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Two rare species of Danielsseniinae (Copepoda: Harpacticoida: Pseudotachidiidae) from the Kara and East Siberian Seas, with description of their previously unknown sexes

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Abstract

The previously unknown females of *Danielssenia spitsbergensis* Gee & Huys, 1994 and males of *Mucrosenia kendalli* Gee & Huys, 1994 (Pseudotachidiidae, Danielsseniinae) are described based on specimens collected in the Kara and East Siberian Seas.

Females of *D. spitsbergensis* exhibit the main diagnostic features of the genus *Danielssenia* Boeck, 1873 (antennule four-segmented; proximal segment of antennary exopod with one seta; structure of all the mouthparts; absence of an inner seta on exopod-1 of P2–P4; P5 not fused medially and with distinct exopod and baseoendopod, the latter with five setae; genital field with small copulatory pore and short copulatory duct leading to seminal receptacle with paired anterior chambers). At the same time, these specimens also exhibit some distinctive features which are unique for the species but disagree with the generic diagnosis. These peculiarities validate the placing of *D. spitsbergensis* as *species incertae sedis* within *Danielssenia* and point out the necessity of examination of other '*Danielssenia*-like' forms before the true taxonomic position of this species can be elucidated.

Both males and females of *M. kendalli* exhibit the autapomorphies of the genus, *viz.* P2 endopod-2 with a mucroniform process reaching almost to end of endopod-3 (this sexually dimorphic character is more pronounced in the males but also present in females); P2 endopod-2 without inner seta; posterior displacement of caudal ramus seta II; presence of tuft of long setules at inner distal corner of caudal ramus; P2 endopod shorter than exopod; P2–P4 exopod-1 without inner seta. Furthermore, some particular features (anal somite and pseudoperculum morphology; female P1 endopod distinctly longer than exopod; P5 exopod with distinct suture on dorsal surface separating it from the baseoendopod; prominent mucroniform process on P2 endopod-2) of the Kara and East Siberian Sea specimens conform fully with the original description of *M. kendalli* but apparently differ from *M. kliei* (Smirnov, 1946), the single female of which was collected from the same region and depth. Therefore, the validity and definite status of the specimen described by Smirnov is still a matter of conjecture pending additional findings and, particularly, the discovery of the male.

Key words: *Danielssenia spitsbergensis* Gee & Huys, 1994, *Mucrosenia kendalli* Gee & Huys, 1994, Harpacticoida, Pseudotachidiidae, Danielsseniinae, taxonomy, Arctic

Introduction

During ecological studies of benthic communities on the Arctic Ocean shelf, a set of meiofauna samples was obtained from 9–335 m depth in the Kara and East Siberian Seas. These samples yielded many harpacticoid copepods, mostly belonging to the families Ameiridae, Miraciidae, Argestidae, Ectinosomatidae and Pseudotachidiidae (Garlitska & Azovsky 2016; Garlitska *et al.* 2019). Among the latter, several individuals belonged to 'danielsseniid genera' (subfamily Danielsseniinae) and were identified as *Danielssenia spitsbergensis* Gee & Huys, 1994 and *Mucrosenia kendalli* Gee & Huys, 1994. Both species were described from a single specimen (male and female, respectively), and are known exclusively from their respective type locations.

In this paper we record the presence of these species in other Arctic seas and describe the as yet unknown sex for each of them.

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Material and methods

The material was collected in September 2015 in the eastern part of the Kara Sea and in September 2017 in the East Siberian Sea during the 63th and 69th cruises of the R/V Akademik Mstislav Keldysh. The sediments were collected by a multicorer or by a Niemistö gravity corer. Meiofauna samples of the upper 5 cm of the sediments were taken by a syringe core tube (2 cm inner diameter). The samples were fixed on board in 5% formalin and ubsequently washed in the laboratory with tap water. The meiofauna was extracted from the sediment by centrifugation using Levasil (colloidal silica polymer) as a flotation medium and kaolin to cover the sand particles (McIntyre & Warwick 1984). The samples were centrifuged three times at 4,000 rpm for five minutes. After centrifugation, the upper fraction containing the meiobenthic organisms was sieved using a mesh size of 40 µm, washed with fresh water and stained with Rose Bengal. The copepods were picked out and sorted under a stereomicroscope.

