



A new species of *Maraenobiotus* (Copepoda, Harpacticoida) from Lena River Delta (North-Eastern Siberia)

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Abstract

A new species of harpacticoid copepod of the family Canthocamptidae, *Maraenobiotus supermario* **sp. nov.** is described. The new species was found in interstitial waters of the moss tundra of the Lena River Delta, Siberia. This species belongs to the *vej dovskyi*-species group. The new species differs from its congeners in the apical caudal setae lacking a bulbous proximal part, and in the unique structure of the mandibular palp with only one seta. We also present detailed figures and description of sensilla and pores on the somites surface, which could be used in the future to diagnose and solve taxonomic issues of this complex genus.

Key words: Canthocamptidae, Arctic fauna, interstitial habitat

Introduction

Maraenobiotus Mrázek, 1893 is a fairly large genus of the family Canthocamptidae Brady, 1880, which currently includes 40 species and subspecies (Walter & Boxshall 2020). The species of *Maraenobiotus* usually live in cold water, often in moss and in underground biotopes. They are quite common in tundra water bodies (Borutzky 1952).

Identification of the species of *Maraenobiotus* is problematic due to inaccurate original descriptions and to the lack of knowledge on the intraspecific variability of its species. Some authors have reduced all the described subspecies and varieties to just a few large polymorphic species (Borutzky 1952). However, Brancelj and Karanovic (2015) observed very low intraspecific variability in the troglobiont *M. slovenicus* Brancelj and Karanovic, 2015. They (Brancelj and Karanovic 2015) suggested that all the previously described interpopulation variants may be different closely related species. The situation is aggravated by the absence of molecular data. Here we describe a new species of *Maraenobiotus* from the Lena River Delta. It belongs to the *vej dovskyi*-species complex. The new species clearly differs from all previously described species and subspecies in the following features: mandibular palp, armature of swimming legs, ornamentation of abdominal somites.

Materials and methods

The specimens examined were collected at Samoylov Island in the Lena River Delta (72°22'22"N 126°28'47"E), North-Eastern Siberia. Samples were taken in peat under mosses using the Karaman-Chappuis method. The depth of the pit is about 40 centimeters to the border with permafrost. We washed the water samples and the peat slices using a small plankton net (mesh size = 100 µm). Washings were fixed in 4% formalin. Also, isolated copepods were found in meiobenthic samples from polygonal tundra waterbodies in Samoylov and America islands. The final drawings were prepared using the program Corel Draw X7. Type specimens were deposited in the collection of the Zoological Museum of Kazan Federal University, Kazan, Russia.

The following abbreviations were used throughout the text and in the figures: ae= aesthetasc, acr= acrothek, P1–P6 = legs 1–6. Nomenclature and descriptive terminology follows Huys and Boxshall (1991).

Taxonomic account

Order Harpacticoida Sars, 1903

Family Canthocamptidae Sars, 1906

Genus *Maraenobiotus* Mrázek, 1893

Maraenobiotus supermario sp. nov.

Etymology. This species is named after the character of the video game Super Mario®, who, like our species, goes often underground and wears a funny mustache (mandibular palp). The epithet is used as a noun in apposition.

Type locality. Samoylov Island, Lena river delta (72°22'22"N 126°28'47"E); wet moss; water temperature 3.9°C; conductivity 54 µS/cm; pH 7.22; September 10, 2019; coll. A. Novikov.

aterial examined. Holotype: female, dissected and mounted on 2 slides (ZM&G BP 541/1-a; 541/1-b). Allotype, male dissected and mounted on one slide (541/2). Paratypes: one female dissected and mounted on one slide (541/3), and two females and one copepodite V preserved in formalin (541/4).

Description. *Female holotype.* Body almost cylindrical, vermiform. Total body length of holotype from tip of rostrum to posterior margin of caudal rami: 0.419 mm. Cuticle very thin. Body colourless. Naupliar eye not discernible. Cephalothorax (Fig. 1) as wide as remaining somites. With cuticular window on cephalothorax dorsally, and on P2-bearing somite laterally. Rostrum small, fused to cephalothorax. Posterior margin of all somites smooth.

Cephalothorax with 27 pairs of sensilla and 4 pairs of pores. Second pedigerous somite with 5 pairs of sensilla, and one paired and one unpaired pore. Third pedigerous somite with 6 pairs of sensilla, and one unpaired pore. Fourth pedigerous somite with 5 pairs of sensilla, and single pore. Fifth pedigerous somite with 3 pairs of sensilla. Pedigerous somites 2-5 with rows of small spinules dorsally and laterally.

Genital-double somite (Figs. 2A, B) wider than long with dorsolateral rows of spinules; with 6 pairs of sensilla, and 1 pair of lateral pores, 1 pair of ventral double-pores and one unpaired dorsal pore. P6 strongly reduced to 1 pinnate seta. Genital field dense, with massive chitinous thickenings, and one pore and one short spinular row on each side; copulatory pore large; copulatory duct wide and short. Nodular thickening (arrow in Fig. 2B) round, closely spaced. Second abdominal somite with some dorsolateral transverse spinular rows as shown, with 3 pairs of sensilla, 1 pair of lateral pores, and 1 pair of ventral double-pores; with an interrupted, transverse, posterior spinular row latero-ventrally. Third abdominal somite with one lateral spinular row on each side, with 1 pair of lateral pores, and 3 pairs of ventral pores; with a continuous posterior spinular row latero-ventrally.

Anal somite (Fig. 2A, B) with 1 pair of sensilla, and 2 pair of pores dorsally; with spinular rows laterally and ventrally close to joint with caudal rami; anal operculum rounded, with 9 strong posterior spinules.

Caudal rami (Fig. 2A, B) small, length/width ratio 1.5, with 2 ventral pores; with spinules at base of setae I and II, and II, and with posterior spinules dorsally and ventrally; 7 setae as follows: apical setae IV and V long (0.025 and 0.036 mm) with spinules; seta VI parallel to seta V; seta VII triarticulated.

Antennule (Fig. 3A): short, 8-segmented. Segment 4 with large aesthetasc fused at base with long seta; aesthetasc on 4th segment larger than aesthetasc on last segment. Segment 8 with acrothek consisting of slender aesthetasc and two setae fused basally. Armature formula: 1-[1], 2-[8], 3-[5], 4- [1+(1+ae)], 5-[1], 6-[3], 7-[2], 8-[5+acr].

Antenna (Fig. 3B) with unornamented coxa. Allobasis with one proximal and one medial rows of spinules, with one abexopodal seta. Free endopodal segment with one proximal and one subdistal spinule rows on inner margin, with 2 lateral spines, and one medial and one subdistal outer frill; apically with 3 geniculate setae, 2 spines and 1 small seta; outermost geniculate spinulose seta fused basally to small slender seta. Exopod 2-segmented, elongate; first segment with pinnate seta, second segment with 3 naked setae.

