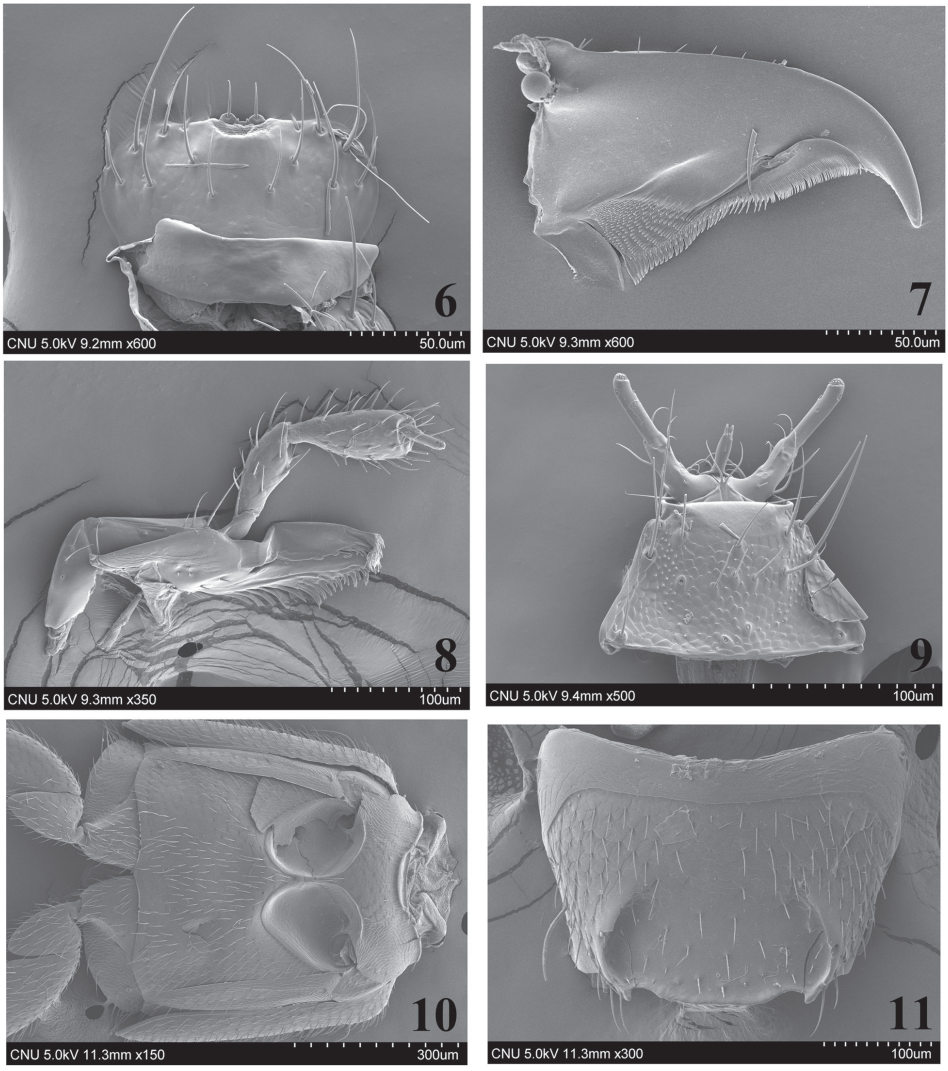
4 Male tergite VII with a distinct tubercle (Fig. 21); male tergite VIII without lateral process (Fig. 22); tergite X with medial setal patch subpentagon, loss of setae postero-medially ..... ***H. plana***

– Male tergite VII without tubercle; male tergite VIII with short lateral processes (Fig. 11); tergite X with medial setal patch subquadrate, with transverse row of large spines posteriorly ..... ***H. fraterna***

***Homalota fraterna* (Sharp, 1888)**
Figs 1, 6–14

Epipeda fraterna Sharp, 1888: 376.
Homalota fraterna: Fenyes 1914: 46; Fenyes 1918: 87; Smetana 2004: 448.

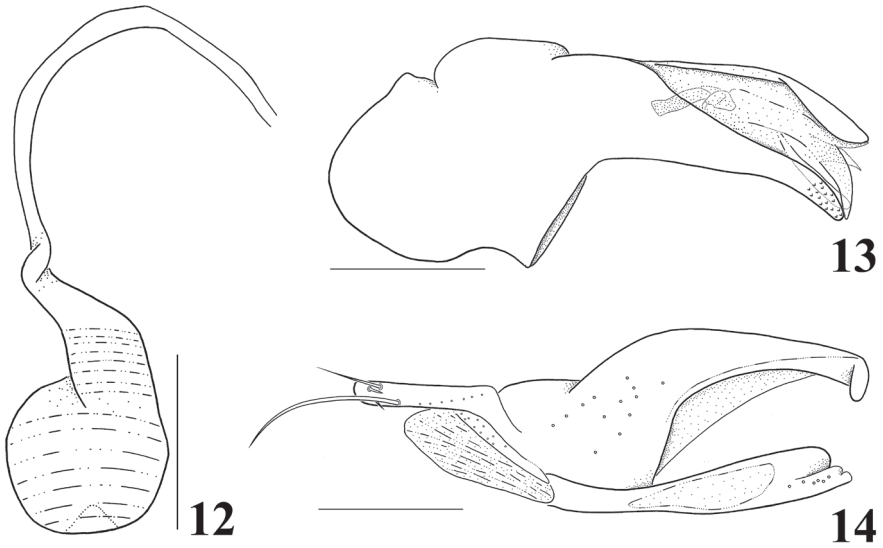
Specimens examined. KOREA: Chungbuk Prov., Yeongdong-gun, Sangchon-myeon, Mulhan-ri, Mt. Minjujisan, 36°03'35.2"N, 127°52'31.3"E 518 m, 18 V 2011, JG Lee,



Figures 6–11. SEM photos, *Homalota fraterna*: **6** labrum, ventral aspect **7** right mandible, ventral aspect **8** maxilla, ventral aspect **9** labium, ventral aspect **10** meso- and metaventrites, ventral aspect **11** male tergite VIII, dorsal aspect.

TK Kim, decaying persimmon (16 exx., 3♂♂, 2♀♀ on slides); Jeonnam Prov., Hadong-gun, Hwahye-myeon, Ssanggyesa, 25 V 2000, K.-J. Ahn, *ex* under bark (3♀♀); Kangwon Prov., Hoengsunggun, Unduryeng, 9–10 ix 1998, K.-J. Ahn, *ex* under bark (1♂); Jeju Prov., Seongpanak, 28 IV 1985, KS Lee (3♂♂, 1♀, 1♂ on slide).

