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New species of *Stygiopontius* (Copepoda: Siphonostomatoida: Dirivultidae) from a deep-sea hydrothermal volcano in the New Ireland Fore-Arc system (Papua New Guinea)

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A male of the new species Stygiopontius senckenbergi *belonging to the family Dirivultidae Humes & Dojiri, 1980 (Copepoda: Siphonostomatoida) and endemic to deep-sea hydrothermal vents, is described from a raised fault block structure south of Edison seamount of the New Ireland Fore-Arc system (Papua New Guinea). The copepods were collected in by box-corer during cruise SO-133 of the RV 'Sonne' at a depth of 1610–1625 m, 3°19′S 152°35′E. The new species belongs to a group of eight species that are separate from 21 congeners on the basis of setation of legs 1 and 4: the coxa of leg 1 has an inner seta (absent on the others) and the third exopodal segment of leg 4 has three outer spines (instead of two spines). The new species shares with* S. pectinatus *Humes, 1987 a pectinate maxilliped but differs from it in lacking two pectinate, terminal claw-like setae on the endopod of the antenna.*

Keywords: *Stygiopontius*, Dirivultidae, Siphonostomatoida, Copepoda, Edison seamount, New Ireland Fore-Arc, West Pacific, deep-sea

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INTRODUCTION

Dirivultidae Humes & Dojiri, 1980 (Copepoda: Siphonostomatoida) is a diverse family restricted to deep-sea hydrothermal sites of the Pacific and Atlantic Oceans (Humes & Dojiri, 1980; Humes & Segonzac, 1998; Gollner *et al.*, 2010; Ivanenko *et al.*, 2011). Among 13 genera of dirivultids, *Stygiopontius* Humes, 1987 is the most diverse and widespread genus, currently including 21 valid species. *Stygiopontius lomonosovi* Ivanenko & Martínez Arbizu, 2006 from the Logachev hydrothermal field of the Mid-Atlantic Ridge is the most recently described species of the genus (Ivanenko *et al.*, 2006). Two species, *S. lumiger* Humes, 1989 and *S. bulbisetiger* Humes, 1996, were recognized as juveniles of known species and synonymized with *S. sentifer* Humes, 1987 and *S. pectinatus* Humes, 1987, respectively (Ivanenko & Defaye, 2006; Ivanenko *et al.*, 2011). The lecithotrophic nauplius of *Stygiopontius pectinatus* Humes, 1987 from specimens associated with alvinocaridid shrimps from the southern Mid-Atlantic Ridge was described (Ivanenko *et al.*, 2007). Studies of DNA diversity (partial cytochrome c oxidase subunit I) of *S. hispidulus* Humes, 1987, *S. lauensis* Humes, 1991, and *S. brevispina* Humes, 1991 from different geographical areas have shown small molecular distinctions and support the morphological divergence among the species (Gollner *et al.*, 2011).

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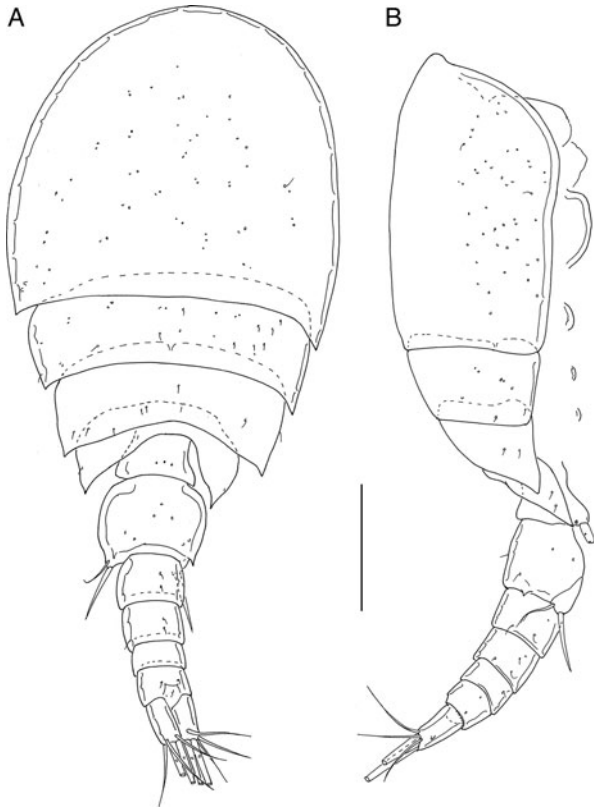

Fig. 1. *Stygiopontius senckenbergi* sp. nov., holotype ♂: (A) habitus, dorsal; (B) habitus, lateral. Scale bar: 0.2 mm.