Mandible (Fig. 4A). Coxa elongated, with few spinules. Gnathobase with 2 bicuspidate teeth, several multicuspitate teeth, and one pinnate dorsal seta. Palp reduced, 1-segmented, with single short seta.

Maxillule (Fig. 4B). Praecoxa with 2 rows of spinules. Praecoxal arthrite with 7 strong pectinate setae, and one pinnate ventral seta. Coxal endite with one pinnate filiform seta and one strong seta. Basis with 5 setae one of which stronger. Endopod and exopod incorporated into basis, each represented by 1 setae

Maxilla (Fig. 4C). Syncoxa with inner and outer spinules as shown, with 2 elongated endites each with 3 pinnate setae. Allobasis drawn out into strong claw with 2 setae. Endopod small 1-segmented, with 2 setae.

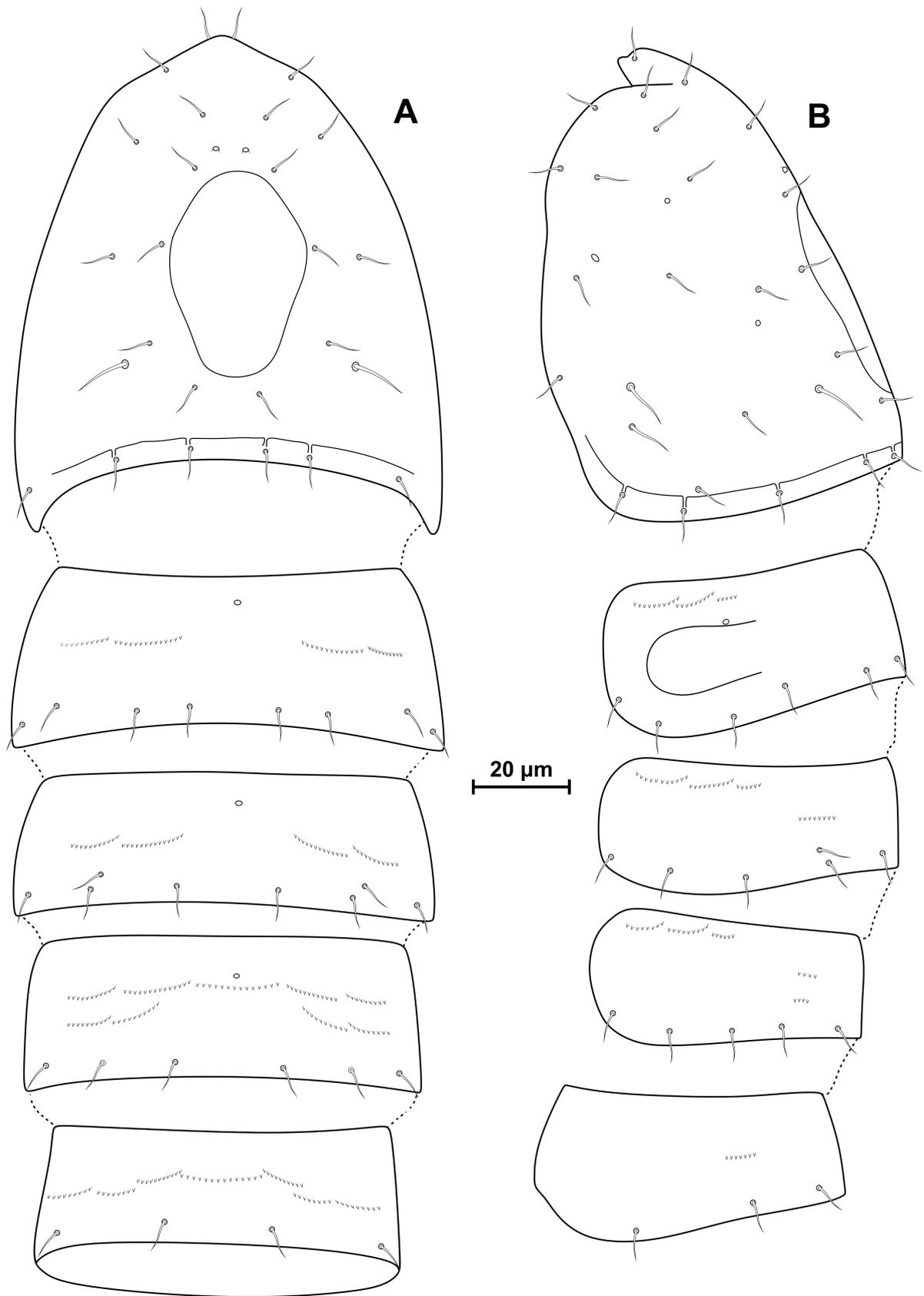


FIGURE 1. *Maraenobiotus supermario* n. sp. Female holotype: A, cephalothorax and thoracic segments, dorsal; B, cephalothorax and thoracic segments, lateral.