Description. Body length 2.3–2.6 mm (Fig. 1). Body dark brown, antennae and legs brown; dorsoventrally flattened, parallel-sided; surface subglossy, slightly pubescent. *Head.* Subquadrate, almost as wide as pronotum; eyes moderate in size, as long as



Figures 12–14. *Homalota fraterna*: **12** spermatheca **13** median lobe, lateral aspect **14** paramere, lateral aspect. Scale bars 0.1 mm.

tempora; infraorbital carina well developed, complete; antennomeres 4–10 transverse, 5–10 slightly incrassate toward apex. *Mouthparts.* Labrum (Fig. 6) transverse, 7 pairs of macrosetae present, sensilla of antero-medial sensory area shallow and narrowly emarginated, α-sensillum with a setose process, β and γ minute and conical, ε with a short setose process, distinctly shorter than α; two lateral sensilla present on lateral margins of epipharynx, without transverse row of sensory pores on basal region of epipharynx; right mandible (Fig. 7) with small median tooth, prostheca well developed; maxillary palpomere (Fig. 8) 2 and 3 dilated distally, 4 without small spines at apex; labium (Fig. 9) with ligula moderate in length and bifid in its apical half, almost as long as labial palpomere 1, labial palpus with two palpomeres, palpomere 1 almost as long as 2, two medial setae present on prementum, contiguous and one laterally behind the other, median pseudopore field of prementum narrow and with pseudopores, mentum not emarginated in anterior margin. *Thorax.* Pronotum slightly transverse, about 1.25 times wider than long, widest at apical third, surface pubescent, directed anteriorly in narrow median strip and directed antero-laterally to laterally in lateral area, with some distinct macrosetae, hypomeron broadly visible in lateral aspect; prosternum with a median knob; elytra slightly wider than pronotum, postero-laterally slightly sinuate; mesoventrite (Fig. 10) without longitudinal carina, mesoventral process narrow, apex point; metaventral process round at apex, distinctly shorter than mesoventral process; isthmus present; mesocoxae narrowly separated; tarsomere 1 as long 2, without empodial seta between tarsal claws. *Abdomen.* Tergites III–VI transversely impressed; tergite X with medial setal patch

subquadrate, with transverse row of large spines posteriorly, 4 macrosetae on each side. *Genitalia.* Spermatheca (Fig. 12) simple and elongate at base; median lobe (Fig. 13) bulbous at base, apical process slender and short with some tubercles, distinctly shorter than basal bulb, flagellum well sclerotized and short; paramere (Fig. 14) with apical lobe of paramerite subcylindrical, with four setae, basal one largest, condylite subequal in length to apex of paramerite. *Secondary sexual characteristics.* Posterior margin of male tergite VIII (Fig. 11) with two short lateral processes, middle margin broadly round.

Distribution. Korea (South), China (Hainan), Japan, Taiwan.

Remarks. *Homalota fraterna* is similar to *H. plana*, but can be distinguished by the following features: antennomere 4 transverse, male tergite VII without tubercle, male tergite VIII with short lateral processes; tergite X with medial setal patch subquadrate, with transverse row of large spines posteriorly.

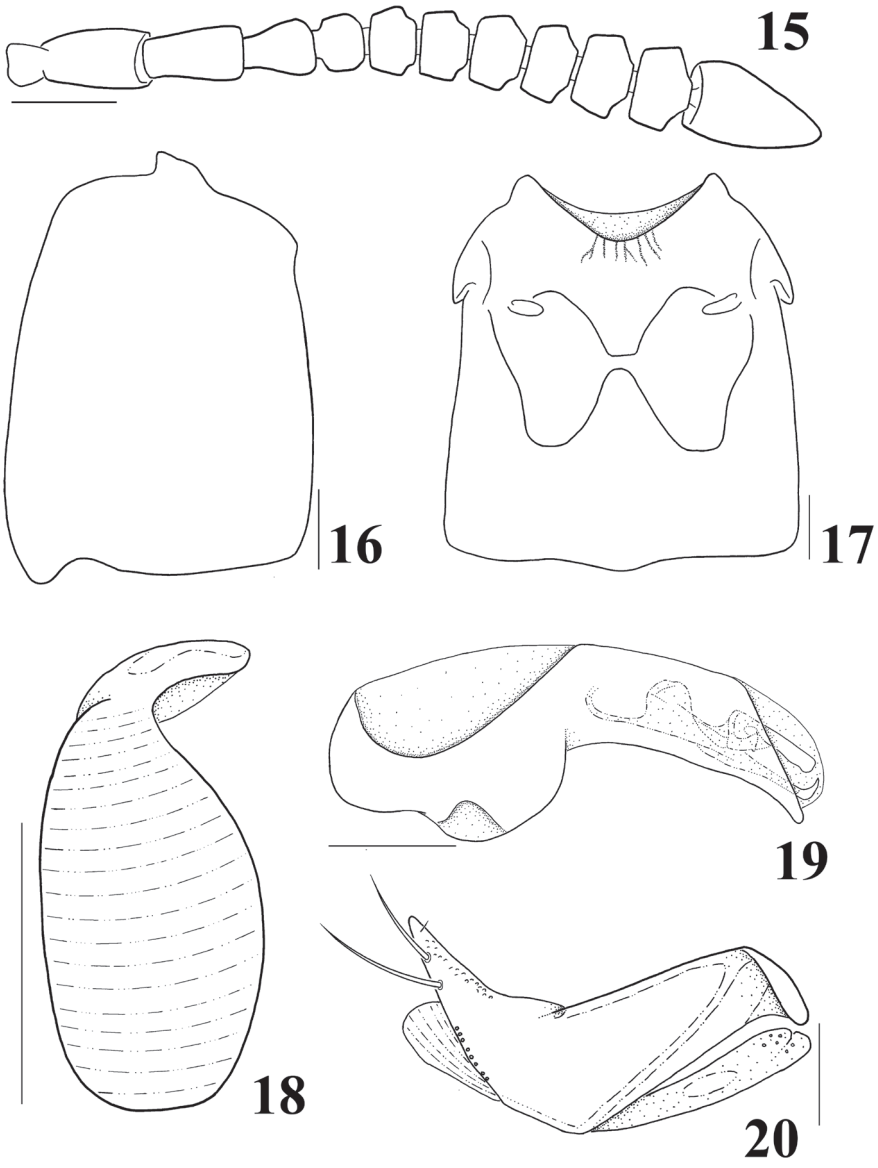
Homalota mikado Likovský, 1984

Figs 2, 15–20

Homalota mikado Likovský, 1984: 6 [Replacement name]; Smetana 2004: 448.
Epipeda granigera Sharp, 1888: 375 [Homonym].
Homalota granigera: Fenyes 1914: 45.

