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Copepods of the family Dirivultidae (Siphonostomatoida) from deep-sea hydrothermal vent fields on the Mid-Atlantic Ridge at 14°N and 5°S

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Abstract

Five species of three genera of Dirivultidae Humes and Dojiri, 1980 were found at deep-sea hydrothermal vent fields on the Mid-Atlantic Ridge, at the Logachev-1 field at 14°N and at two new sites (Turtle Pits and Red Lion) explored at 5°S. The copepods were collected with a Remotely Operated Vehicle (ROV Quest 4000) and Video Controlled Grab, operated from the *R/V Meteor* during two cruises (M60/3 and M64/1) conducted in 2004 and 2005 at depths 2992–3048 m. The male of *Stygiopontius lomonosovi* n. sp. from the Logachev field shares a medioventrally prolonged syncoxa of the maxilliped with *S. mirus* Humes, 1996 and *S. latulus* Humes, 1996 from the Snake Pit at 23°N of the Mid-Atlantic Ridge, but differs from them in having two, instead of three, outer spines on the distal exopodal segment of leg 4. *Aphotopontius atlanteus* Humes, 1996 previously known from the Lucky Strike and the Menez Gwen sites at 37°N and *Rimipontius mediospinifer* Humes, 1996 known from three sites (Logachev, Snake Pit, and Broken Spur at 29°N) are recorded from the Logachev field. *Stygiopontius pectinatus* Humes, 1987 previously recorded from the Mid-Atlantic Ridge hydrothermal vent fields TAG (26°N), Snake Pit, Broken Spur (29°N), and from the Mariana Back-Arc Basin of the Pacific Ocean and *Stygiopontius cladarus* Humes, 1996 previously known only from Snake Pit and Broken Spur, were found associated with alvinocaridid shrimps (*Rimicaris* sp.) from the hydrothermal vent field at 5°S. The discovery of dirivultids at 5°S represents the first record of copepods from a deep-sea hydrothermal vent southward of the Logachev field in the Atlantic Ocean.

Key words: Copepoda, Siphonostomatoida, Dirivultidae, deep-sea hydrothermal vents, Mid-Atlantic Ridge, symbiosis

Introduction

Studies of deep-sea fauna during the last few years have revealed a high diversity of copepods with a number of new species awaiting description (Ivanenko & Defaye 2004a–c; Willen 2004; Ivanenko *et al.* 2005; Markhaseva & Ferrari 2005; Rose *et al.* 2005; Ivanenko 2006; Ivanenko & Defaye 2006a). Some of these species, such as the cyclopoid *Heptnerina confusa* Ivanenko and Defaye, 2004b and the harpacticoid families Tegastidae and Tisbidae from the Lucky Strike field, surprisingly are very similar to species from shallow-water environments (Lang 1948; Ivanenko & Defaye 2004b, c; Ivanenko & Defaye, in preparation). Others, such as copepods of a new calanoid genus (Spinocalanidae) from the giant pockmark Regab on the Gabon continental margin, swarm in gas fluids, like calanoids of the sister genus described before from a hydrothermal vent community on the East Pacific Rise (Fleminger 1983; Ivanenko, Defaye & Cuoc, submitted).

Copepods of the family Dirivultidae Humes and Dojiri, 1980 were reported from many distinct hydrothermal fields of the Atlantic and Pacific Oceans on different substrates, in plankton over hydrothermal vents and in washings of hydrothermal vent bivalves, polychaetes and crustaceans (Ivanenko 1998; Humes & Segonzac 1998; Heptner & Ivanenko 2002; Ivanenko & Defaye 2006b). Eleven of the 48 known species of dirivultid copepods are reported from the Mid-Atlantic Ridge (MAR): the monotypic genus *Rimipontius* Humes, 1996, found in the MAR only; two of the 10 known species of *Aphotopontius* Humes, 1987; and eight of the 20 known species of *Stygiopontius* Humes, 1987 (for synonymy of four dirivultid species see Ivanenko & Defaye 2006b).

The present paper describes a new species of *Stygiopontius* from the Logachev-1 hydrothermal field (14°N) and reports on new findings of dirivultids belonging to three genera (*Aphotopontius*, *Rimipontius* and *Stygiopontius*) from this and two new hydrothermal vent sites (Turtle Pits and Red Lion) discovered recently on the MAR at 5°S (Devey *et al.* 2005). This is the first record of the family Dirivultidae in the South Atlantic Ocean.

Material and methods

The copepods were collected during cruises M60/3 and M64/1 of the *R/V Meteor* on the MAR conducted in 2004 and 2005. The fauna and sediment were sampled at depths 2992–3048 m by nets (mesh sizes 100 µm and 300 µm) handled by manipulating arms of the Remotely Operated Vehicle (ROV Quest 4000, MARUM, University of Bremen) and by the Video Controlled Grab (GTV) enclosing 2 m². The Video Controlled Grab had a black and white video camera communicating images via coaxial cable. The samples were preserved with 4% seawater buffered formalin and 72% ethanol.

IRINA II, the site of the Logachev-1 hydrothermal field explored during cruise M60/3,

was previously described by Gebruk *et al.* (2000a). This site is characterized by the presence of a 3-m long and 2-m high smoker complex consisting of four big chimneys. Copepods were found in two samples collected on 26 January 2004:

—Sample 38 ROV-4 (mesh size 300 μm) was collected by the ROV at 14°45.19'N, 44°58.75'W, depth 3036 m, musselbed of *Bathymodiolus puteoserpentis* Cosel, Metivier and Hashimoto, 1994 near the active chimney at the southern end of the site.

—Sample 35 GTV was collected by the Video Controlled Grab at 14°45.19'N, 44°58.75'W, depth 3019 m, musselbed of *B. puteoserpentis* near the smoker-complex (Fig. 1A). Crabs *Segonzacia mesatlantica* (Williams, 1988), snails *Phymorhynchus moskalevi* Sysoev and Kantor, 1995 and ophiuroids *Ophioctenella acies* Tyler *et al.* 1995 were observed among *B. puteoserpentis*. The sample included grey altered sediment layers on a sulphidic hydrothermal crust built up by atacamite and serpentinite. The maximum temperature of this sediment (measured on deck) was 106°C.

Turtle Pits (cruise M64/1) is a depression with a 6-m high active chimney “Tower”. Several shrimps of different sizes were collected on this chimney using a net (Fig. 1B). Smaller active chimneys and aggregations of *Bathymodiolus* sp. were observed near the margin of this depression as well. Samples 123 ROV-5 (mesh size 100 μm) and 123 ROV-6 (mesh size 300 μm), were collected by the ROV on 11 April 2005 at 4°48.6'S, 12°22.4'W, depth 2992 m.

The Red Lion Field (cruise M64/1) consists of four active chimneys situated in a small area (about 400 m²) on a pillow lava floor. The chimneys were covered by dense aggregations of *Rimicaris* cf. *exoculata*. Many shrimps were observed swimming over the hydrothermal field 20 m away from the chimneys. The 3 m high active chimney “Shrimp Farm” from which the shrimps *Rimicaris* cf. *exoculata* were collected possesses flanges characterized by shimmering waters (Fig. 2A–B). Sample 146 ROV-6 (mesh size 300 μm) was collected by the ROV on 16 April 2005 at 4°47.82'S, 12°22.60'W, depth 3048 m.

Copepods associated with shrimps *Rimicaris* sp. were shaken on board in filtered sea water and sieved through a 40 μm net. In addition, the branchial chamber and appendages of the shrimps preserved in ethanol were observed under a Leica MZ12 microscope.