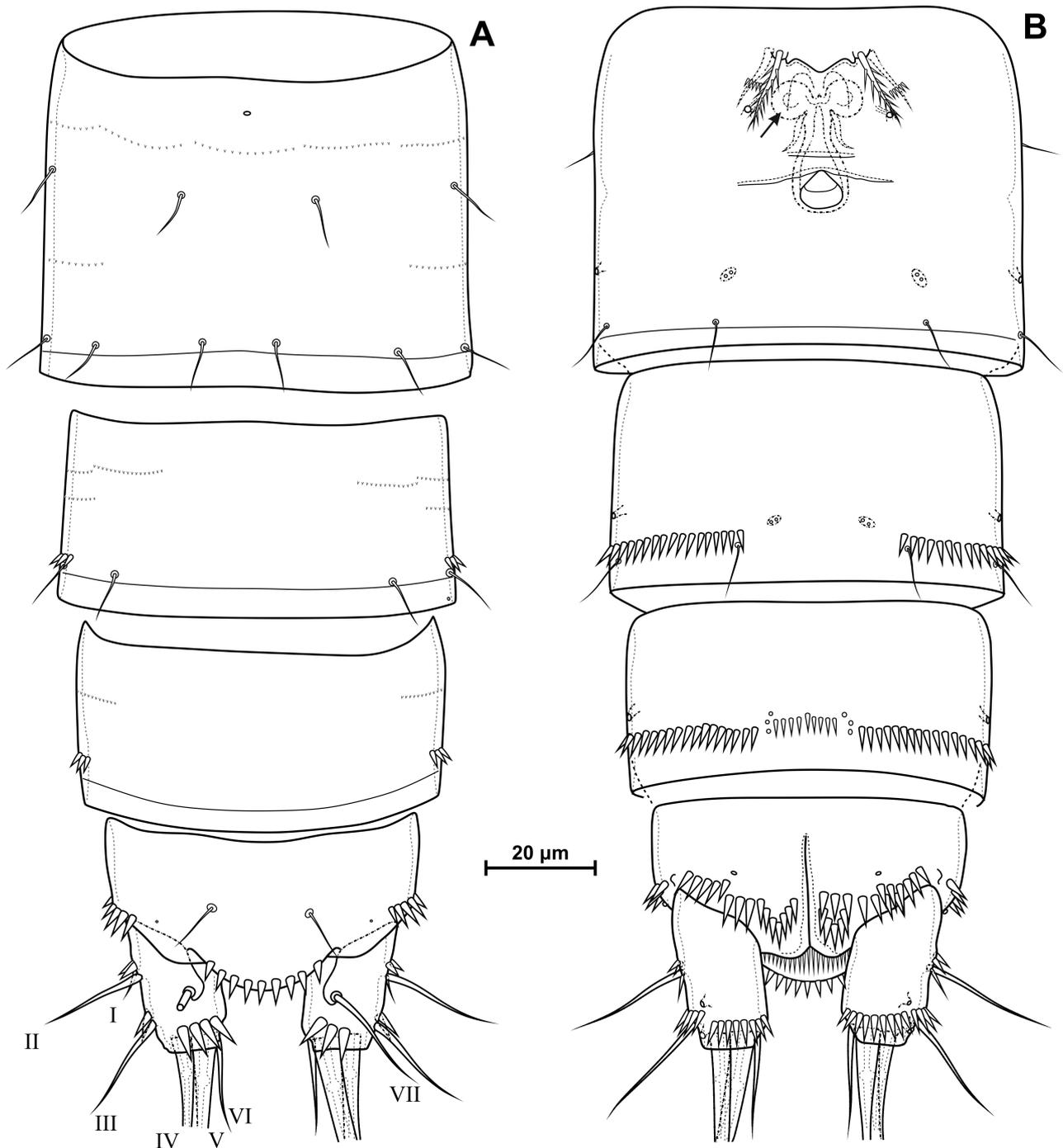


FIGURE 2. *Maraenobiotus supermario* n. sp. Female holotype: A, abdomen, dorsal; B, abdomen, ventral. Arrow is nodular thickening.

Maxilliped (Fig. 4D) subchelate, comprising syncoxa, basis and 1-segmented endopod. Syncoxa with one pinnate seta and with 2 groups of spinules. Basis elongated, with one row of large inner spinules, and 3 rows of outer spinules. Endopod with 1 small seta and strong spinulose claw.

P1 (Fig. 4E) with 2-segmented rami. Praecoxa with rows of spinules. Coxa with 1 proximal, 3 lateral and 4 distal rows of spinules. Intercoxal sclerite wide. Basis with one proximal pore, with rows of spinules as figured, with one inner and one outer spinulose spine. Exopodal and endopodal segments with outer spinules as shown. First exopodal segment with one outer spine; second segment with 3 outer spines and 2 long geniculate apical setae. Endopod short, reaching middle of third exopodal segment; first endopodal segment and first exopodal segment subequal in length, with one inner seta; second segment with one strong outer spine, one long geniculate seta, and one small inner seta.

P2 (Fig. 5A): Praecoxa with one row of spinules. Coxa with 5 rows of spinules as figured. Basis with rows of spinules at base of endopod and exopod and with row of small spinules medially. Exopod 3-segmented; exopodal segments with outer spinules; first and second segments with one outer spine, without inner armature; third segment with two outer spines, two apical elements, and one inner seta. Endopod 2-segmented, short, reaching tip of second exopodal segment; first segment unornamented, with 1 inner seta; second segment with 1 inner, 2 apical, and 1 outer spine.

P3 (Fig. 5B): Praecoxa with one row of spinules. Coxa with rows of spinules as figured. Basis with one pinnate seta and with rows of spinules at base of exopod and endopod. Exopod 3-segmented; first and second segments as in P2; third segment with 2 outer spines, 2 apical elements, and 2 inner setae. Endopod as in P2.

P4 (Fig. 5C): Praecoxa and coxa with one row of spinules. Intercoxal sclerite with concave distal margin. Basis as in P3. Exopod 3-segmented; all segments with rows of outer spinules; first segment with one outer spine, and without inner armature; second segment with outer spine and inner seta; third segment with 2 outer spines, 2 apical elements, and 1 inner seta. Endopod as in P2.

Armature of swimming legs as follows:

	coxa	basis	endopodite	exopodite
leg 1	0-0	1-1	0-1; 1,1,1	1-0; 3,2,0
leg 2	0-0	1-0	0-1; 1,2,1	1-0; 1-0; 2,2,1
leg 3	0-0	1-0	0-1; 1,2,1	1-0; 1-0; 2,2,2
leg 4	0-0	1-0	0-1; 1,2,1	1-0; 1-1; 2,2,1

P5 (Fig. 8A) with left and right baseoendopods fused medially; baseoendopod reaching about midlength of exopodal segment, outer seta of basis pinnate, slender. Endopodal lobe with 4 pinnate setae and 2 tube pores. Exopod with 2 slender and 1 pinnate setae.

Male allotype. Total body length from tip of rostrum to posterior margin of caudal rami: 0.336 mm. Sexual dimorphism expressed in the antennule, P2–P6, genital segmentation and ornamentation. Sensilla and pores on cephalothorax and thoracic somites as in female. Abdominal somites (Fig. 6) 1–3 with rows of small spinules dorsally; first abdominal somite with P6, the latter a plate completely fused to somite with one bare seta; second abdominal somite with four pairs of sensilla, and with posterior spinular row; third abdominal somite ornamented as in previous somite except for three pairs of sensilla only; fourth abdominal somite with ventral row of spinules, and 1 pair of lateral pores. Anal somite as in female. Anal operculum with posterior row of 5 strong spines.

Caudal rami (Fig. 6) small, length/width ratio 1.25, without spinules dorsally, laterally with some spinules at base of setae I and II, ventrally with row of spinules at the base of setae IV and V. All setae as in female.

Antennule (Fig. 3C) 10-segmented, haplocer with geniculation between segments 7 and 8. Segment 5 with large aestetasc fused at base with long seta. Segment 7 with pronounced articular surface, with one filiform seta, one thick seta and with two modified laminar setae. Segment 8 with 3 similar laminar modified setae. Segment 10 with acrothek consisting of slender aestetasc and two setae. Armature formula: 1-[1],2-[8],3-[8],4-[2],5-[5+(1+ae)],6-[2],7-[2+2 modified],8-[3 modified],9-[1],10-[7+acr].

P2 (Fig. 7A): Praecoxa, coxa, basis and exopod, largely as in female, except for shape of segments and setae length. Ornamentation of coxa and basis as figured. Endopod 2-segmented; first segment with row of outer spinules, with small inner seta; second segment elongated, with notch on distal outer margin, with row of outer spinules, with 2 apical and one inner seta.