Specimens examined. KOREA: Gangwon Prov., Pyeongchang-gun, Pyeongchang-eup, Noron-ri, Mt. Sambangsan, 13 VII–15 VIII 2001, KJ Ahn, SJ Park, CW Shin, *ex* FIT (2 exx., 1♀ on slide); Mt. Bokjusan, Seo-myeon, Cheolwon-gun, N38°08'38.2"E127°28'26.7"138 m, 25 IX 2005, YB Cho (2 exx.); Jeonnam Prov., Jangseong-gun, Mt. Naejangsan, Baekyangsa Area, 25 VI 2000, HJ Kim, *ex* sifting (3 exx., 1♂ on slide); Chungbuk Prov., Mt. Sokrisan, Beobjusa Temple, Naesokri-myeon, Boeun-gun, *ex* FIT, 1–31 V 2007, YB Cho, 36°32'21.5"N, 127°50'10.4"E (1 ex.).

Description. Body (Fig. 2) length about 1.8–2.1 mm. Body dorsoventrally slightly flattened, widest at posterior margin of elytra; surface punctuate, subglossy, slightly pubescent; light brown to brown, abdominal tergite VI dark brown. *Head.* Subquadrate, slightly narrower than pronotum; eyes moderate in size, as long as tempora; head narrowed from behind of eyes to apical half of tempora but rarely narrowed to occipital construction; antennomere (Fig. 15) 4 slightly transverse, 5–10 transverse, slightly incrassate toward. *Mouthparts.* Labrum transverse, 8 pairs of macrosetae present, sensilla of antero-medial sensory area distinct, shallowly and width moderately emarginated; α-sensillum with a setose process, β and γ minute and conical, ε with a minute setose process, distinctly shorter than α, two lateral sensilla present on lateral margins of epipharynx, transverse row of sensory pores absent on basal region of epipharynx; right mandible with small median tooth, prostheca well developed, divided into 3 distinct area; maxillary palpomeres 2–3 dilated distally, 4 without small spine at apex; labium with ligula slender and elongated, bifid at apical third, almost as long as labial palpomere 1, labial palpus with two palpomeres, 1 longer than 2, two medial setae



Figures 15–20. *Homalota mikado*: **15** antenna **16** elytron, dorsal aspect **17** meso- and metaventrites, ventral aspect **18** spermatheca **19** median lobe, lateral aspect **20** paramere, lateral aspect. Scale bars 0.1 mm.

contiguous on prementum, side by side, median pseudopore field of prementum narrow and with pseudopores, mentum strongly emarginated in anterior margin. *Thorax.* Pronotum transverse, about 1.3 times wider than long, widest at apical third, surface pubescent, without distinct macrosetae; hypomeron broadly visible in lateral aspect; prosternum with a median knob; elytra (Fig. 16) wider than pronotum, postero-later-

ally sinuate; wings fully developed; mesoventrite (Fig. 17) without longitudinal carina, mesoventral process truncate at apex; metaventral process round at apex, longer than metaventral process; isthmus present; mesocoxae moderately separated; tarsomere 1 of front leg as long as 2, 1 slightly longer than 2 in middle and hind legs, without empodial setae between tarsal claws. *Abdomen.* Tergites III–VI transversely impressed; tergite X with medial setal patch subquadrate, with 3 macrosetae on each side. *Genitalia.* Spermatheca (Fig. 18) simple and elongate at base, duct short; median lobe (Fig. 19) bulbous at base, apical process slender and elongate, longer than basal bulb, flagellum well sclerotized and short; paramere (Fig. 20) with apical lobe of paramerite with four setae, two setae longer than others, condylite subequal in length to apex of paramerite. *Secondary sexual characteristics.* Absent.

Distribution. Korea (South), Japan, Taiwan.

Remarks. The taxonomic position of *H. mikado* is unclear, considering the numerous characters that distinguish it from other *Homalota* species, including the type species *H. plana*: body not subparallel-sided; surface with numerous large punctures; labrum with 8 pairs of macrosetae; ligula slender and elongate, mentum deeply emarginated in anterior margin; mesocoxae moderately separated. However, we are not sure what other aleocharine genus it may belong to. Therefore, the position of *H. mikado* in *Homalota* is tentatively maintained here, pending further comprehensive research of this species.

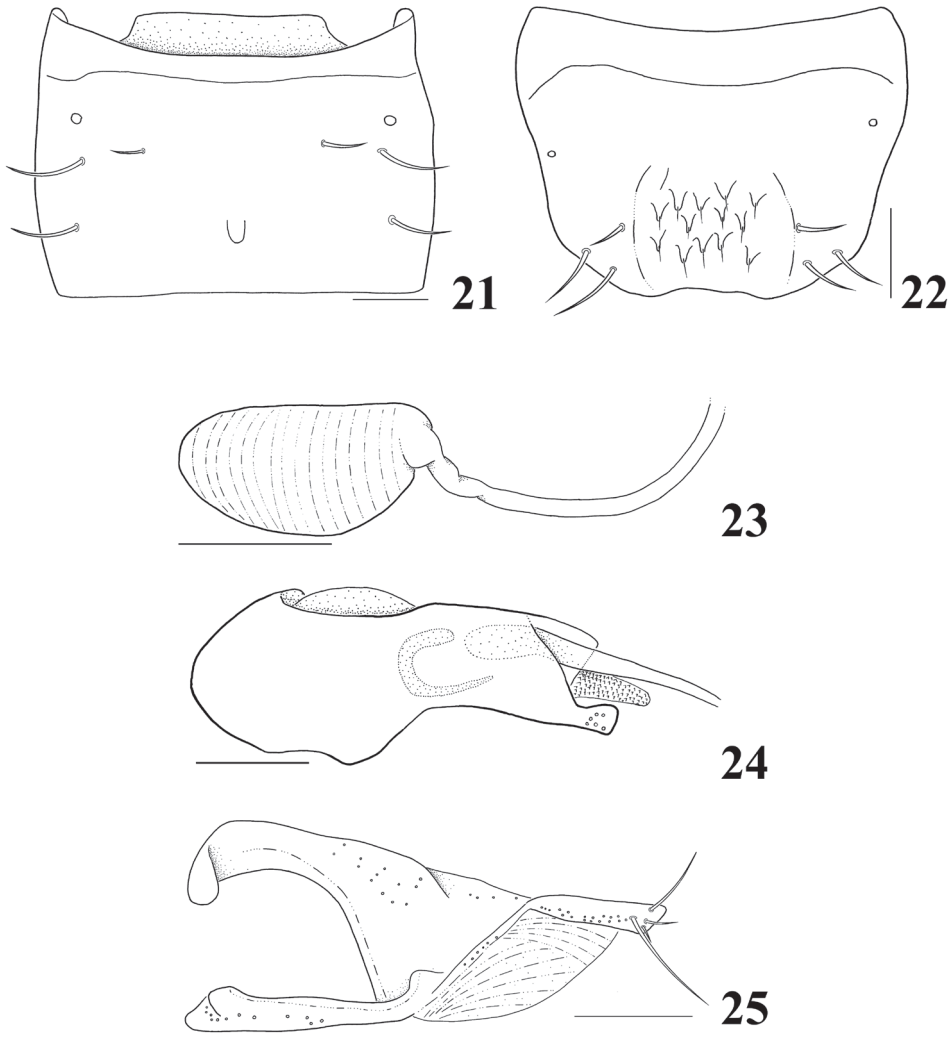
Homalota plana (Gyllenhal, 1810)

Figs 3, 21–25

Aleochara plana Gyllenhal, 1810: 402.
Homalota plana: Mannerheim 1830: 73; Fenyes 1918: 87; Smetana 2004: 448.
See Smetana (2004) for additional references.