Copepods were studied using the “hanging drop method” as described in Ivanenko and Defaye (2004a). The copepods were dissected under a Leica MZ12 microscope. All specimens or appendages were studied with a Leica DMR compound microscope with bright-field and differential interference optics. Drawings were made with the aid of a drawing tube mounted on the compound microscope. For long-term preservation, the dissected copepods were mounted on slides in glycerol and sealed with paraffin.

The type material is deposited in the collection of the Senckenberg Museum, Frankfurt (SMF), Germany. The other copepods are in the Deutsches Zentrum für Marine Biodiversitätsforschung (Forschungsinstitut Senckenberg, Wilhelmshaven, Germany).

A



B

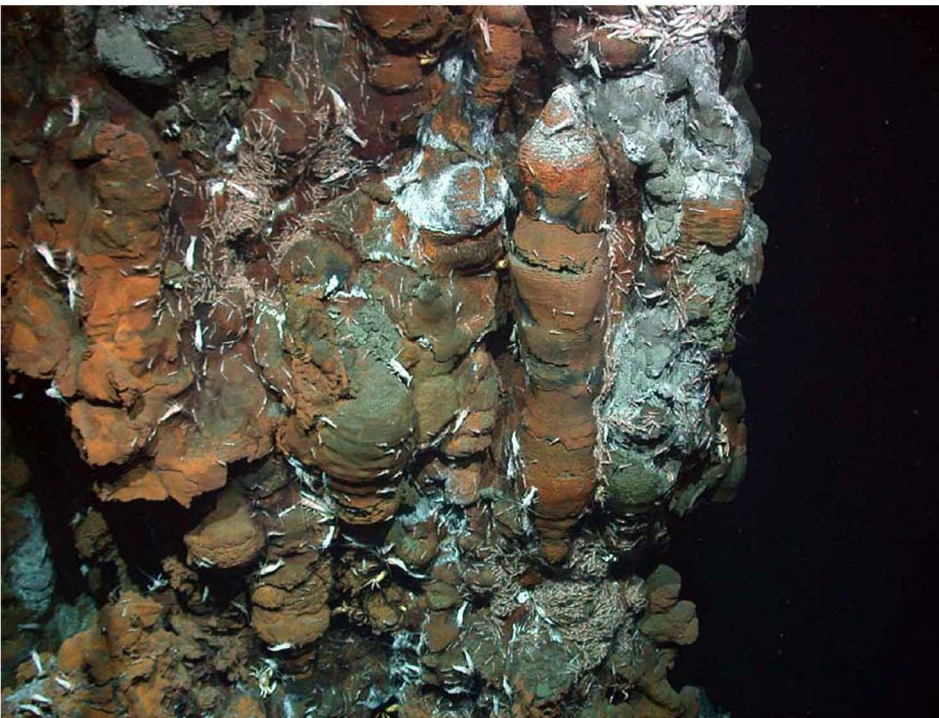


FIGURE 1. Mid-Atlantic Ridge: A, Logachev hydrothermal field at 14°N, IRINA II site, musselbed of *Bathymodiolus puteoserpentis*, at the southwest from the smoker-complex; B, Turtle Pits hydrothermal site at 5°S, active chimney “Tower” with alvinocaridid shrimps of different size. (Photos courtesy by MARUM© 2005, University of Bremen.)

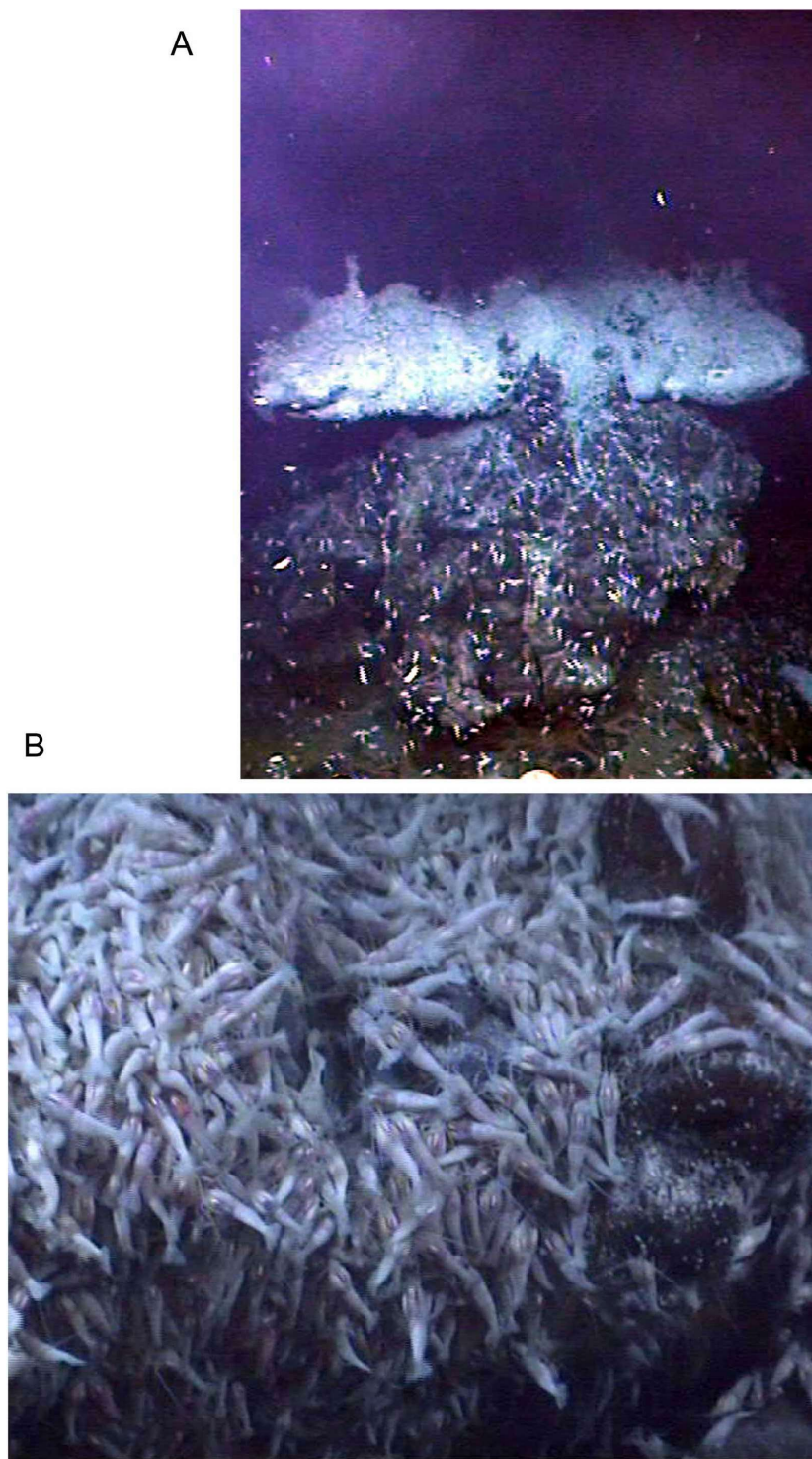


FIGURE 2. Mid-Atlantic Ridge, Red Lion hydrothermal site at 5°S: A, active chimney "Shrimps Farm", white spots=swimming shrimps; B, aggregation of alvinocaridid shrimps (*Rimicaris* sp.) on the chimney "Shrimps Farm". (Photos courtesy by MARUM© 2005, University of Bremen.)

Description**Siphonostomatoida Burmeister, 1835****Dirivultidae Humes and Dojiri, 1980*****Stygiopontius* Humes, 1987*****Stygiopontius lomonosovi* Ivanenko and Martínez Arbizu, new species**

Figs 3–9

Type material. Dissected holotype ♀ mounted on 3 slides (SMF 31035), dissected allotype ♂ mounted on 5 slides (SMF 31036), 2 paratype ♀♀ mounted on 2 slides (SMF 31037 and SMF 31038), and 1 paratype ♂ mounted on 1 slide (SMF 31039).