The habitus was photographed and body length measurements made from whole specimens mounted in glycerin. Harpacticoids were dissected in glycerin; the parts were individually mounted in lactophenol under coverslips which were subsequently sealed with transparent nail varnish. Observations were made under maximum magnification with a Leica MZ APO and Olympus CX41. Identification to species level was achieved by using the tabular keys by Wells (2007) and checking against the original literature. All drawings were made with a drawing tube attached to the light microscope Olympus BX 41 or Olympus CX 41. Morphological terminology follows Huys & Boxshall (1991). Abbreviation used in the text and figure legends: *P2–P6*, 2nd–6th thoracic legs; *exopod(endopod)-1(2, 3)*, proximal (middle, distal) segment of exopod (endopod). All material is deposited in the P.P. Shirshov Institute of Oceanology, Russian Academy of Science.

Systematics

Order Harpacticoida Sars, 1903

Family Pseudotachidiidae Lang, 1936

Subfamily Danielsseniinae Huys & Gee in Huys *et al*., 1996

Genus *Danielssenia* Boeck, 1873

Danielssenia spitsbergensis Gee & Huys, 1994

(Fig. 1)

Specimens examined. Female dissected on four slides (collection numbers IORAS-Har199–202), collected from 104 m depth at location 78°00’9”N 87°37’3”E (Kara Sea) and female partly dissected on one slide (collection number IORAS-Har203), collected from 335 m depth at location 80°00’0”N 85°32’0”E (Kara Sea). Both specimens were collected in September 2015, leg. A. Udalov.

Description of female. Total body length measured from tip of rostrum to posterior margin of caudal rami: 310 µm. Genital field (Fig. 1A) with small copulatory pore; short copulatory duct leading to seminal receptacle with paired anterior chambers extending to anterior margin of genital double-somite; vestigial P6 with one pinnate seta and one spinule.

Antennule (Fig. 1B) short, stout, four-segmented. Segment 1 largest, almost rectangular, with two rows of spinules on dorsal surface and a pinnate seta at distal corner. Segment 2 almost triangular, with eight setae (one pinnate seta proximally on anterior margin, five setae at anterior distal corner and two setae on posterior margin). Segment 3 triangular with eleven setae (five setae medially on anterior margin, and six setae and an aesthetasc at anterior distal corner). Segment 4 triangular with row of spinules on dorsal surface and seven setae at proximal margin (two long pinnate setae, two plane setae and three sort pinnate setae) and an aesthetasc.

P2 (Fig. 1C). Intercoxal sclerite well-developed, bearing two groups of setules at distal margin. Coxa almost rectangular with two groups of setules at proximal and distal outer corner of distal margin on anterior face. Basis with outer seta and row of spinules halfway down anterior margin. Both rami three-segmented, almost equal in