Specimens examined. KOREA: Cerjong, Hvanghe-pukto, IX 1971, leg. J. Pawlowski, *Homalota plana* (Gyllenhal), det. G. Paśnik, 2000, Col ISEZ K-ow from box-no: KOR 1, Species name in box: *Homalota plana* (2♂♂, 2♀♀) (ISEA); HUNGARY: Ócsa, Pest m, 30 X 1952, nyárfakéreg, alólrostálva, leg Kaszab Z., *Homalota plana* (Gyll.) Det.: Adàm, 1987 (17 exx., 1♂, 1♀ on slides).

Description. Body (Fig. 3) length about 2.4–3.3 mm. Body dorsoventrally flattened, subparallel-sided; subglossy, slightly pubescent; dark brown, antennae, elytra and legs brown. *Head.* Subquadrate, narrower than pronotum; eyes moderate in size, almost as long as tempora; antennomeres 4–10 slightly transverse. *Mouthparts.* Labrum transverse, 7 pairs of macrosetae present, sensilla of antero-medial sensory area distinct, depth and width moderately emarginated; α-sensillum with a setose process, β and γ minute and conical, ε with a short setose process, distinctly shorter than α, two lateral sensilla present on lateral margins of epipharynx, transverse row of sensory pores absent on basal region of epipharynx; right mandible with small median tooth, prostheca well developed, divided into 3 distinct area; maxillary palpomere 2 dilated distally, 3 distinctly



Figures 21–25. *Homalota plana*: **21** male tergite VII, dorsal aspect **22** male tergite VIII, dorsal aspect **23** spermatheca **24** median lobe, lateral aspect **25** paramere, lateral aspect. Scale bars 0.1 mm.

dilated to apical third and then slightly convergent toward apex, 4 without small spine at apex; labium with ligula moderate and bifid at half, slightly shorter than labial palpomere 1, labial palpomere 1 slightly longer than 2, two medial setae contiguous on prementum, one laterally behind the other, median pseudopore field of prementum narrow and with pseudopores, mentum slightly emarginated in anterior margin. *Thorax*. Pronotum slightly transverse, about 1.2 times wider than long, widest at half, surface pubescent, directed postero-laterally; hypomeron visible in lateral aspect; prosternum with a median knob; elytra wider than pronotum, postero-laterally slightly sinuate; mesoventrite without lon-

gitudinal carina, mesoventral process narrow, apex narrowly round; metaventral process round at apex, distinctly shorter than mesoventral process; isthmus present; mesocoxae narrowly separated, tarsomere 1 as long as 2, with an empodial seta between tarsal claws. *Abdomen.* Tergites III–VI transversely impressed; tergite X with a medial setal patch subquadrate, with 4 macrosetae on each side. *Genitalia.* Spermatheca (Fig. 23) simple and elongate, tube slightly curved; median lobe (Fig. 24) elongate, bulbous at base, apical process slender and elongate, surface with some tubercles, flagellum well sclerotized and moderately long; paramere (Fig. 25) with apical lobe of paramerite subcylindrical, with four setae, two distinctly smaller than others, condylite subequal in length to apex of paramerite. *Secondary sexual characteristics.* Posterior margin of male tergite VII (Fig. 21) with a more or less distinct tubercle (occasionally missing); male tergite VIII (Fig. 22) impressed postero-medially, apex emarginated and without lateral process.

Distribution. Korea (North). See Smetana (2004) for additional distribution.

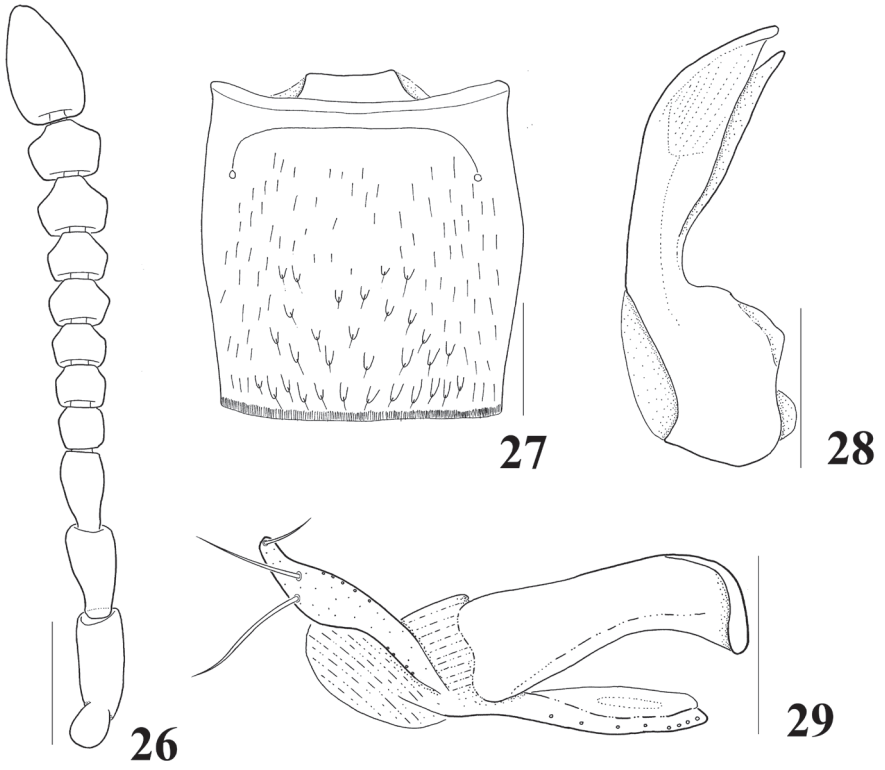
Homalota sauteri Bernhauer, 1907

Figs 4, 26–29

Homalota sauteri Bernhauer, 1907: 391; Fenyes 1918: 87; Smetana 2004: 448.