Type locality. Mid-Atlantic Ridge, Logachev-1 hydrothermal field, IRINA II site, station 35-GTV, 14°45.19'N, 44°58.75'W, depth 3019 m. Periphery of the smoker complex covered by *Bathymodiolus puteoserpentis* (Fig. 1A). Collected 25 January 2004.

Etymology. The specific epithet is derived from the family name of the outstanding Russian scientist Michail V. Lomonosov (1711–1765), one of the founders of the Moscow State University established in 1755. It is the Latinized, masculine, genitive form of Lomonosov.

Female holotype. Body (Fig. 3A) with broad flattened prosome. Total length, excluding caudal setae, 0.93 mm, greatest width 0.50 mm. Prosome with ventrolateral folds as shown for male in Fig. 7B. Urosome (Fig. 3B) 5-segmented, consisting of fifth pedigerous somite, genital double-somite and 3 postgenital somites. First somite of urosome trapezoidal in dorsal view. Lateral expansions in anterior part of genital double-somite with dorsolateral genital fields bearing small seta (Fig. 3B–C). Posteroventral margin of the genital double-somite with lateral spiniform processes (Fig. 3B & D). Anal opening near posterior margin of the last abdominal somite (Fig. 3E).

Rostrum weakly developed, oral cone short and robust as in male (Fig. 7B).

Caudal ramus (Fig. 3B, E & F) short, with 6 setae, outermost terminal seta smooth, innermost terminal seta with setules on inner side (2 dorsal setae lost in holotype).

Antennule (Fig. 4A) 12-segmented: first segment with 1 seta; second segment the longest, with 14 unequal setae; segment 3 subdivided, with 10 unequal setae, 2 setae very small; segment 4 short with 2 setae; segment 5 double, with 4 (2 pairs) of setae; segments 6–9 each with 2 setae, 1 seta near the middle, and another seta near the distal edge; segment 10 with 2 setae and 1 aesthetasc near the distal edge; segment 11 bearing six setae; segment 12 with 8 setae. All setae, except distal seta of segment 5, smooth.

Antenna (Fig. 4B): small coxa without ornamentation, elongate basis with setules on outer and inner margins. Exopod small, 1-segmented, with 3 smooth setae. Endopod 2-segmented; segment 1 elongate and unarmed, with setules on outer and inner margins;

segment 2 short, ornamented with setules, armed with 5 setae: 4 terminal setae (3 elongate of different lengths and 1 short) and 1 short subterminal seta.

Mandible (Fig. 4C): gnathobase stylet-like and flattened; terminal teeth of unequal size, proximoventral margin with a row of small teeth.

Maxillule (Fig. 4D–E): inner lobe with a row of slender setules on inner margin and 5 terminal setae, 1 short and 4 long; outer lobe articulate, with 3 long, terminal and 1 short, subterminal setae. All long setae ornamented with setules of different lengths.

Maxilla (Fig. 5A) 2-segmented: segment 1 wide; segment 2 elongate, with flattened spoon-like tip ornamented with setules. Long inner seta near juncture of segments; its distal part ornamented with setules.

Maxilliped (Fig. 5B): syncoxa with 1 long, inner, bipinnate seta; basis with shorter, inner seta along inner margin of the segment, ornamented with spinules. Endopod 3-segmented: segment 1 with 2 short, posterior setae; segment 2 with 1 long, posterior seta ornamented with spinules; segment 3 bearing 2 terminal setae with setules on inner margin, 1 seta very long and thick.

Swimming legs 1–4 (Figs 5C–D, 6A–C) with 3-segmented rami, except for leg 4, with 2-segmented endopod. Formula for the armature of legs 1–4 in Table 1. Distal endopodal segment of legs 1–3 and distal exopodal segment of leg 3 ornamented with groups of slender posterior setules as shown in the figures. Leg 1: inner seta of basis slender and smooth; outer spine of exopodal segment 2 small and curved proximally; 1 outer spine of first exopodal segment and 3 outer spines of third ornamented with long subterminal setule; this setule absent on spines of other swimming legs. Leg 4: inner seta of exopodal segment 1 smooth in proximal part and ornamented with small setules in distal part (Fig. 6C). Intercoxal sclerites of legs 3–4 expanded. Distal exopodal segment of leg 4 with 2 outer spines.

TABLE 1. *Stygiopontius lomonosovi* n. sp., holotype ♀, armature formulae of the swimming legs 1–4. Roman numerals indicate spines, Arabic numerals, setae.

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

Leg 5 (Fig. 6D) indistinctly 2-segmented; segment 1 with 1 long outer seta; segment 2 armed with 3 setae of different lengths (lost seta arrowed).

Leg 6 (Fig. 3C) represented by a flap covering gonopores and bearing 1 small seta.

Color of living specimens unknown.