P3 (Fig. 7B) strongly modified. Ornamentation of praecoxa, coxa, basis, and exopod as in female. Third segment of exopod shortened, with pectinate short inner setae. Endopod short; first segment flat and wide, with small inner seta; second segment with inner apophysis reaching tip of exopod, with spear-shaped tip; distal segment with two rounded thickenings, with one pinnate, and one whip-like thick setae.

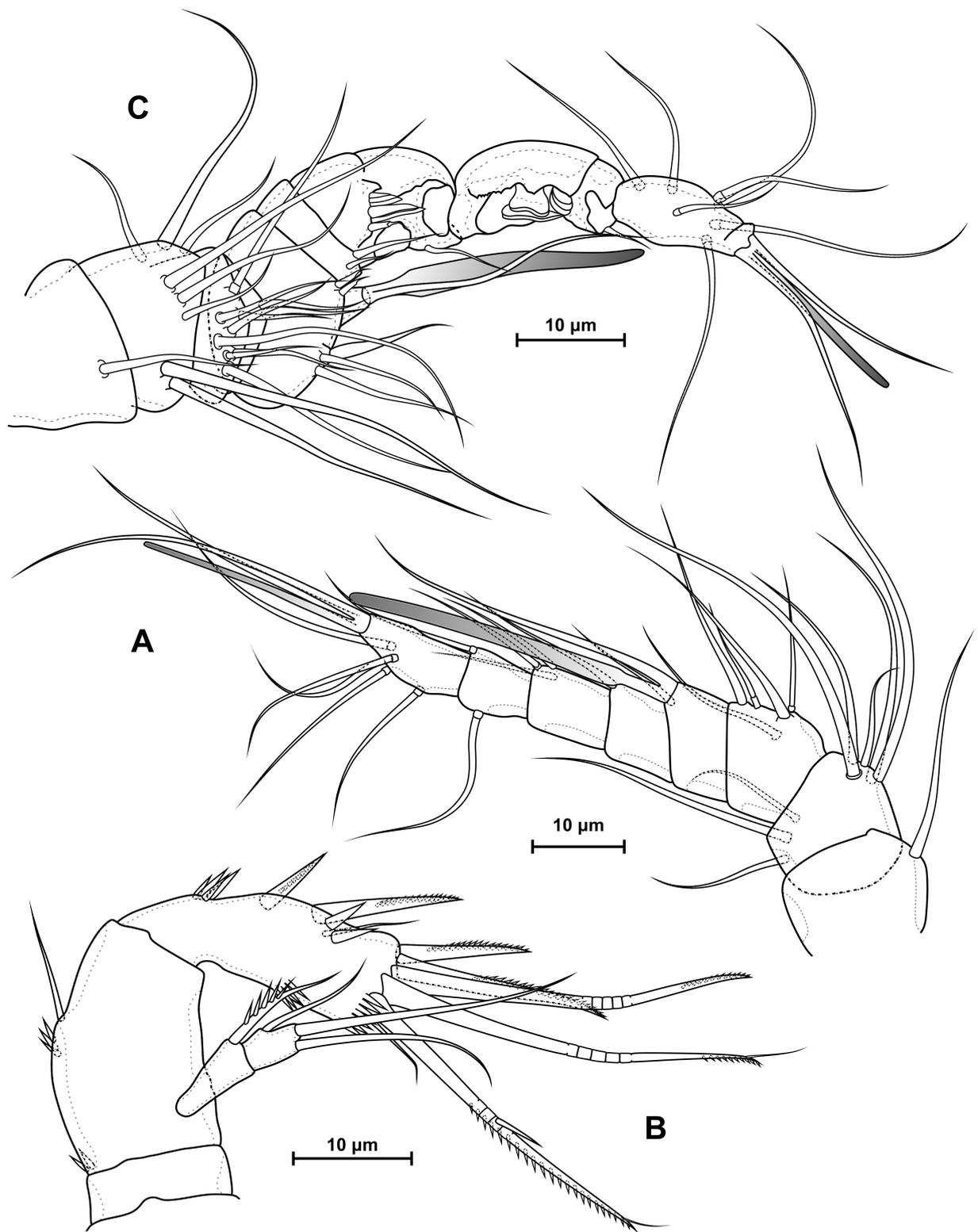


FIGURE 3. *Maraenobiotus supermario* n. sp. Female holotype: A, antennule; B, antenna. Male allotype: C, antennule