Specimens examined. KOREA: Jeonnam Prov., Jangseon-gun, Jangseon-eup, Yutang-ri, N35°18‘54.8“E126°48‘34.0“90m, 22 V 2007, TK Kim, YH Kim, *ex* under bark (5 exx.); Chungnam Prov., Daejeon city, Sutongol, 18 IV 1998, KJ Ahn, HJ Kim, HJ Kim, KL Yu, *ex* sifting (2 exx.); Daejeon-si, Dong-gu, Secheon-dong, Mt. Sikjangsan, 36°19'34.7"N, 127°29'1.4"E 156 m, 11 IV 2010, IS Yoo, SG Lee, under bark (2 exx.); Gangwon Prov., Sokcho-city, Mt. Seolak, Hwa-amsa, 21 VI 2002, SJ Park, CW Shin, ex fungus on log (2 exx.).

Description. Body (Fig. 4) length about 1.4–1.7 mm. Body dorsoventrally strongly flattened, parallel-sided; surface glossy, pubescent; light brown, head and abdominal tergite VI brown. *Head.* Subquadrate, narrower than pronotum, eyes moderate in size, slightly shorter than tempora; antennomere 4 subquadrate, 5–10 transverse, incrassate toward (Fig. 26). *Mouthparts.* Labrum transverse, 7 pairs of macrosetae present, sensilla of antero-medial sensory area distinct, shallow and moderately emarginated, α-sensillum with a minute setose process, β and γ minute and conical, ε with a setose process, slightly longer than α, insertion more or less distant from anterior margin of labrum, two lateral sensilla present on lateral margins of epipharynx, without transverse row of sensory pores on basal region of epipharynx; right mandible with small median tooth, prostheca well developed, divided into 2 distinct area; maxillary palpomere 2 dilated distally, 3 distinctly dilated to apical third and then slightly convergent toward apex, 4 without small spine at apex; labium with ligula moderate in length and bifid at half, almost as long as labial palpomere 1, labial palpomere 1 longer than 2, two medial setae present on prementum, side by side and narrowly separated, median pseudopore field moderate and with pseudopores, mentum slightly emarginated in anterior margin. *Thorax.* Pronotum trans-



Figures 26–29. *Homalota sauteri*: **26** antenna **27** male tergite VII, dorsal aspect **28** median lobe, lateral aspect **29** paramere, lateral aspect. Scale bars 0.1 mm.

verse, about 1.3 times wider than long, widest at basal third, surface pubescent, directed postero-laterally, without distinct macrosetae, hypomeron broadly visible in lateral aspect; prosternum with a distinct median knob; elytra wider than pronotum, postero-laterally sinuate; mesoventrite without longitudinal carina, mesoventral process narrow, apex pointed; metaventral process narrowly round at apex, shorter than mesoventral process; isthmus very slightly present, tarsomere 1 of front and middle legs as long as 2, 1 slightly longer than 2 in hind leg, with an empodial seta between tarsal claws. *Abdomen.* Tergites III–VI transversely impressed; tergite X with medial setal patch chevron shaped, with 4 macrosetae on each side. *Genitalia.* Spermatheca elongate at base, duct convoluted and coiled; median lobe (Fig. 28) elongate, bulbous at base, apical process elongate, distinctly longer than basal bulb, flagellum well sclerotized and short; paramere (Fig. 29) with apical lobe of paramerite long and subcylindrical, with four setae, 2 relatively longer than the others, condylite subequal in length to apex of paramerite. *Secondary sexual characteristics.* Postero-medial margin of male tergite VII (Fig. 27) with 16 to 18 tubercles; posterior margin of male tergite VIII emarginate at middle, female tergite VIII more or less round.

Distribution. Korea (South), Japan, Taiwan.

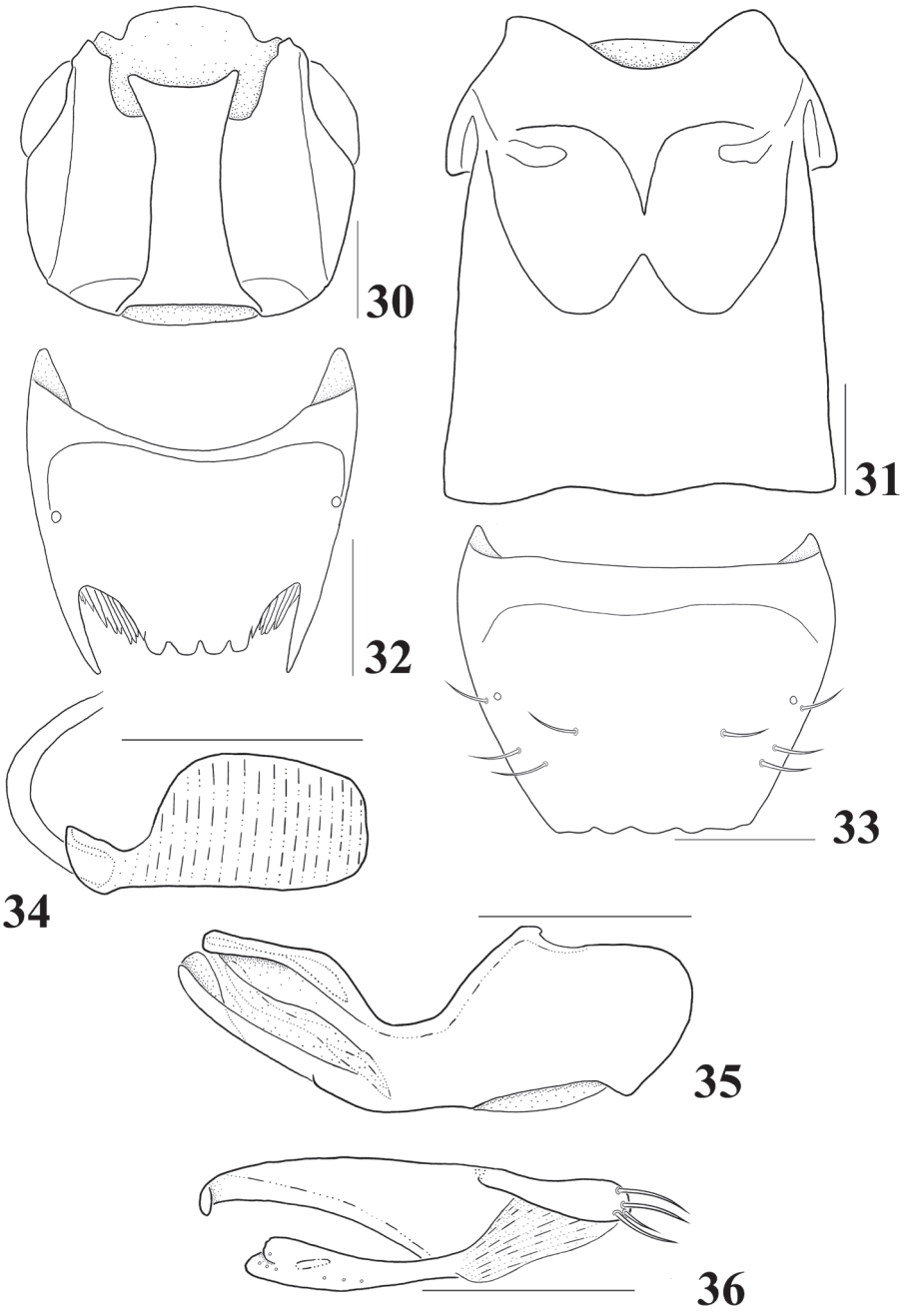
Remarks. *Homalota sauteri* is similar to *H. serrata*, but can be distinguished by the following features: body pubescent, head narrower than pronotum, male tergite VII with 16 to 18 tubercles. The taxonomic position of *H. sauteri* in *Homalota* is unclear and tentatively maintained here, pending further comprehensive research of this species.