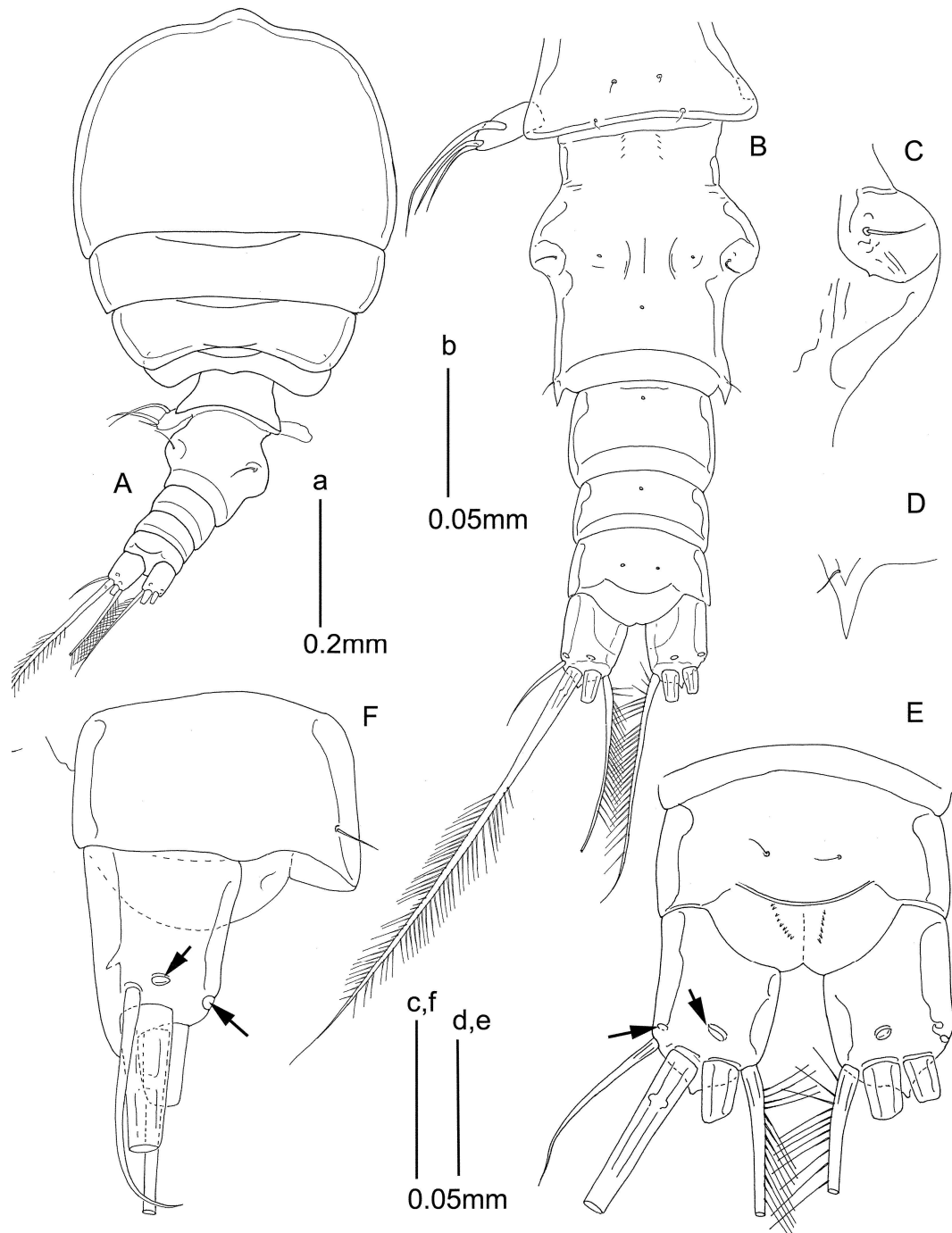


FIGURE 3. *Stygiopontius lomonosovi* n. sp., holotype ♀: A, habitus, dorsal; B, urosome, dorsal; C, right genital field, seta of right leg 6; D, ventro-lateral outgrowth near posterior edge of genital double-somite; E, anal somite and caudal rami, dorsal; F, anal somite and left caudal ramus, lateral. Arrows indicate missing setae.

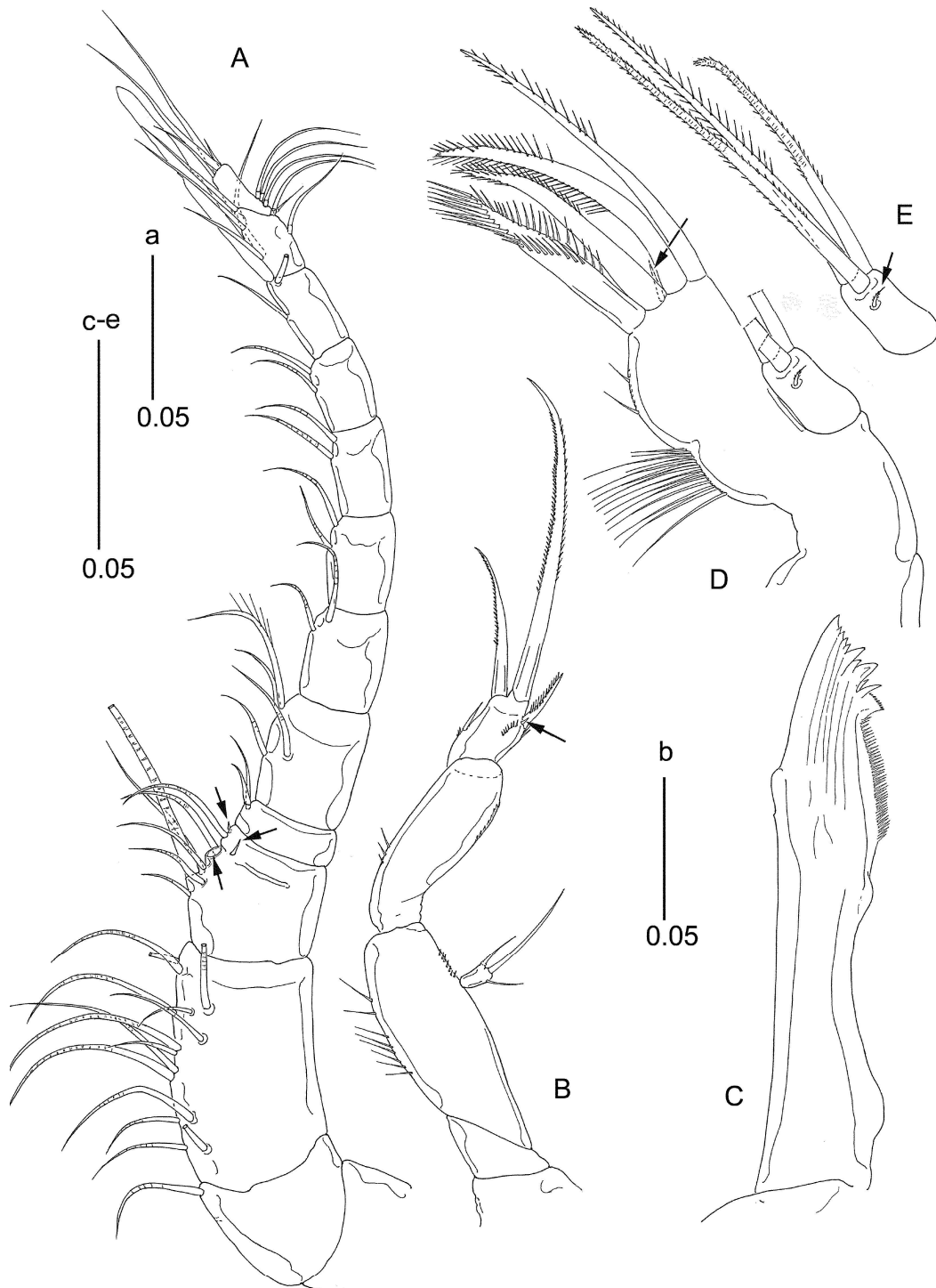


FIGURE 4. *Stygiopontius lomonosovi* n. sp., holotype ♀: A, antennule, arrows indicate 1 missing and 2 short seta; B, antenna, arrow indicates short seta; C, mandible; D, maxillule, arrow indicates short seta; E, outer lobe of maxillule, arrow indicates short seta.