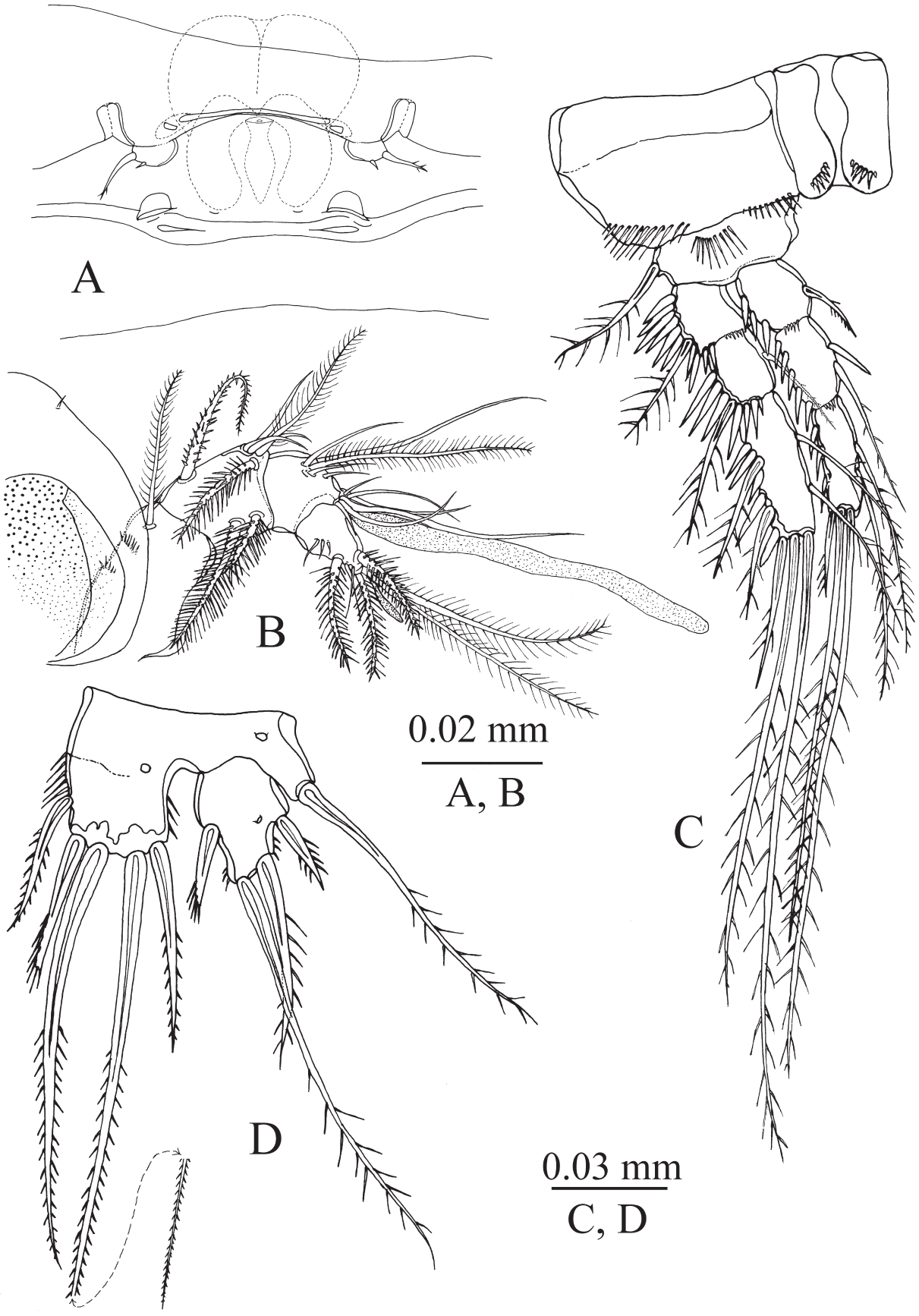

FIGURE 1. *Danielssenia spitsbergensis* Gee & Huys, 1994, female: A, genital field; B, antennule; C, P2; D, P5.

length. Exopod-1 with rows of spinules on outer and distal margin, and one outer seta; exopod-2 with rows of spinules on outer and distal margin, one outer seta and one inner seta; exopod-3 only with outer row of spinules, and seven setae (223). Endopod-1 with outer rows of spinules and one inner seta; endopod-2 with outer row of spinules, long inner spinule and one inner seta; endopod-3 with outer rows of spinules and five setae (221).

P5 (Fig. 1D). Element of each side not fused medially. Baseoendopod and exopod separate. Endopodal lobe with five pinnate setae; fourth seta the longest. Exopod slightly longer than wide with four setae; second seta the longest with plumose tip. Outer seta long and well developed.

Variability. Only two females and two males were collected and examined. No variable features or asymmetries were observed, and differences between male and female specimens are all part of a normal sexual dimorphism.