***Homalota serrata* (Assing), comb. n.**
Figs 5, 30–36

Anomognathus serratus Assing, 2011: 306.

Specimens examined. KOREA: Gangwon Prov., Sokcho-city, Mt. Seolak, Hwaamsa, 21 vi 2002, SJ Park, CW Shin, *ex* fungus on log (1♂ on slide); Gyeongnam Prov., Sacheon-si, Guam, 16 v 1986, KS Lee (2♀♀); Jeju Prov., Wimiri, 29 iii 1985, KS Lee, under bark (1♀); Tongyeong-si, Sanyang-eup, minam-ri, 34°46'20.69"N, 128°24'44.03"E 135 , 15 IV 2011, YH Kim, under bark (1♂).

Description. Body (Fig. 5) length about 1.4–2.0 mm. Body dorsoventrally strongly flattened, parallel-sided; surface glossy, slightly pubescent; yellowish brown, head and abdominal tergite VI dark brown. *Head.* (Fig. 30) Subquadrate; eyes moderate in size, almost as long as tempora; antennomeres 5–10 transverse; incrassate toward. *Mouthparts.* Labrum transverse, 7 pairs of macrosetae present; α-sensillum with a setose process, β and γ minute and conical, ε with a minute setose process, two lateral sensilla present on lateral margins of epipharynx, transverse row of sensory pores absent on basal region of epipharynx; right mandible with median tooth, prostheca well developed, divided into 3 distinct area; maxillary palpomere 2 and 3 dilated distally, 4 without small spines at apex; labium with ligula moderate in length and bifid at half, as long as labial palpomere 1, labial palpomere 1 longer than 2, two medial setae present on prementum, contiguous, side by side, median pseudopore field of prementum narrow and with pseudopores, mentum slightly emarginated in anterior margin. *Thorax.* Pronotum slightly transverse, about 1.2 times wider than long, widest at apical third, surface pubescent, directed posteriorly in narrow median strip and directed postero-laterally to laterally in lateral area; hypomeron broadly visible in lateral aspect; prosternum with a median knob; elytra slightly wider than pronotum, postero-laterally slightly sinuate; mesoventrite (Fig. 31) without longitudinal carina, mesoventral process narrow, apex acute; metaventral process round at apex, almost as long as mesoventral process; isthmus present; mesocoxae narrowly separated; tarsomere 1 as long as 2 in front leg, 1 longer than 2 in middle and hind legs, without empodial seta between tarsal claws. *Abdomen.* Tergites III–V transversely impressed; medial setal patch of tergite X with medial setal patch subquadrate, with transverse row of setae anteriorly. *Genitalia.* Spermatheca (Fig. 34) simple and round at base; median lobe (Fig. 35) elongate, bulbous at base, apical process slender and short, distinctly shorter than basal bulb, flagellum well sclerotized and short; paramere (Fig. 36) with apical lobe of paramerite subcylindrical,



Figures 30–36. *Homalota serrata*: **30** head, ventral aspect **31** meso- and metaventrites, ventral aspect **32** male tergite VIII, dorsal aspect **33** female tergite VIII, dorsal aspect **34** spermatheca **35** median lobe, lateral aspect **36** paramere, lateral aspect. Scale bars 0.1 mm.

with four setae, 2 setae longer than others, condylite shorter than in length to apex of paramerite. *Secondary sexual characteristics.* Posterior margin of male tergite VIII (Fig. 32) with two long lateral processes, apex acute, median area with 4 short and broad processes, several long spines placed between them, posterior margin of female tergite VIII (Fig. 33) truncate and serrate.

Distribution. Korea (South), China (Zhejiang).

Remarks. *Homalota serrata* can be distinguished from other Palearctic *Homalota* species by the following features: body slightly pubescent, head as wide as pronotum, male tergite VII without tubercles and distinct structure of tergite VIII in both sexes.

Assing (2011) described *Anomognathus serratus* from China (Zhejiang Province). However, we propose that *A. serratus* be placed in the genus *Homalota*, based on the following characters: infraorbital carinae complete; medial setae of prementum contiguous; scutellum posteromedially round; mesocoxae narrowly separated; isthmus distinctly less than half of the mesocoxae length. According to article 34.2 of the International Code of Zoological Nomenclature (ICZN), the name *serratus* must agree in gender with the generic name *Homalota* Mannerheim (feminine); therefore, it is corrected to *serrata*.

Acknowledgments

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Two new species of *Lobrathium* Mulsant & Rey (Coleoptera, Staphylinidae, Paederinae) from China

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Abstract

Lobrathium jianqingi **sp. n.** (Guangxi: Shiwanda Shan) and *L. atanggei* **sp. n.** (Yunnan: Nabanhe) from southwest China are described and illustrated.

Keywords

Coleoptera, Staphylinidae, *Lobrathium*, new species, China

Introduction

In a recent checklist provided by Assing (2012), 43 species of the genus *Lobrathium* Mulsant & Rey, 1878 were reported from China. Since then, 17 additional species have been described from mainland China (Assing 2013, 2014; Li et al. 2013; Li et al. 2013a, b, c) and one name has been synonymized, thus raising the total number of species known from China to 59.

During two recent field trips we collected some *Lobrathium* specimens. Among them, two new species are recognized.

Material and methods

The material treated in this study is deposited in the Insect Collection of Shanghai Normal University, Shanghai, China (SNUC).

Type labels are cited in their original spelling. A slash (/) is used to separate different labels.

The specimens were killed with ethyl acetate and then dried. Materials were stored in 75% ethanol; genitalia and small parts were embedded in Euparal on plastic slides that were attached to the same pin with the specimens.

Morphological studies were carried out using an Olympus SZX 16 stereoscope. A digital camera Canon EOS 7D with MP-E 65 mm Macro Photo Lens was used for the habitus photos. An Olympus CX31 microscope and a Canon G9 digital camera were used for the photos of small structures.