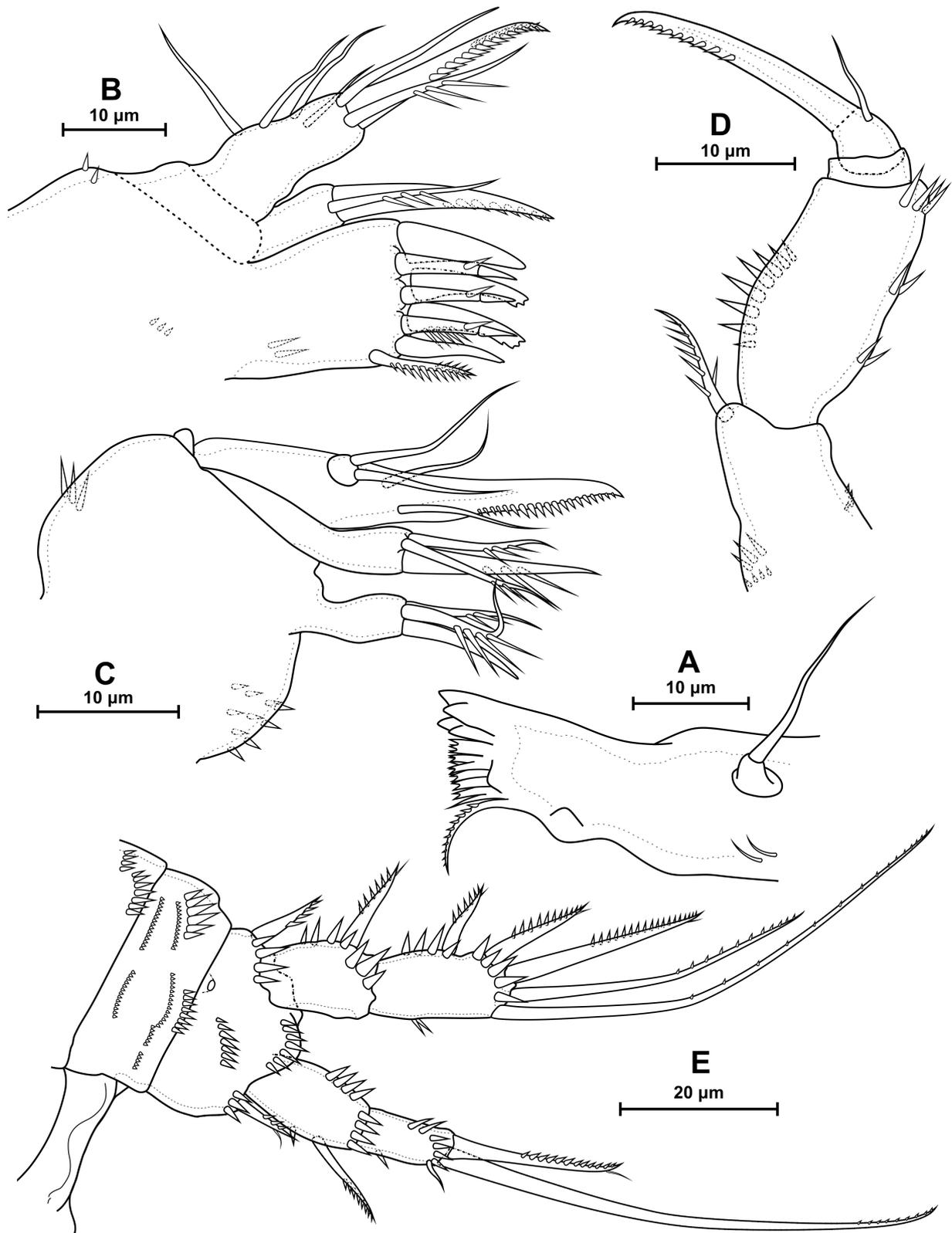


FIGURE 4. *Maraenobiotus supermario* n. sp. Female holotype: A, mandible; B, maxillule; C, maxilla; D, maxilliped; E, P1, anterior.

P4 (Fig. 7C) as in female except for third exopodal segment and with pectinate inner seta. Endopod small, 2-segmented; first segment without inner seta; second segment with only 3 setae.

P5 (Fig. 8B) small. Baseoendopod short, outer basal seta slender. Endopodal lobe with 2 tube pores, and 2 pinnate setae. Exopod with 1 inner pectinate, 2 pinnate apical, and 1 outer naked seta.

Variability. P5 and ornamentation of anal operculum variable. One of female paratypes with asymmetric P5, exopod of one side with 4 setae. Paratype females have anal operculum with 8-9 spinules.

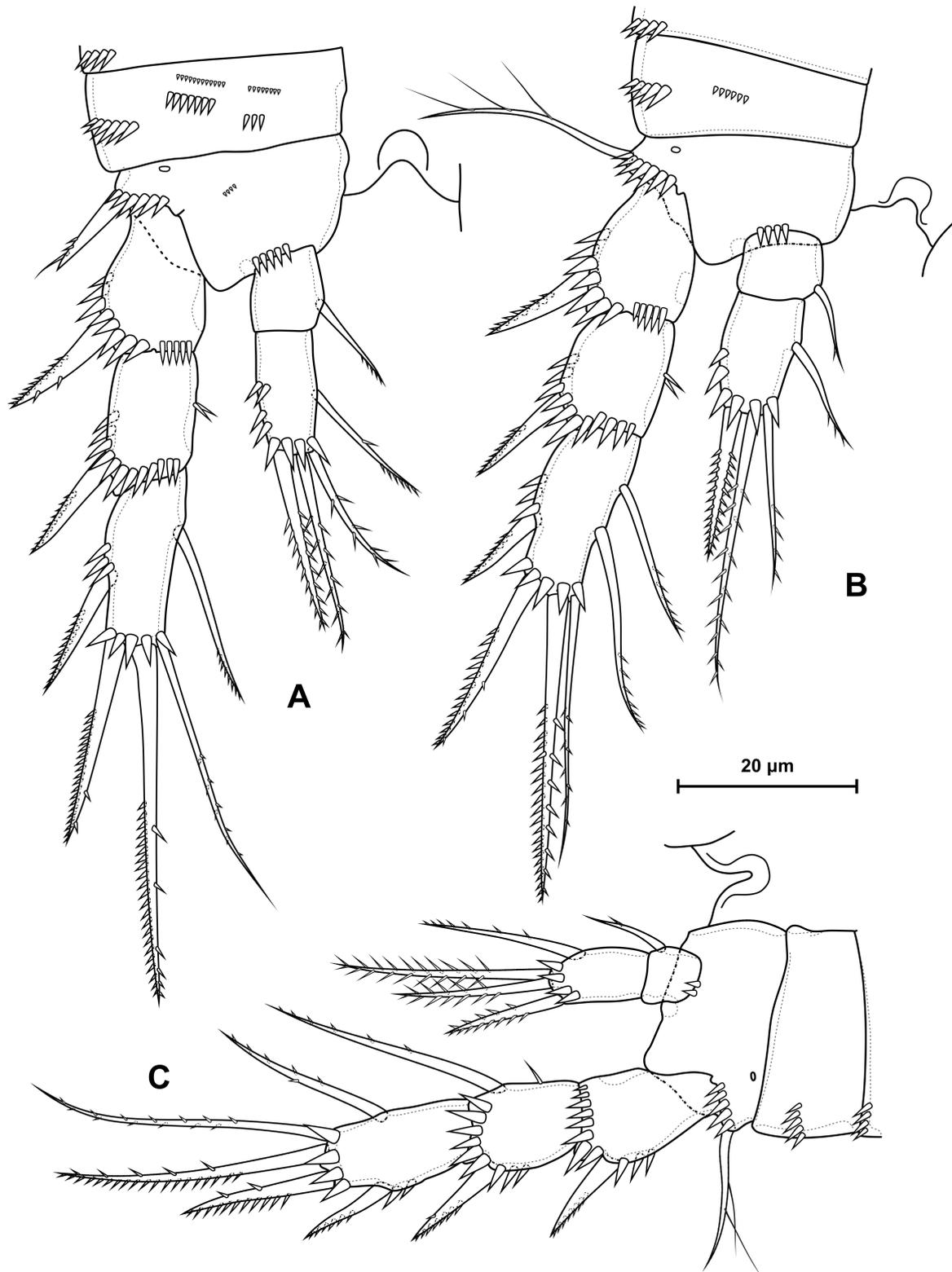


FIGURE 5. *Maraenobiotus supermario* n. sp. Female holotype: A, P2, anterior; B, P3, anterior; C, P4, anterior.