Remarks. *Danielssenia spitsbergensis* was described by Gee & Huys (1994) from a single male specimen. It can easily be distinguished from other known species by the presence of only two outer spines on exopod-3 of P3 and P4. However, because of differences in the structure of the P2 endopod and P5, the species placed *incertae sedis* within *Danielssenia* pending the discovery of the female. A single female was also found and, according Gee & Huys (1994), had only two outer spines on exopod-3 P3 and P4, but was lost before detailed inspection. The lack of some details of female morphology, particularly the segmentation of the female antennule and the detailed structure of the genital field and the seminal receptacle, made Gee & Huys (1994) refrain from determining the exact taxonomic status of this species.

Our specimens exhibit all diagnostic features of the genus *Danielssenia* as redefined by Huys & Gee (1993): four-segmented antennule; one seta on exopod-1 of antennary exopod; structure of all mouthparts; absence of inner seta on exopod-1 of P2–P4; P5 not fused medially; distinct P5 exopod and baseoendopod; five setae on P5 baseoendopod; and genital field with large copulatory pore and short copulatory duct leading to seminal receptacle with paired anterior chambers. Since our females have only two outer spines on exopod-3 of P3 and P4, this differentiating feature that is unique for *D. spitsbergensis*, should be included in species diagnosis. Examined males have the same features like in Gee & Huys' (1994) original description: (1) the mucroniform process on endopod-2 of P2 reaches to the distal margin of endopod-3; and (2) the exopod of the male P5 is fused to the baseoendopod. Although the confirmation of the deviating armature formula of the P3–P4 exopod-3 in both sexes would require an emendation of the generic diagnosis, we prefer to concur with Gee & Huys (1994) in placing *D. spitsbergensis* as *species incertae sedis* in *Danielssenia*.

Genus *Mucrosenia* Gee & Huys, 1994

Mucrosenia kendalli Gee & Huys, 1994

(Fig. 2)

Specimens examined. Male dissected on four slides (collection number IORAS-Har204–207), collected from 27 m depth at location 73°14'044"N 156°25'957"E (East Siberian Sea); and two additional males dissected on four slides each (collection numbers IORAS-Har208–211 and IORAS-Har212–215), collected at same location. Specimens were collected in September 2017, leg. A. Udalov. Additional material: two males collected from the Kara Sea in September 2015 (at 125 and 301 m depth); seven males and four females from East Siberian Sea in September 2017 (at 27, 45 and 58 m depth).

Description of male. Total body length measured from tip of rostrum to posterior margin of caudal rami: 330 μm.

Antennule (Fig. 2A–E) six-segmented, sub-chirocer. Segment 1 (Fig. 2A) with three rows of spinules on dorsal surface and a pinnate seta at anterior distal corner. Segment 2 (Fig. 2 A) short with pinnate seta at anterior distal corner. Segment 3 (Fig. 2B) almost triangular with ten setae: two strongly pinnate setae at posterior margin, one pinnate seta at anterior proximal corner, seven (three of which are pinnate) setae medially on anterior margin. Segment 4 (Fig. 2C) short and rectangular with eight setae at anterior distal corner (one of them long and pinnate). Segment 5 (Fig. 2D) moderately swollen with convoluted anterior face bearing two rows of denticles; ten setae and on anterior distal corner, five setae pinnate, one short and four long simple setae, and an aesthetasc at distal corner. Segment 6 (Fig. 2E) convoluted; with row of spinules and three pinnate setae at proximal margin, three pinnate and three plane setae and an aesthetasc at distal margin.