The measurements of various body parts are abbreviated as follows: BL – length of the body from the apical margin of the labrum to the abdominal apex; HL – length of the head from the anterior margin of the frons to the posterior constriction; HW – maximum width of the head; PL – length of the pronotum along midline; PW – maximum width of the pronotum; EL – length at the suture from the apex of the scutellum to the posterior margin of the elytra; EW – maximum width of the elytra; AL – length of the aedeagus from the apex of the ventral process to the base of the aedeagal capsule.

Taxonomy

***Lobrathium jianqingi* Lü & Li, sp. n.**
http://zoobank.org/03A1E854-D49F-4F6A-AE4D-3F9AE603791D
Fig. 1

Type material. Holotype: ♂, labelled 'China: Guangxi Prov., Shangsi County, Shiwanda Shan N. R., 21°54'16"N, 107°54'13"E, 300–500 m, 25.IV.2011, Zhu, Peng & Zhai leg. / HOLOTYPE [red], *Lobrathium jianqingi* sp. n., Lü & Li det. 2014, SNUC'. Paratype, 1 ♀: same data as holotype.

Description. Body length 6.84–7.34 mm, length of forebody 3.73–3.78 mm. Habitus as in Fig. 1A. Coloration: body black, elytra with blue hue and subcircular large yellow spot, this spot reaching neither suture, nor lateral or posterior margins; legs black with paler tarsi, antennae blackish brown to dark brown.

Head weakly transverse (HW/HL 1.23–1.28); posterior angles broadly rounded, weakly marked; punctation dense and coarse, sparser in median dorsal portion; interstices without microsculpture. Eyes large, approximately half as long as distance from posterior margin of eye to neck in dorsal view. Antenna slender, 2.22 mm long.

Pronotum 1.13–1.24 times as long as broad and 0.90–0.97 times as wide as head, lateral margins weakly convex in dorsal view; punctation similar to that of head, midline with broad and complete impunctate band; interstices without microsculpture.

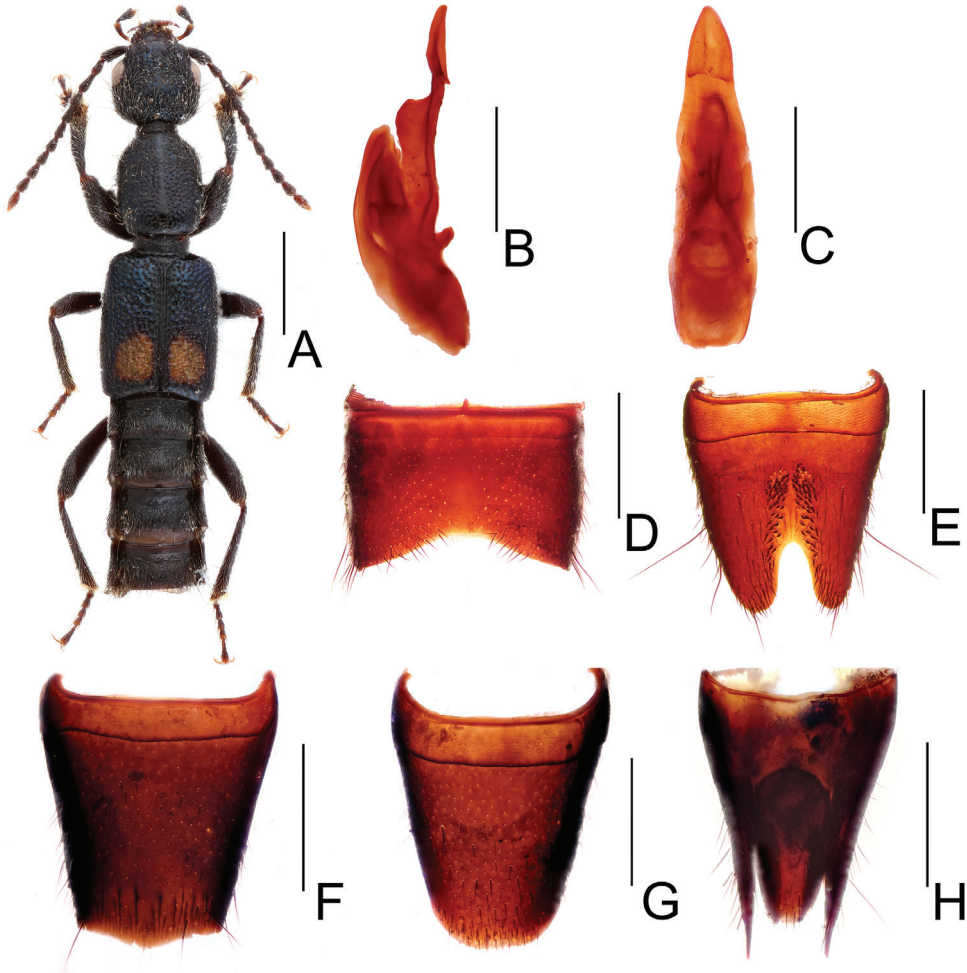

Figure 1. *Lobrathium jianqingi*. **A** habitus **B** aedeagus in lateral view **C** aedeagus in ventral view **D** male sternite VII **E** male sternite VIII **F** female tergite VIII **G** female sternite VIII **H** female tergites IX–X. Scale bars: **A** 1 mm, **B**–**H** 0.5 mm.

Elytra distinctly broader and longer than pronotum (EW/PW 1.33–1.39; EL/PL 1.08–1.17), humeral angles marked; punctation dense and coarse; interstices without microsculpture and glossy. Hind wings fully developed.

Abdomen narrower than elytra; punctation very fine and dense, dorsal surface nearly matt; posterior margin of tergite VII with palisade fringe.

Male: Sternites III–VI unmodified; sternite VII (Fig. 1D) strongly transverse with median impression posteriorly, this impression impunctate in the middle and on either side of middle with pubescence diagonally directed postero-mediad, posterior margin broadly and deeply concave; sternite VIII (Fig. 1E) weakly oblong, with pronounced long median impression, this impression with numerous modified, short and stout

black setae, posterior excision relatively deep and almost U-shaped; aedeagus (Figs 1B, C) 1.37 mm long, ventral process long and spear-shaped apically in ventral view.

Female: Posterior margin of tergite VIII (Fig. 1F) weakly convex; posterior margin of sternite VIII (Fig. 1E) broadly convex; tergite IX (Fig. 1H) undivided anteriorly; tergite X of subovoid shape.

Distribution and natural history. The type locality is situated in the Shiwanda Shan Natural Reserve, to the south of Shangsi, southern Guangxi. The specimens were found on the bank of a stream at altitudes of 300–500 m.

Etymology. The species is named after Jian-Qing Zhu, one of collectors of the type specimens.

Remarks. In external characters (moderate size, black body, elytra with large subcircular yellow spot), the chaetotaxy of the male sternites VII and VIII and the morphology of the aedeagus (especially long ventral process), *L. jianqingi* is most similar to *L. anatinum* Li & Li, 2013 from Guangxi. The new species is distinguished from *L. anatinum* by the more deeply concave posterior margin of the male sternite VII, the deeper posterior excision of the oblong male sternite VIII, and by the shape of the ventral process of the aedeagus in lateral view. For illustrations of *L. anatinum* see Li et al. (2013a).