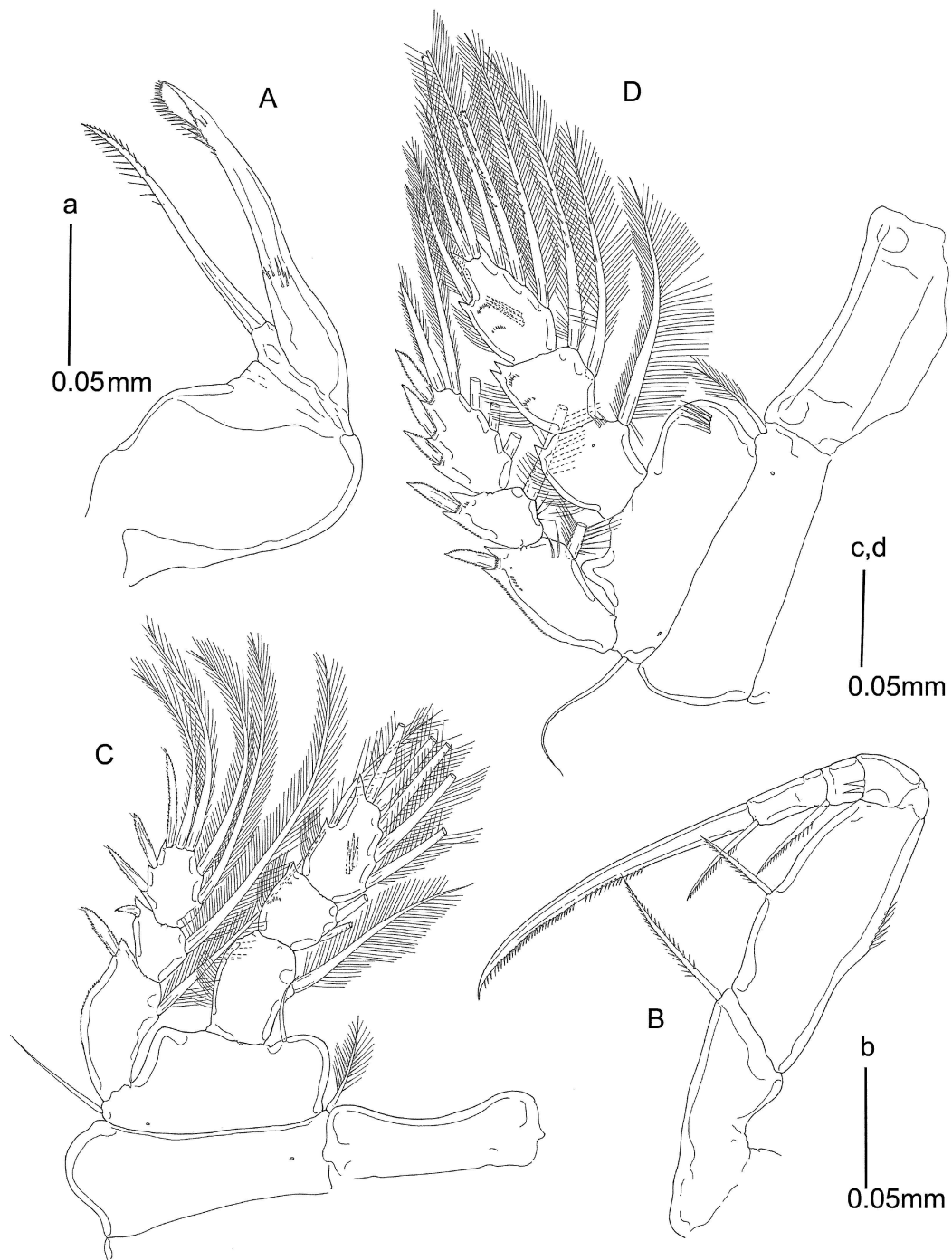


FIGURE 5. *Stygiopontius lomonosovi* n. sp., holotype ♀: A, maxilla; B, maxilliped, posterior view; C, leg 1, anterior; D, leg 2, anterior.

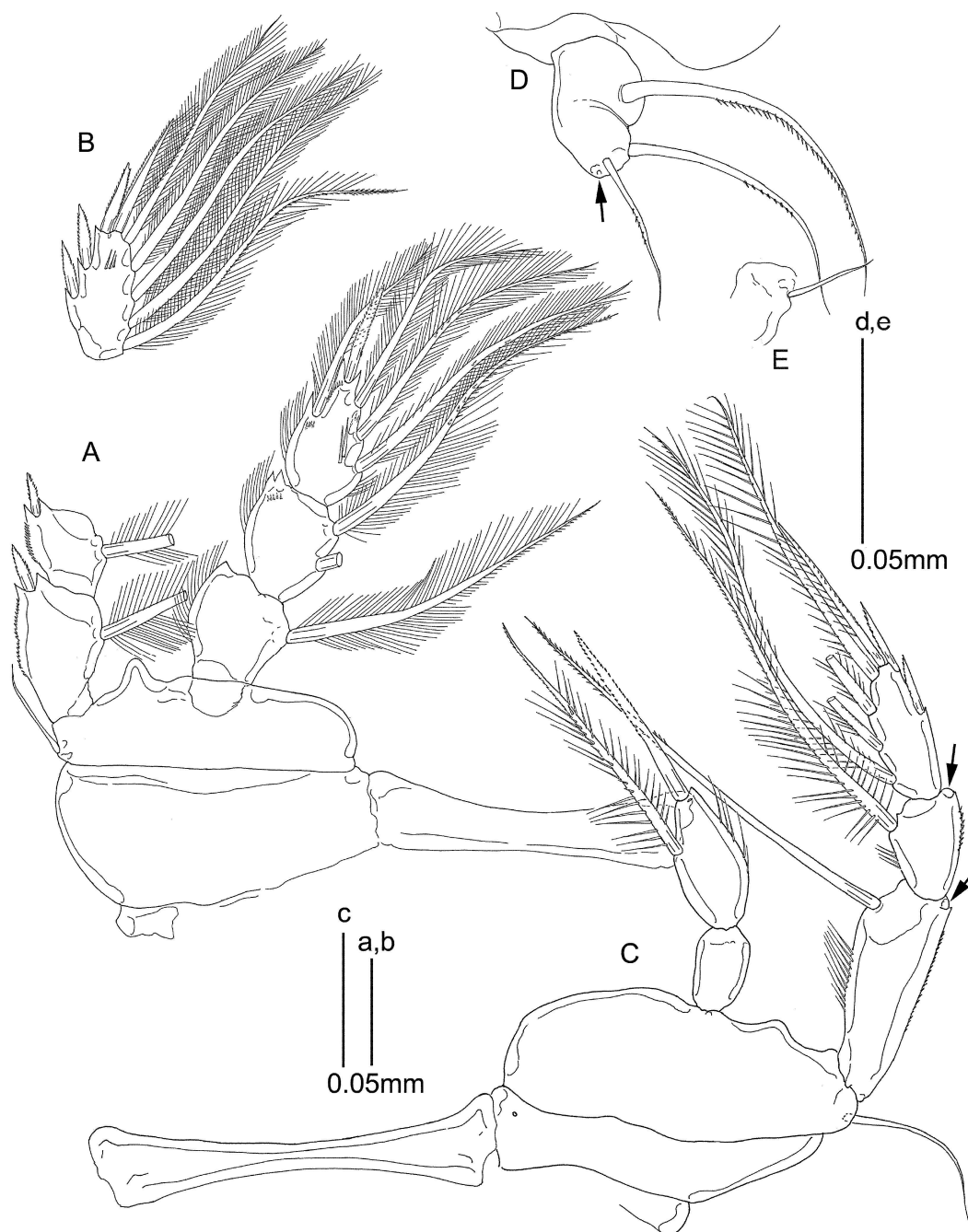


FIGURE 6. *Stygiopontius lomonosovi* n. sp., holotype ♀: A, leg 3, posterior; B, distal exopodal segment of leg 3, posterior; C, leg 4, anterior, arrows indicate missing spines; D, leg 5, left, lost seta arrowed; E, leg 6, left.