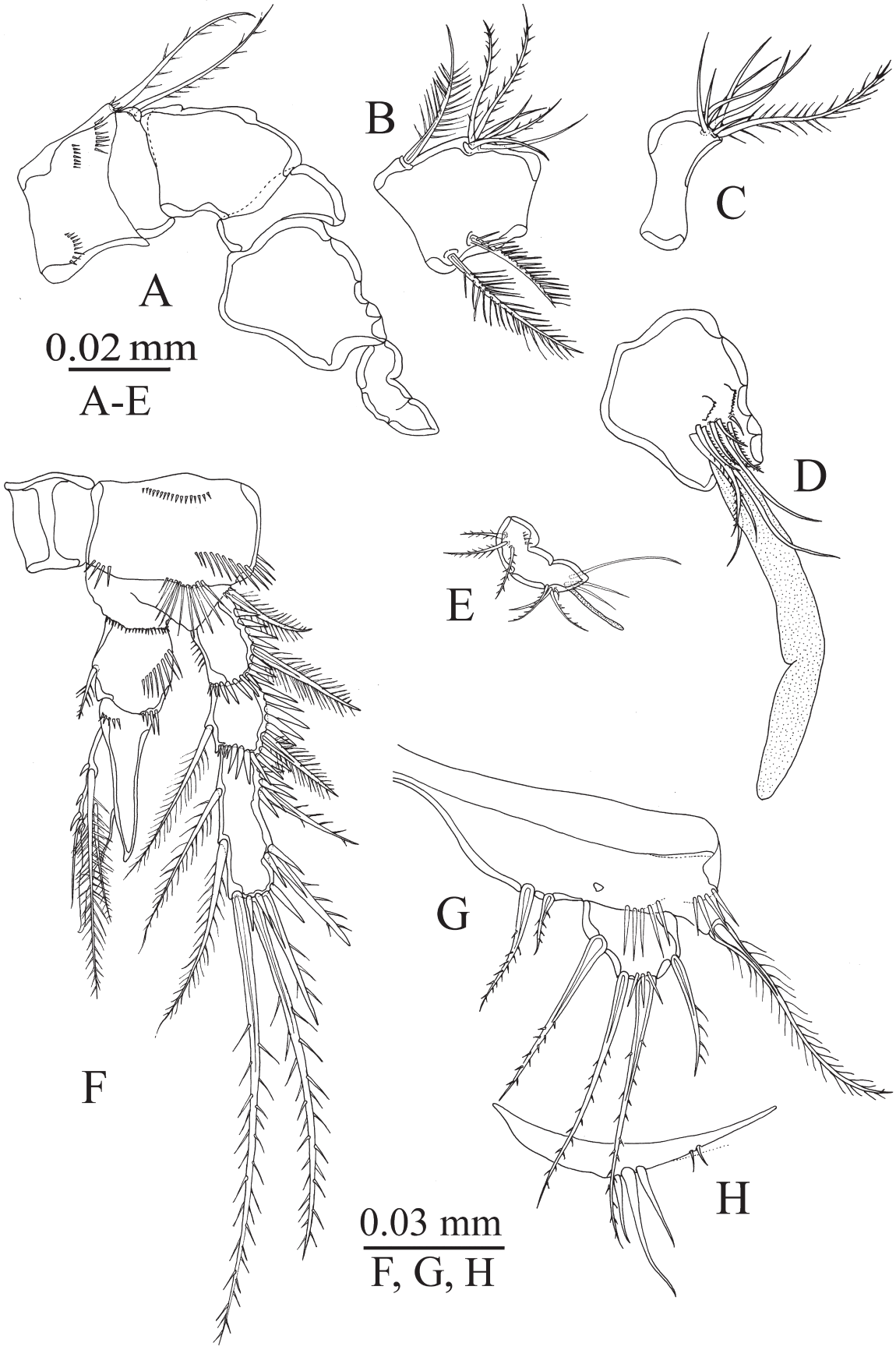

FIGURE 2. *Mucrosenia kendalli* Gee & Huys, 1994, male: A, first two segments of antennule; B, third segment of antennule; C, fourth segment of antennule; D, fifth segment of antennule; E, sixth segment of antennule; F, P2; G, P5; H, P6.

P2 (Fig. 2F). Intercoxal sclerite almost square and unadorned. Coxa with row of small spinules in centre of anterior part and tree rows of spinules on distal margin. Basis with outer pinnate seta and row of spinules at base of rami. Both rami three-segmented, almost equal length. Exopod-1 with rows of spinules on outer and distal margin, and one outer seta; exopod-2 with rows of spinules on outer and distal margin, one outer seta and one inner seta; exopod-3 with patches of spinules on outer and distal margin, and seven pinnate setae (223). Endopod-1 with two rows of spinules on outer margin and one small inner seta; endopod-2 modified into mucroniform process reaching middle of endopod-3. Endopod-3 modified with two inner setae (one pinnate and one simple) and one seta in center of anterior face, inner margin bearing three dentate elements.