Lobrathium atanggei Lü & Li, sp. n.

http://zoobank.org/B28715BD-EBD3-4AF5-9EC5-ADA4909BC853
Fig. 2

Type material. Holotype: ♂, labelled 'China: Yunnan Prov., Xishuangbanna, Nabanhe N. R., alt. 700 m, 22°10'00"N, 100°39'38"E, 1.VII.2004, Liang Tang leg. / HOLOTYPE [red], *Lobrathium atanggei* sp. n., Lü & Li det. 2014, SNUC'.

Description. Body length 6.56 mm; length of forebody 3.11 mm. Habitus as in Fig. 2A. Coloration: body black, elytra with pronounced blue hue and small subcircular yellow spot, this spot reaching neither suture, nor lateral or posterior margins; legs black with paler tarsi, antennae blackish brown to dark yellow.

Head almost as broad as long (HW/HL 1.05), posterior angles broadly rounded, weakly marked; punctation dense and coarse, sparser in median dorsal portion; interstices without microsculpture. Eyes large, more than half as long as distance from posterior margin of eye to neck in dorsal view. Antenna slender, 2.0 mm long.

Pronotum 1.24 times as long as broad and 0.94 times as wide as head, lateral margins weakly convex in dorsal view; punctation dense and coarser than that of head, midline with broad and complete impunctate band; interstices without microsculpture.

Elytra distinctly broader and longer than pronotum (EW/PW 1.42; EL/PL 1.55), humeral angles marked; punctation dense and coarse; interstices without microsculpture and glossy. Hind wings fully developed.

Abdomen narrower than elytra; punctation very fine and dense, dorsal surface matt; posterior margin of tergite VII with palisade fringe.

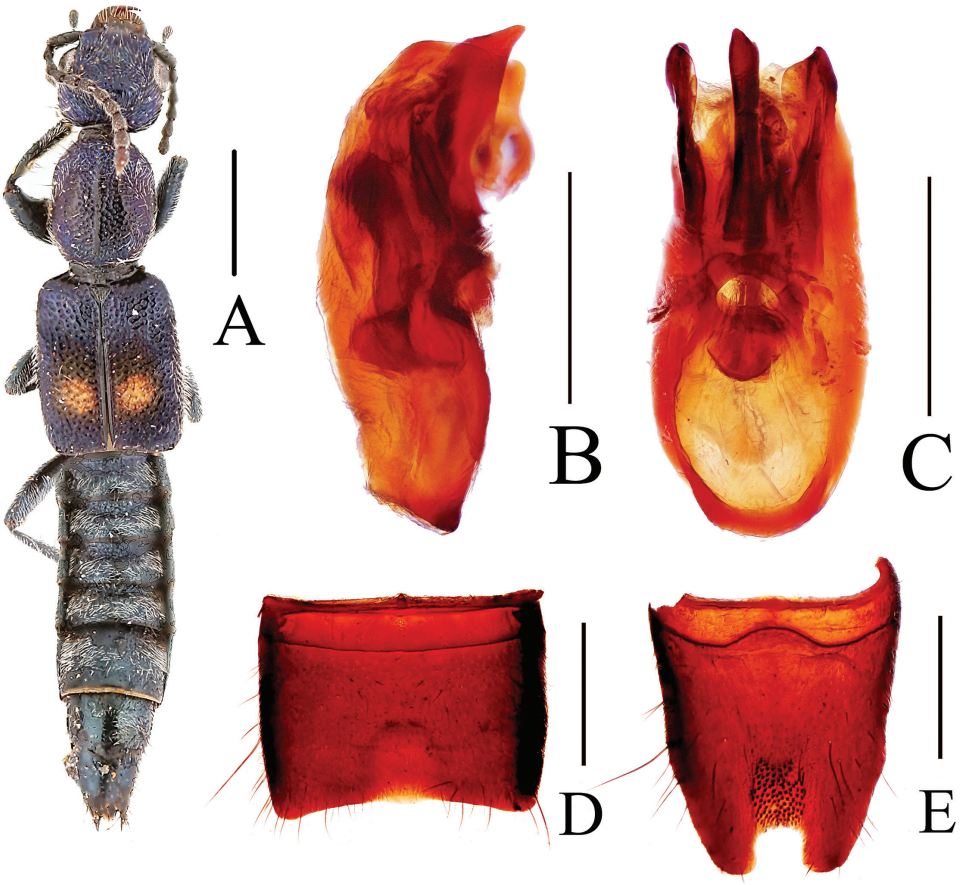

Figure 2. *Lobrathium atanggei*. **A** habitus **B** aedeagus in lateral view **C** aedeagus in ventral view **D** male sternite VII **E** male sternite VIII. Scale bars: **A** 1 mm, **B**–**E** 0.5 mm.

Male: Sternites III–VI unmodified; sternite VII (Fig. 2D) strongly transverse, with pronounced median impression posteriorly, with sparse unmodified pubescence, and with broadly concave posterior margin; sternite VIII (Fig. 2E) weakly oblong, with deep median impression posteriorly, this impression with numerous modified, very short and stout black setae, posterior excision deep and almost U-shaped; aedeagus (Figs 2B, C) 1.10 mm long, ventral process somewhat asymmetric and of distinctive shape.

Female: unknown.

Distribution and natural history. The type locality is situated in the Nabanhe Natural Reserve, to the northwest of Xishuangbanna, southwestern Yunnan. The holotype was found on the bank of a stream at an altitude of 700 m.

Etymology. The species is named after Liang Tang (nickname "Atangge"), who collected the holotype.

Remarks. In external characters (black body, weakly transverse head, slender pronotum, elytra with small subcircular spot), as well as the shape and chaetotaxy of the

male sternites VII and VIII, *L. atanggei* is similar to *L. ablectum* Assing, 2012 from Hubei. The new species is readily distinguished from *L. ablectum* by the somewhat smaller size, the pronounced blue hue of the body and a stout ventral process of the aedeagus. Regarding the morphology of the aedeagus (robust and with short ventral process), however, the new species is most similar to *L. quadrum* Li, Solodovinikov & Zhou, 2013 from Sichuan. It is distinguished from *L. quadrum* by the pronounced blue hue of the body; the yellowish spot on elytra, reaching neither suture, nor lateral or posterior margins; the modifications of the male sternites VII–VIII (sternite VII with pronounced median impression posteriorly, sternite VIII with numerous modified, very short and stout black setae; deep posterior excision). For illustrations of *L. ablectum* and *L. quadrum* see Assing (2012) and X.-Y. Li et al. (2013), respectively.

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