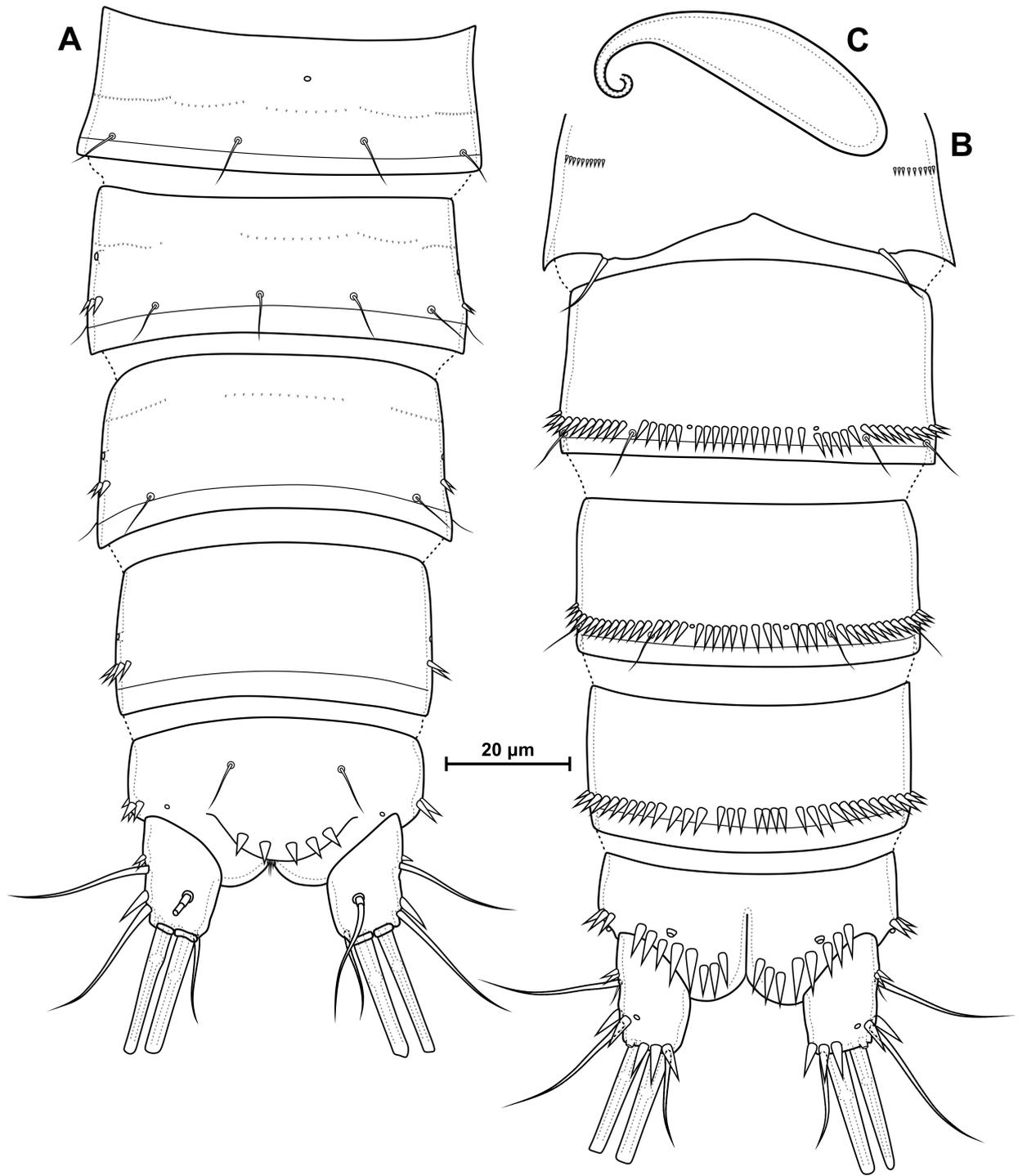


FIGURE 6. *Maraenobiotus supermario* n. sp. Male allotype: A, abdomen, dorsal; B, abdomen, ventral; C, spermatophore.

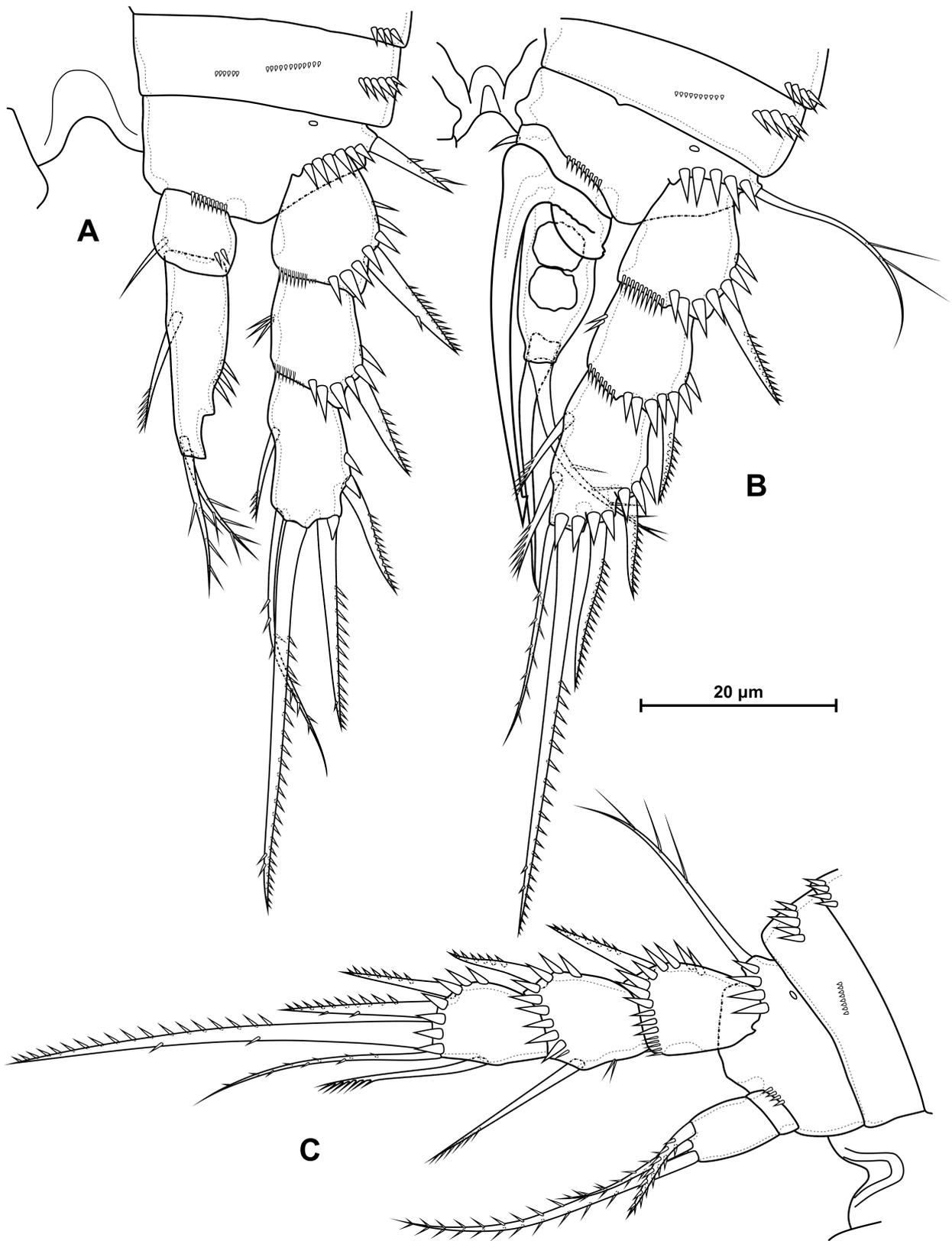


FIGURE 7. *Maraenobiotus supermario* n. sp. Male allotype: A, P2, anterior; B, P3, anterior; C, P4, anterior.