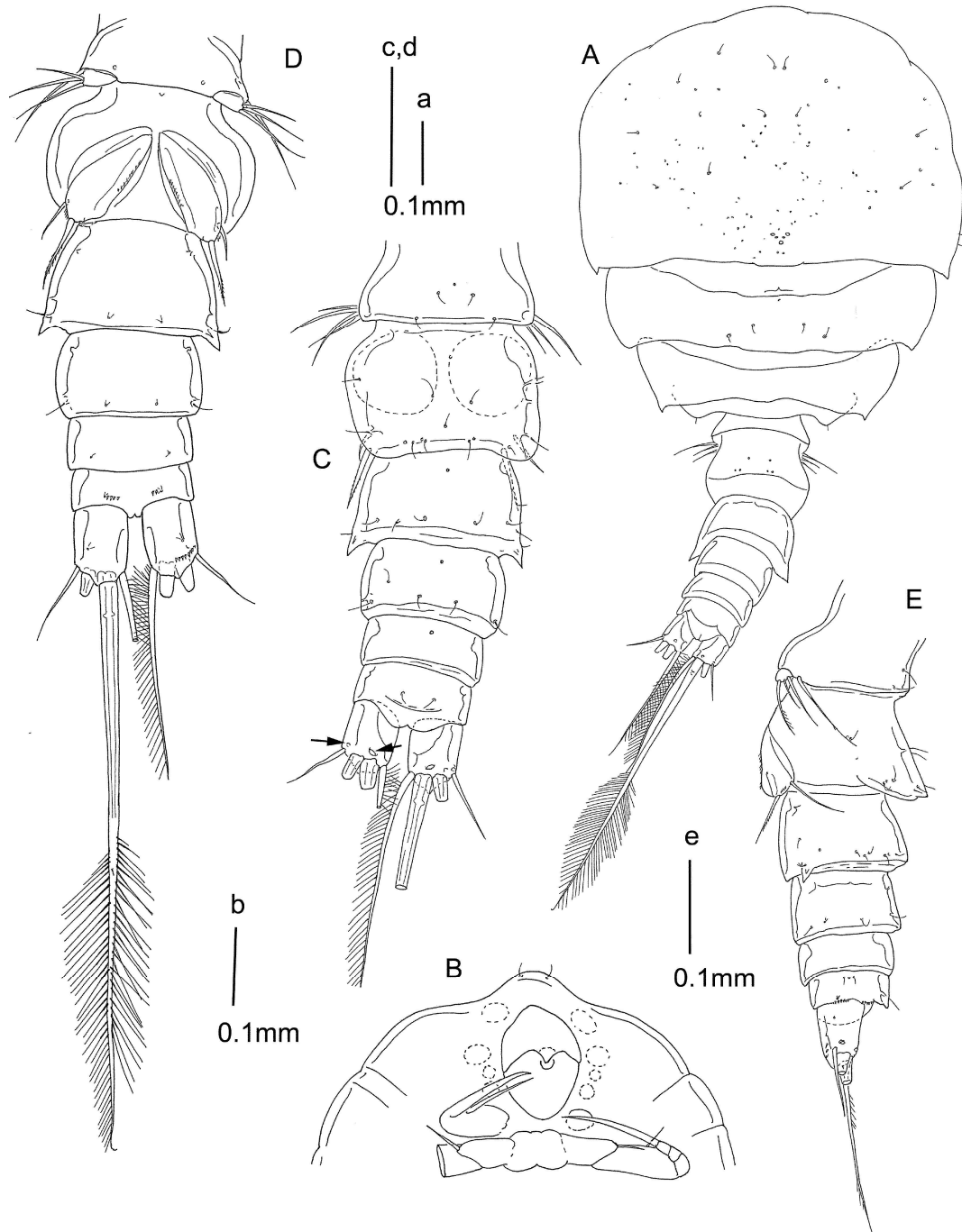


FIGURE 7. *Stygiopontius lomonosovi* n. sp., allotype ♂: A, habitus, dorsal; B, ventral view of cephalothorax, position of cephalic appendages marked by dashed circles; C, urosome, dorsal, arrow indicates missing seta; D, urosome, ventral; E, urosome, lateral.

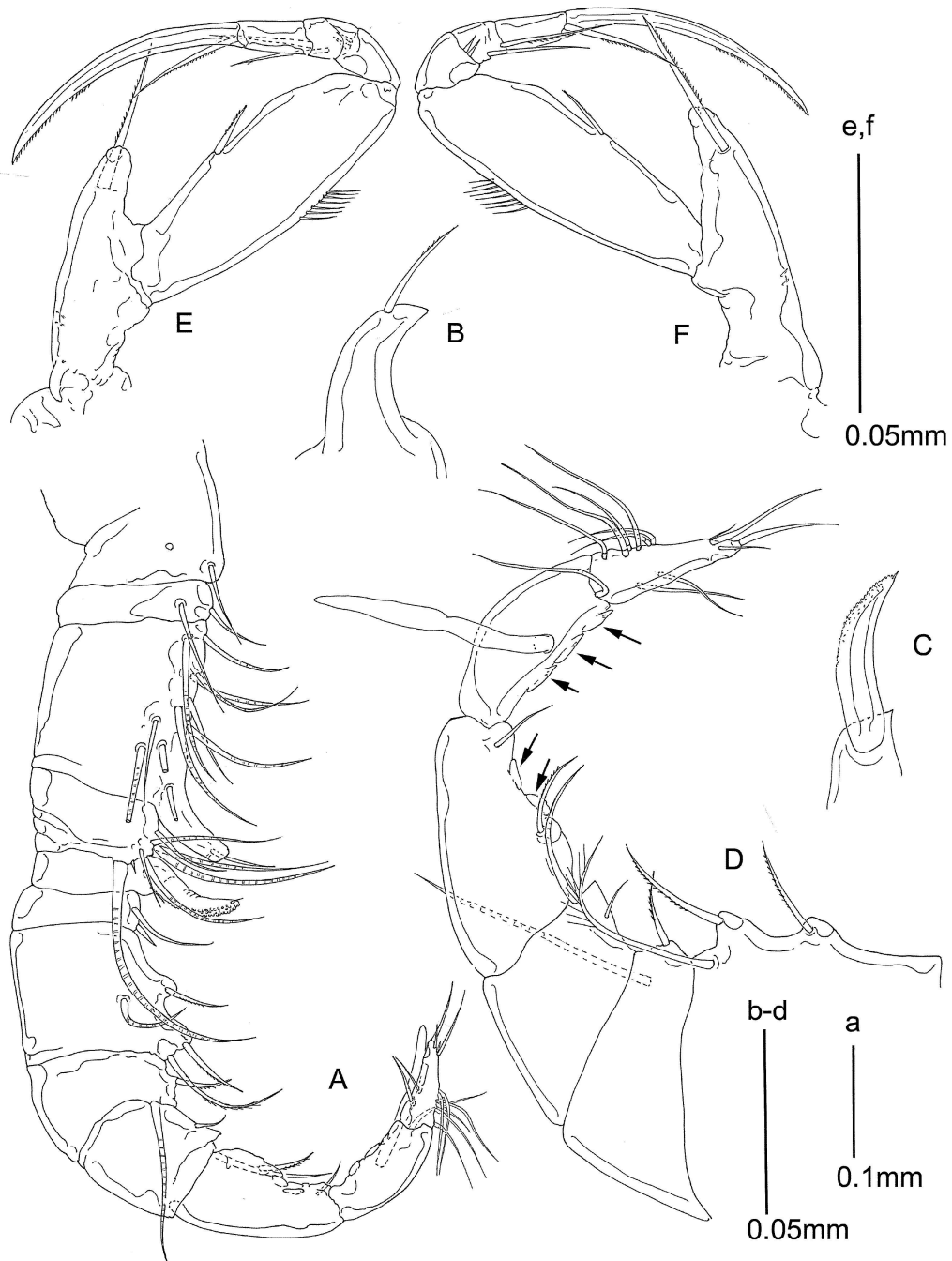


FIGURE 8. *Stygiopontius lomonosovi* n. sp., allotype ♂: A, antennule; B, antennule, outgrowth of segment 3; C, modified seta of segment 5; D, 6 distalmost segments of antennule, modified setae arrowed; E, maxilliped, anterior; F, maxilliped, posterior.