P5 (Fig. 2G). Elements fused medially, exopod not fused to baseoendopod. Baseoendopod with patches of spinules at distal outer margin, outer seta long and pinnate; endopodal lobe reduced, bearing two setae of different length; exopod with four setae, inner and outer setae inserted at a distance from terminal two.

P6 (Fig. 2H). A single plate fused to somite bearing tree setae and several spinules on each side.

Variability. No variable features or asymmetries were observed among the twelve males and four females examined, and most differences between male and female specimens are all part of the typical sexual dimorphism expressed in this family.

Remarks. The genus *Mucrosenia* (type species *M. kendalli*) was established on the basis of a single female. The second member of the genus, *M. kliei* (Smirnov, 1946), was originally described as *Psammis kliei* by Smirnov (1946), also from a single female taken at 60 m depth from the East Siberian Sea. Our specimens exhibit autapomorphies of the genus *Mucrosenia* (as defined by Gee & Huys 1994) which can be seen in both sexes, *viz.* P2 endopod-2 with a mucroniform process reaching almost to the end of endopod-3 (this sexually dimorphic character is more pronounced in the males but also present in females); P2 endopod-2 without inner seta; posterior displacement of seta II on the caudal ramus; presence of tuft of long setules at inner distal corner of caudal ramus; P2 endopod shorter than exopod; and absence of inner seta on exopod-1 of P2–P4.

Furthermore, some particular features (morphology of anal somite and pseudoperculum; P1 endopod of female distinctly longer than exopod; separation of P5 exopod and baseoendopod marked by distinct suture on dorsal surface; P2 endopod-2 with prominent mucroniform process) displayed by the females from the Kara and East Siberian Seas conform fully to the description of *M. kendalli* but apparently differ from *M. kliei*. The single female of the latter species was collected from the same region and depth as some of our specimens (Smirnov 1946). The discrepancies between Smirnov's illustrations and text description have been expounded in detail by Gee & Huys (1994). Since the male is still unknown for *M. kliei*, the comparison of males for both species is impossible. Therefore, the validity and definite status of the specimen described by Smirnov (1946) is still a matter of conjecture.

Notes about ecology and distribution. Both above-mentioned species were originally discovered in muddy sediments off the western coast of Spitsbergen, Greenland Sea, at depths of 30 m (*D. spitsbergensis*) and 95 m (*M. kendalli*) (Gee & Huys 1994). Our specimens were found in similar habitats but in rather distant locations. *Danielssenia spitsbergensis* was found in silt in the Kara Sea (Voronin Trench) at 108 and 335 m depth. *Mucrosenia kendalli* was collected from silty sediments in the Kara Sea (Voronin Trench) at 125 and 301 m depth, and in the East Siberian Sea (inn silt at 27–58 m depth). These findings substantially extend the distribution ranges for both species, both geographically (eastward) and bathymetrically (from the sublittoral zone down to the lower continental shelf). This suggests a wide circum-Arctic distribution for both species, just like for some other genera in the Danielseniinae, *e.g. Danielssenia*, *Archisenia* Huys & Gee, 1993 and *Paradanielssenia* Soyer, 1970.

Harpacticoids of the Siberian Arctic Seas are poorly studied. Not more than a dozen Pseudotachidiidae species have been reported before from this region (Smirnov 1946). In particular, the subfamily Danielsseniinae includes 63 definitive species from 19 genera. Taking the recent data (Garlitska & Azovsky 2016; Chertoprud *et al.* 2018; Garlitska *et al.* 2019) into account, 18 of these species (ten genera) have been reported from the Arctic seas. So, this subfamily is equally represented in polar waters and in the tropics (19 species, 12 genera).

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