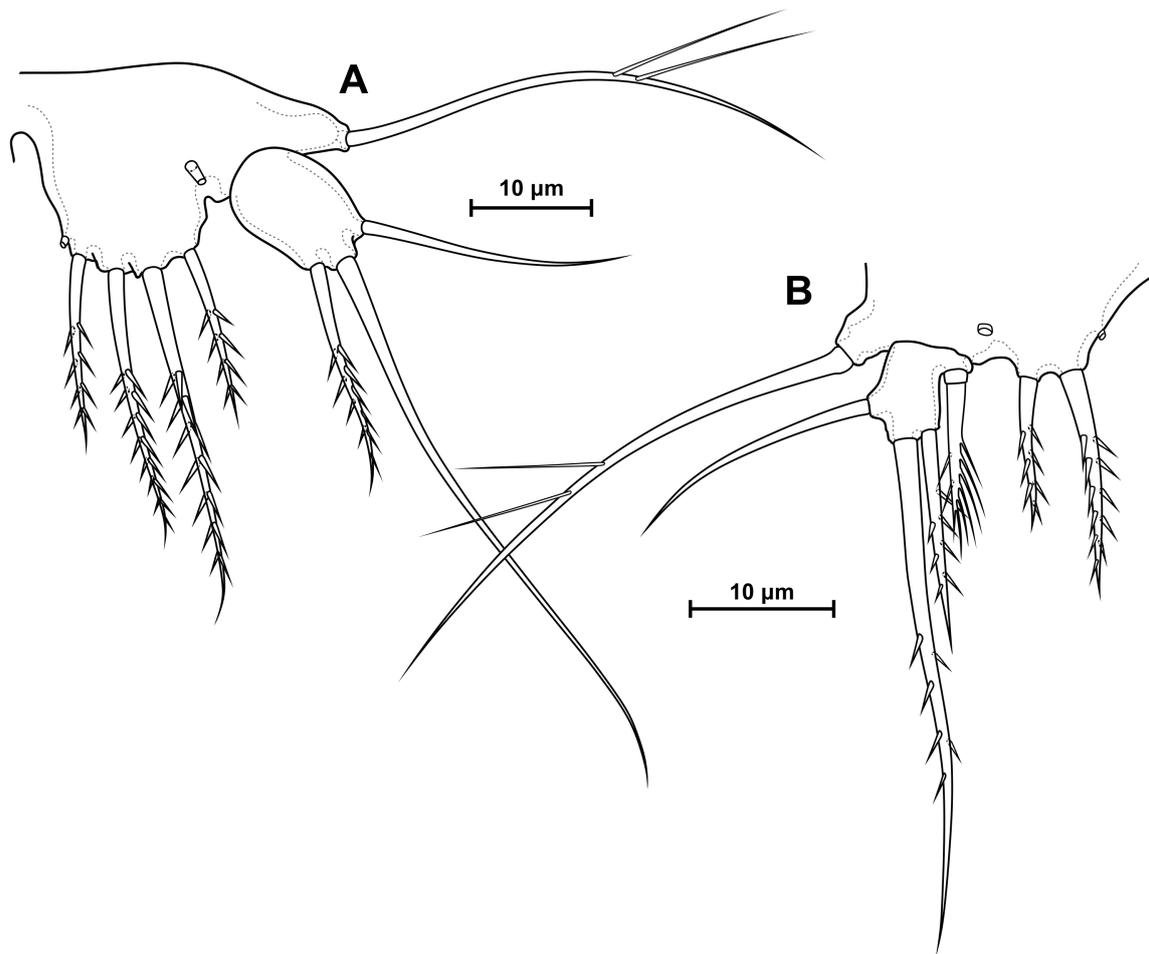


FIGURE 8. *Maraenobiotus supermario* n. sp. Female holotype: A, P5, anterior; Male allotype: A, P5, anterior.

Discussion

Maraenobiotus supermario n. sp. belongs to the *M. vej dovskyi* - species group. Brancelj and Karanovic (2015) identified a group but did not describe its distinguishing characters. We offer the following characters to recognize the group: mandibular palp 1-segmented, distal exopodal segments of P2 and P3 with 5 and 6 setae respectively, distal endopodal segment endopod of P4 with 4 setae, P5 baseoendopod with 4 setae. This combination of characters is shared by: *M. anglicus* Gurney, 1932, *M. arcticus* Keilhack, 1909, *M. canadensis* Flössner, 1992, *M. galassiae* Brancelj & Karanovic, 2015, *M. ishidae* Brancelj & Karanovic, 2015, *M. parainsignipes* Apostolov, 1991, *M. pescei* Brancelj & Karanovic, 2015, *M. slovenicus* Brancelj & Karanovic, 2015, *M. tenuispina* Roy, 1924, *M. truncatus* Gurney, 1932, *M. vej dovskyi* Mrázek, 1893, *M. veris* Ishida, 1995, *M. zschokkei* Kreis, 1920 and *M. supermario* n. sp. (Table 1).

The systematic within the group is problematic. Most of the species and subspecies have long been incompletely described, and considerable interpopulation variability within the group has also been noted. However, as Brancelj and Karanovic (2015) showed, there is no reliable evidence of high morphological variations within the same population, except for the evidence of Ishida (1987). In the population of *M. vej dovskyi* from the island of Hokkaido, he encountered two variants of the structure of setae on the caudal rami. But apparently there he found 2 different species (Brancelj & Karanovic 2015). Low intraspecific variability may indicate that we are dealing not with a single polymorphic species, but with a large complex of closely related isolated species.

TABLE 1. *M. vejdvovskiyi* species complex.