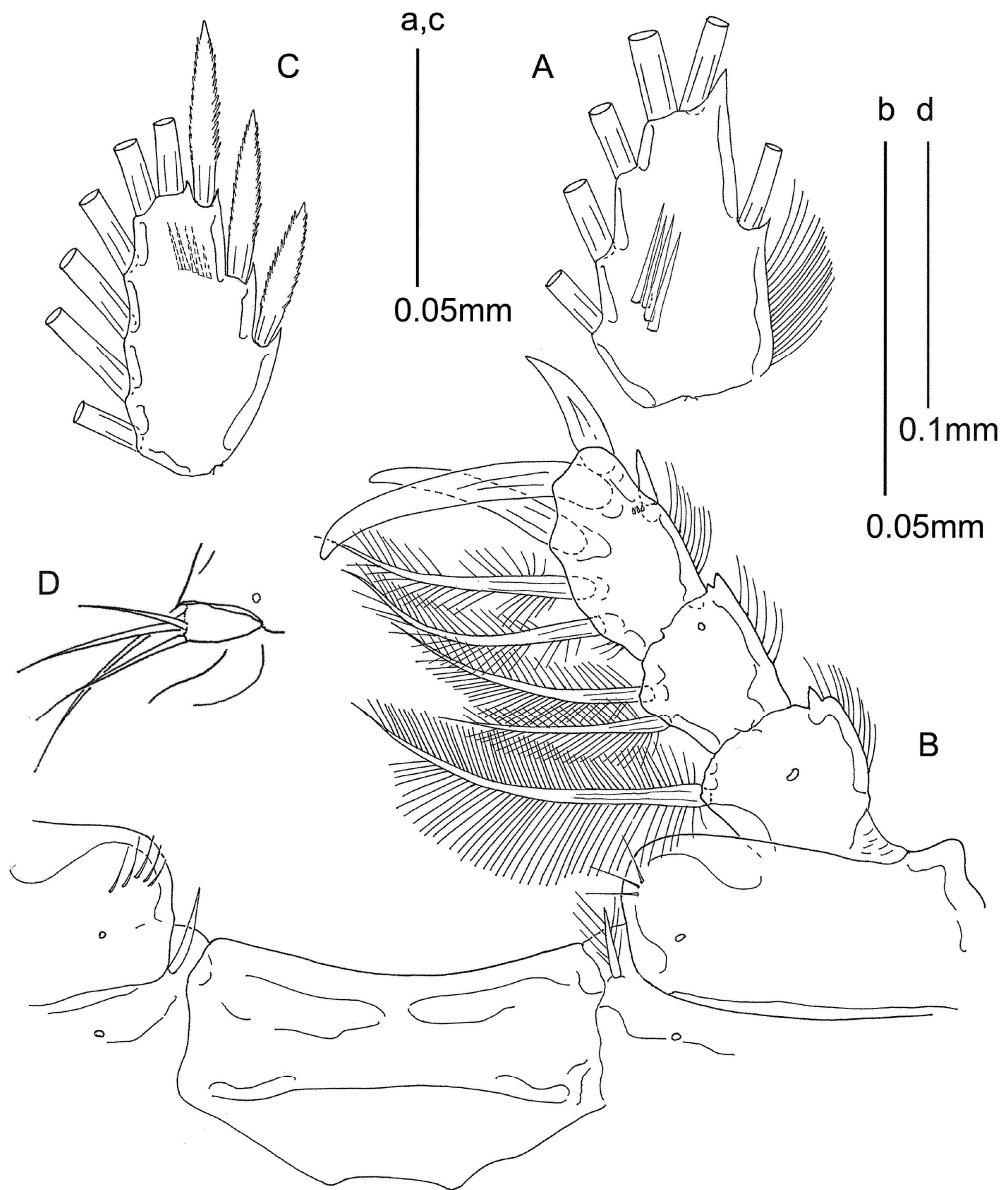


FIGURE 9. *Stygiopontius lomonosovi* n. sp., allotype ♂: A, distal endopodal segment of leg 1, posterior; B, endopod, inner margin of coxa and basis, intercoxal sclerite of leg 2, anterior; C, distal exopodal segment of leg 3, anterior; D, leg 5, ventral.

Egg sacs not observed.

Male allotype. Differs from female as follows:

Body (Fig. 7A–B): total length of allotype, excluding caudal setae, 1.03 mm, greatest width 0.56 mm. Shield of cephalothorax and tergites of 2 anterior metasomites with small pointed posterolateral processes, also present in female, but not visible in dorsal view.

Urosome (Fig. 7C–E) 6-segmented, consisting of fifth pedigerous somite, genital somite, and 4 postgenital somites. Genital somite with pair of posterior genital flaps on ventral side (Fig. 7D) and posterodorsal prominence visible from lateral view (Fig. 7E). First abdominal somite corresponding to abdominal somite included in the female genital double-somite and possessing posterolateral spiniform processes.

Antennule (Fig. 8A–D) 12-segmented, geniculate between segments 10 and 11; formula of setation as follows: 1, 2, 12, 8, 2, 2, 4, 2, 2, 4, 4+aesthetasc, 12. Segments 2 and 3 correspond to segment 2 of female antennule. Distal part of segment 3 with long curved process bearing subterminal seta (Fig. 8B). Segment 4 with 3 incomplete arthrodistal membranes indicating a segment complex. Segment 5 with ventral process and curved stout spine on it (Fig. 8C). Two setae on segment 10 and 3 setae of segment 11 modified to short flattened element (Fig. 8D, arrowed).

Maxilliped (Fig. 8E–F). Syncoxa prolonged medioventrally into terminal clawlike process with subterminal barbed seta. Inner seta of basis shorter than that of female. Segment 2 of endopod with 2 posterior setae, 1 distal and 1 middle (the last is absent in female).

Distal endopodal segment of leg 1 (Fig. 9A) and distal exopodal segment of leg 3 (Fig. 9C) with group of slender posterior setules. Leg 2 (Fig. 9B): distal endopodal segment of leg 2 with 1 outer, 2 terminal, and 1 distomedial spine (formula I,II,I,2), outermost terminal spine curved inwardly; coxal seta short.

Leg 5 (Figs 7D, 9D) located ventrally. Basis fused with somite represented by 1 outer seta, exopodal segment articulate, armed with 3 setae.

Leg 6 (Fig. 7D–E) represented by genital flap bearing 2 long posterior setae.

Colour unknown.

Remarks. *Stygiopontius lomonosovi* **n. sp.** can be easily assigned to the genus *Stygiopontius* by the combination of the following characters: the endopod of leg 1 is 3-segmented; the endopod of leg 4 is 2-segmented, its first segment unarmed and its second segment with two setae (one terminal and one inner) (Ivanenko & Ferrari 2003). The new species is similar to *S. mirus* Humes, 1996 and *S. latulus* Humes, 1996 (described from the Snake Pit (23°N) of the MAR) sharing with the new species the unusual medioventrally prolonged syncoxa of the maxilliped. The new species can be distinguished from both *S. mirus* and *S. latulus* by the absence of one spine on the distal exopodal segment of leg 4: armature formula II,I,4, instead of III,I,4 as found in *S. mirus* and *S. latulus*. Five other congeners possess only two outer spines on the third exopodal segment of leg 4, viz. *S. cinctiger* Humes, 1987; *S. mucroniferus* Humes, 1987; *S. teres* Humes, 1996; *S. rimivagus* Humes, 1997; *S. verruculatus* Humes 1987. In this group, only females are known for the first three species and only males are described for the last two species. The following attributes distinguish these species from *S. lomonosovi* **n. sp.**: the maxilliped of *S. rimivagus* and *S. verruculatus* lacks an elongation of the syncoxa; leg 5 of *S. teres* is short and 1-segmented, its prosome moderately slender; the coxa and basis of maxilliped of *S.*

mucroniferus are armed with a stout seta; the second abdominal somite of *S. cinctiger* is shorter.

Males of 12 valid species included in the genus *Stygiopontius* have been described so far. Only males of *S. lomonosovi* sp. n. and five other species (*S. mirus*, *S. latulus*, *S. brevispina* Humes, 1991, *S. lauensis* Humes, 1991, and *S. rimivagus*) were recorded in the Lau Basin of the West Pacific and the MAR. They are characterized by reduction of two inner setae on the exopod of leg 5 (the segment is fused with the sixth thoracic somite in *S. latulus*). The exopod is armed with three setae instead of a maximum of five setae present in males of congeners. Further investigations of unknown males of dirivultid species are necessary to clarify if the reduction of the setae on the exopod of leg 5 can be used as a character to define a monophyletic lineage of *Stygiopontius* distributed in both the West Pacific and the MAR.

***Stygiopontius cladarus* Humes, 1996**

Material examined. 6 ♀♀, Mid-Atlantic Ridge, Turtle Pits site, chimney "Tower", samples 123 ROV-5 and 123 ROV-6, 4°48.6'S, 12°22.4'W, depth 2992 m, washing of alvinocaridid shrimp *Rimicaris* sp., 11 April 2005 (Fig. 1B).

Differential diagnosis. Anterior part of genital double-somite swollen ventrally in anterior part. Caudal ramus subquadrate. Coxae of legs 1 and 4 without inner seta. Basis of leg 1 with mammilliform inner margin. Segment 3 of exopod of leg 4 with 3 outer spines (III,I,4). Leg 5 of female 2-segmented armed with 1 and 3 setae. Endopodal segment 3 of male leg 2 armed with 4 spines and 2 setae (formula I,II,I,2). Leg 5 of male 1-segmented, exopod bearing 5 setae.

Remarks. *S. cladarus* was previously recorded in washing of *Rimicaris* specimens from the Snake Pit site at 23°N (Humes 1996) and from plankton over a hydrothermal field of the Broken Spur field at 29°N (Ivanenko 1998).

***Stygiopontius pectinatus* Humes, 1987**

Material examined. 39 ♀♀, Mid-Atlantic Ridge, Turtle Pits site, chimney "Tower", samples 123 ROV-5 and 123 ROV-6, 4°48.6'S, 12°22.4'W, depth 2992 m, washing of alvinocaridid shrimps (*Rimicaris* sp.), 11 April 2005 (Fig. 1B). 316 ♀♀, 2 copepodids (stage 1), 3 nauplii (described by Ivanenko, Martínez Arbizu & Stecher, submitted), Mid-Atlantic Ridge, Red Lion site, chimney "Shrimps Farm", sample 146 ROV-6, 4°47.82'S, 12°22.60'W, depth 3048 m, washing of alvinocaridid shrimps (*Rimicaris* sp.) (Fig. 2A–B), 16 April 2005.

Differential diagnosis. Inner margin of claw of both antenna and maxilliped pectinate. Segment 3 of exopod of leg 4 with 3 outer spines (formula III,I,4). Segment 2 of endopod

of leg 4 with short terminal spine (armature formula of the segment I,1).

Remarks. *S. pectinatus* is a widespread species with females reported from three hydrothermal vent fields of the MAR and one site of the Mariana Back-Arc Basin (West Pacific); males are unknown. The females were found in the branchial chambers and in washings of alvinocaridid shrimps (*Rimicaris exoculata* and *Chorocaris chacei*) from TAG at 26°N and Snake Pit at 23°N (Humes 1987; Humes 1996). They were also found in plankton over Broken Spur at 29°N (Ivanenko 1998) and in washings of tubes of the polychaete *Alvinella pompejana* from the Marianna Back-Arc Basin (Humes 1990a).

Our observation of the alvinocaridid shrimps collected at 5°S and the oral cone and the swimming legs of *S. pectinatus* collected on these shrimps supports the suggestion of Humes (1996) that females of this dirivultid live in the shrimps' branchial chamber and feed on chemoautotrophic bacteria growing on the shrimp's feeding appendages and the inner surface of branchial chamber (Van Dover *et al.* 1988; Segonzac *et al.* 1993; Gebruk *et al.* 2000b). It is not clear if the copepods clean the branchial chamber off fouling bacteria or utilize bacterial food of the specialized shrimps.

***Aphotopontius atlanteus* Humes, 1996**

Syn. *A. temperatus* Humes, 1997

Material examined: 2 ♀♀, Mid-Atlantic Ridge, Logachev-1 hydrothermal field, IRINA II site, sample 38 ROV-4, 14°45.19'N, 44°48.75'W, depth 3036 m, musselbed of *Bathymodiolus puteoserpentis*, southwest of smoker-complex, 26 January 2004. 27 ♀♀, sample 35 GTV, 14°45.19'N, 44°58.75'W, depth 3019 m, musselbed of *Bathymodiolus puteoserpentis* near smoker-complex, 26 January 2004 (Fig. 1A).

Differential diagnosis. Anterior part of genital double-somite laterally expanded and rounded. Caudal rami with ratio 1.9:1 in female, 1.4:1 in male. Leg 1 with inner coxal seta and with rounded inner margin of basis. Endopodal segment 3 of leg 2 with 2 terminal setae (formula 1,2,3) in female and 2 terminal spines (1,II,3) in male.

Remarks. The copepods of the genus *Aphotopontius* are not known in the western Pacific, but are common in the eastern Pacific: Nine of 10 species were recorded from eight sites situated from the equator (Galapagos Rift) to the 49°N (Explorer Ridge). A second species of *Aphotopontius* from the MAR, *A. forcipatus* Humes, 1987, was described from the Explorer Ridge and later recorded from the Snake Pit on the MAR (Humes 1996), the Gorda Ridge (Humes 1990b) and the Juan de Fuca Ridge (Humes & Huys 1992). The species can be distinguished from *Aphotopontius atlanteus* by the elongate caudal ramus (ratio 5.6:1) among other attributes.

Aphotopontius atlanteus was previously recorded in many samples from Lucky Strike and Menez Gwen at 37°N (Humes 1996; Humes 1997; Humes & Segonzac 1998). *Aphotopontius temperatus* Humes, 1997 described from Lucky Strike was synonymized with *A. atlanteus* by Ivanenko and Defaye (2006b).

***Rimipontius mediospinifer* Humes, 1996**

Material examined. 2 ♀♀, Mid-Atlantic Ridge, Logachev-1 hydrothermal field, IRINA II site, sample 35-GTV, 14°45.19'N, 44°58.75'W, depth 3019 m, washing from *Bathymodiolus puteoserpentis*, 25 January 2004 (Fig. 1A).

Differential diagnosis. Dorsal surface of genital female double-somite with stout median crest ending with spiniform posterior process. Caudal rami with 5 setae, innermost terminal seta absent. Maxilla with inner sinuous seta. Endopod of leg 4 is 2-segmented and armed with 1 terminal spine (formula 0-0; I,0).

Remarks. The species is the type and only species of the genus *Rimipontius* Humes, 1996. It was previously recorded from the Logachev field (Humes & Segonzac 1998), in washings of *Rimicaris* from Snake Pit site (Humes 1996) and in plankton over the Broken Spur (Ivanenko 1998).

Conclusions

Of all previously reported species of copepods from the Mid-Atlantic Ridge (MAR) only *Rimipontius mediospinifer* Humes, 1996 was known from the Logachev field. The copepods recorded from two new sites (Turtle Pits and Red Lion) are the first ones known from the South Atlantic. The occurrence of both *Stygiopontius pectinatus* and *Stygiopontius cladarus* associated with alvinocaridid shrimps in the North Atlantic and the South Atlantic hydrothermal vents indicates a lack of a strong biogeographic barrier between two parts of the Atlantic Ocean. Further investigation of new samples from the South Atlantic is necessary to verify if a biogeographic barrier or linking stepping stones exist (Devey *et al.* 2005). A combination between barrier-systems and stepping stones is discussed by von Cosel *et al.* (1999) and Desbruyères *et al.* (2001) for distribution patterns of several dominant vent species, like *Bathymodiolus*, along the northern MAR. Hence to those zoo-biogeographic distribution patterns at least four major fraction zones would be important: the Fifteen-Twenty-Fraction-Zone separates the Logachev field from those of the northern MAR, the Vema- and Romanche-Fracture-Zone separates the Logachev field from the new sites at the southern MAR and the Ascension-Fraction-Zone at 7°S separates the vent sites at 5°S and 9°S.

The vast distribution of many species of the family Dirivultidae, which is presumably obligate on the deep-sea hydrothermal vents (see this paper and Ivanenko & Defaye 2006b), indicates that further investigation of copepod diversity, as well as combined morphological and molecular analysis of dirivultids from distinct localities, may reveal unknown patterns in geographical distribution and relationships of the deep-sea hydrothermal vent communities.

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