Species	Reference	Segments antenna exopod	Antenna exopod (number of setae)	Mandibular palp (number of setae)	Distal endopodal segment P3 female (number of setae)	Exopod P5 female (number of setae)	Distal endopodal segment P4 male (number of setae)	Genital somite posterior spinular row	2 somite posterior spinular row	3 somite posterior spinular row	Anal operculum (number of spinules)	Setae IV and V on caudal rami
<i>M. anglicus</i>	Lang 1948	2	4	3	5	3	3	absent	ventro-lateral	dorso-latero-ventral	naked	long
<i>M. arcticus</i>	Lang 1948	2	3	3	5	3	?	?	?	?	naked	ong
<i>M. canadensis</i>	Flössner 1992	1	4	3	4	3	2	absent	absent	ventro-lateral	8	long
<i>M. galassiae</i>	Pesce et al. 1994	2	4	5	5	3	?	?	?	?	?	reduced
<i>M. ishidae</i>	Ishida 1987	?	4	3	5	3	3	ventro-lateral	circum	circum	?	reduced
<i>M. parainsignipes</i>	Apostolov 1991	1	4	?	5	3-4	?	circum	circum	circum	23-24	long
<i>M. pescei</i>	Pesce et al. 1994	2	4	5	5	3	?	?	?	?	?	reduced
<i>M. slovenicus</i>	Brancelj & Karanovic 2015	2	4	5	5	3	3	absent	ventro-lateral	circum	20	reduced
<i>M. supermario</i>	Lang 1948	2	4	1	4	3	3	absent	ventro-lateral	ventro-lateral	8-9	long
<i>M. tenuispina</i>	Lang 1948	2	4	3	5	?	3	absent	ventro-lateral	dorso-latero-ventral	>20	short
<i>M. truncatus</i>	Lang 1948	2	4	2-3	5	?	3	absent	ventro-lateral	dorso-latero-ventral	12-20	reduced
<i>M. vejdvovskiyi</i> s. str.	Lang 1948	2	4	3	5	3	2	absent	ventro-lateral	dorso-latero-ventral	16	long, with bulbous
<i>M. veris</i>	Ishida 1995	2	4	3	5	4	?	absent	circum	circum	20	long
<i>M. zschokkei</i>	Lang 1948	1	4	3	5	3	2	absent	circum	circum	7-21	short

Individuals of *M. supermario* **sp. nov.** show no significant intraspecific variability. All females in the three samples share the same structure of caudal rami and setae, identical ornamentation of the abdomen and mandibular palp. The only variable character we observed is in the P5, which is asymmetrical in one of the female paratypes (one exopod with three setae, the other with four). We also observed a high stability in the structure of somital integument; the number and distribution of both pores and the sensilla of the cephalothorax and the thoracic somites are identical in males and females. Although we do not know their interspecific variability, a detailed qualitative description of pores and sensilla opens new possibilities in the species recognition of taxonomically complex groups. This approach has already been explored for several groups of copepods, such as the harpacticoid families Parastenocaridae (Karanovic et al. 2012) and Stenhelidae (Karanovic & Kim 2014), and the cyclopoid genera *Diacyclops* (Karanovic et al. 2013) and *Eucyclops* (Alekseev 2006).

Species within the *M. vej dovskiyi* species group differ greatly in the shape of the female apical caudal setae IV and V (Table 1); they can vary from a simple filiform shape to proximally swollen. In addition, the apical setae in general can be reduced to a minute knob as in *M. slovenicus*, *M. ishidae*, *M. pescei*, and others (Brancelj & Karanovic 2015). *Maraenobiotus supermario* sp. nov. shows the most primitive variant of caudal setae IV and V, being of normal attributes (lacking a bulbous proximal part), unlike *M. vej dovskiyi* s. str., with caudal setae IV and V with bulbous proximal part (Mrazek 1893). A population with identical bulbous caudal in caudal setae IV and V has been reported from the European North-East of Russia (Fefilova 2010). The males of *M. slovenicus* have strongly modified antennules with a large process for capturing the females caudal ramus, whose apical setae are reduced. It is probable that the various structural variations of the caudal rami contribute to interspecific mechanical precopulatory isolation.

The new species has a remarkable reduction of the mandibular palp, represented by a very small protrusion armed with a single seta. The new species also differs from most other species of the *vej dovskiyi* complex in the reduced number of spinules on the anal operculum, the female having eight or nine spinules and the male only five. In contrast, the females of other species usually have over 12 spinules, and the male over 10 (Wells 2007).

The most similar species to *M. supermario* n. sp. is *M. canadensis* Flössner, 1992 from Eastern Canada (Flössner 1992). These two species are almost identical in the armature of swimming legs and the ornamentation of the abdomen and anal operculum., except for the male *M. canadensis* bearing two setae on the P4 second endopodal segment, whereas the male *M. supermario* sp. nov. has three such setae. These species can be readily distinguished by the number of setae on the mandibular palp (1 seta in the new species vs. 3 in *M. canadensis*).

Key to the females of *Maraenobiotus vej dovskiyi* species complex:

1	Mandibular palp 1-segmented; distal segments exopod P2 and P3 with 5 and 6 setae; distal segment endopod P4 with 4 setae; baseoendopod P5 with 4 setae	2 - <i>M. vej dovskiyi</i> species complex
-	The combination of characters is different	other species of <i>M.</i>
2	Second segment endopod P3 with 4 setae	3
-	Second segment endopod P3 with 4 setae	4
3	Mandibular palp with 1 seta	<i>M. supermario</i> n. sp.
-	Mandibular palp with 3 setae	<i>M. canadensis</i> Flössner, 1992
4	Mandibular palp with 5 setae	5
-	Mandibular palp with 2-3 setae	7
5	Caudal rami cylindrical with L/W ~ 2	<i>M. galassiae</i> Brancelj & Karanovic, 2015
-	Caudal rami shorter	6
6	Lateral setae (II and III) on caudal rami very reduced (or absent)	<i>M. pescei</i> Brancelj & Karanovic, 2015
-	Lateral setae on caudal rami long	<i>M. slovenicus</i> Brancelj & Karanovic, 2015
7	Antenna exopod 1-segmented	8
-	Antenna exopod 2-segmented	9
8	Genital-double somite with posterior spinular row	<i>M. parainsignipes</i> Apostolov, 1991
-	Genital-double somite without posterior spinular row	<i>M. zschokkei</i> Kreis, 1920
9	Antenna exopod with 3 setae	<i>M. arcticus</i> Keilhack, 1909
-	Antenna exopod with 4 setae	10
10	Apical setae (IV and V) on caudal rami reduced	11
-	Apical setae on caudal rami longer than caudal rami	12
11	Genital-double somite with posterior ventro-lateral spinular row; caudal rami cylindrical with L/W ~ 2	<i>M. ishidae</i> Brancelj & Karanovic, 2015
-	Genital-double somite without posterior spinular row; caudal rami shorter	<i>M. truncatus</i> Gurney, 1932

12	Apical setae (IV and V) on caudal rami with large bulbous	<i>M. vej dovskiy</i> Mrázek, 1893
-	Apical setae on caudal rami without large bulbous	13
13	Second and third abdominal somites with posterior circum spinular row	<i>M. veris</i> Ishida, 1995
-	Second and third abdominal somites with posterior ventro-lateral spinular row	14
14	Apical seta V / caudal rami > 2	<i>M. anglicus</i> Gurney, 1932
-	Apical seta V / caudal rami < 2	<i>M. tenuispina</i> Roy, 1924

Acknowledgements

We thank the management and staff of AWI Potsdam for the opportunity to participate in the expedition “Lena 2018” and “Lena 2019”. We thank the staff of the “Samoylov Island” research station for their assistance. We are grateful to Polyakov Vyacheslav (AARI) for assistance in collecting samples. We are also grateful to Samuel Gómez for the quality review, helpful comments and text edits.

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