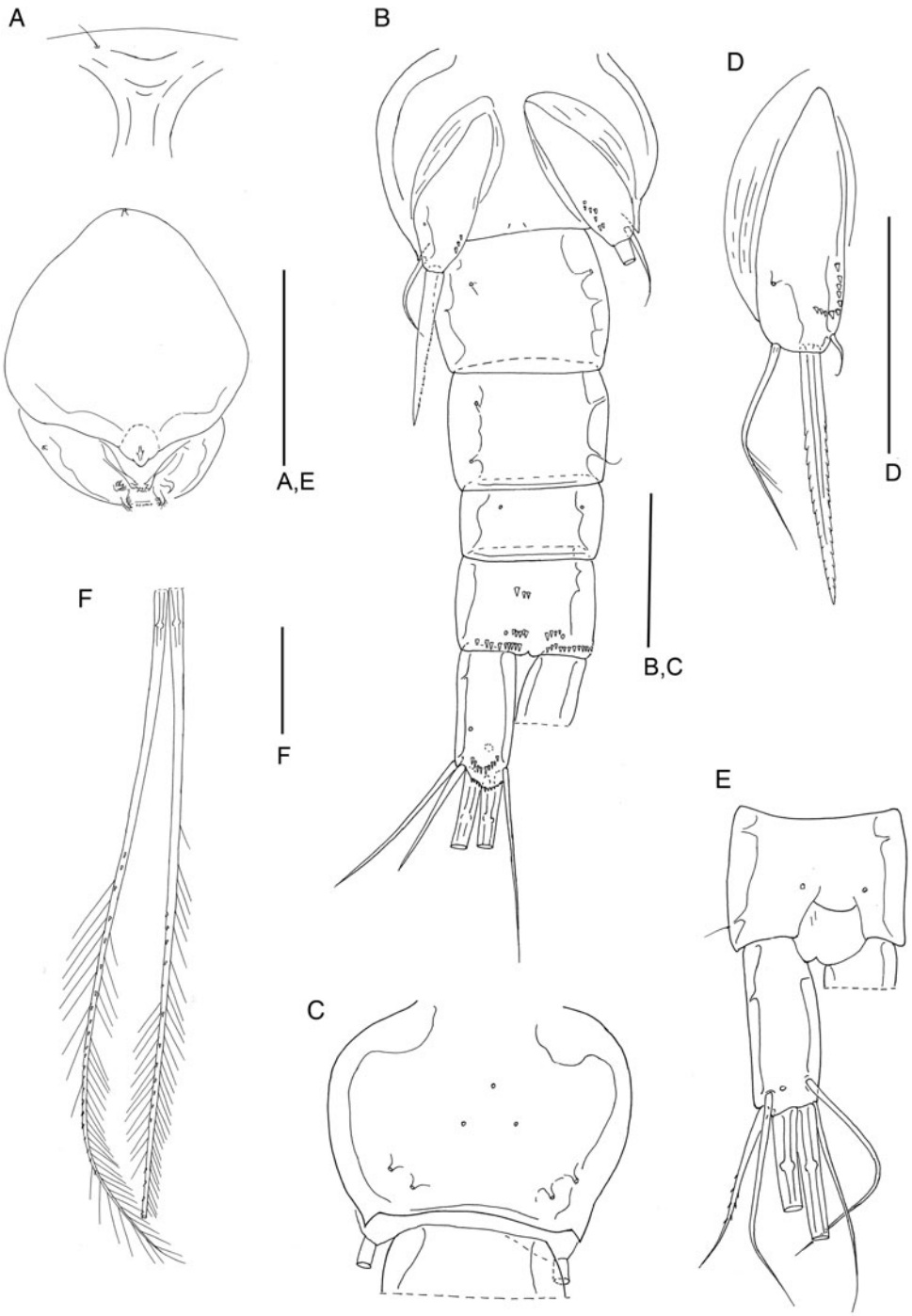

Fig. 2. *Stygiopontius senckenbergi* sp. nov., holotype ♂: (A) rostral area and oral cone, ventral; (B) genital and abdominal somites, caudal ramus, ventral; (C) genital somite, dorsal; (D) right genital flap (leg 6), ventral; (E) anal somite and left caudal ramus, dorsolateral; (F) median terminal setae of caudal ramus, ventral. Scale bar: 0.05 mm.

This paper describes males of a new species of *Stygiopontius* and supports previous studies of the diversity of the type genus *Dirivultus* Humes, 1980 associated with vestimentiferan worms, as well as harpacticoid diversity from the Edison seamount (Humes, 1999; Willen, 2004, 2006).

MATERIALS AND METHODS

The material was collected by box corer at a raised fault block structure, or horst, south of Edison seamount in the New Ireland Fore-Arc system (Papua New Guinea) during cruise SO-133 (20 July–3 August 1998) of the RV 'Sonne', depth of 1610–1625 m, 3°19′S 152°35′E. The copepods were preserved in 5% buffered formalin, rinsed in distilled water and transferred to lactic acid, and studied applying the 'hanging drop method' of Humes & Gooding (1964) as modified by Ivanenko & Defaye (2004). The copepods were dissected under a Leica MZ12 microscope and studied with a Leica DMR compound microscope having bright-field and differential interference contrast optics. Drawings were made with a camera lucida mounted on the microscope. For long-term

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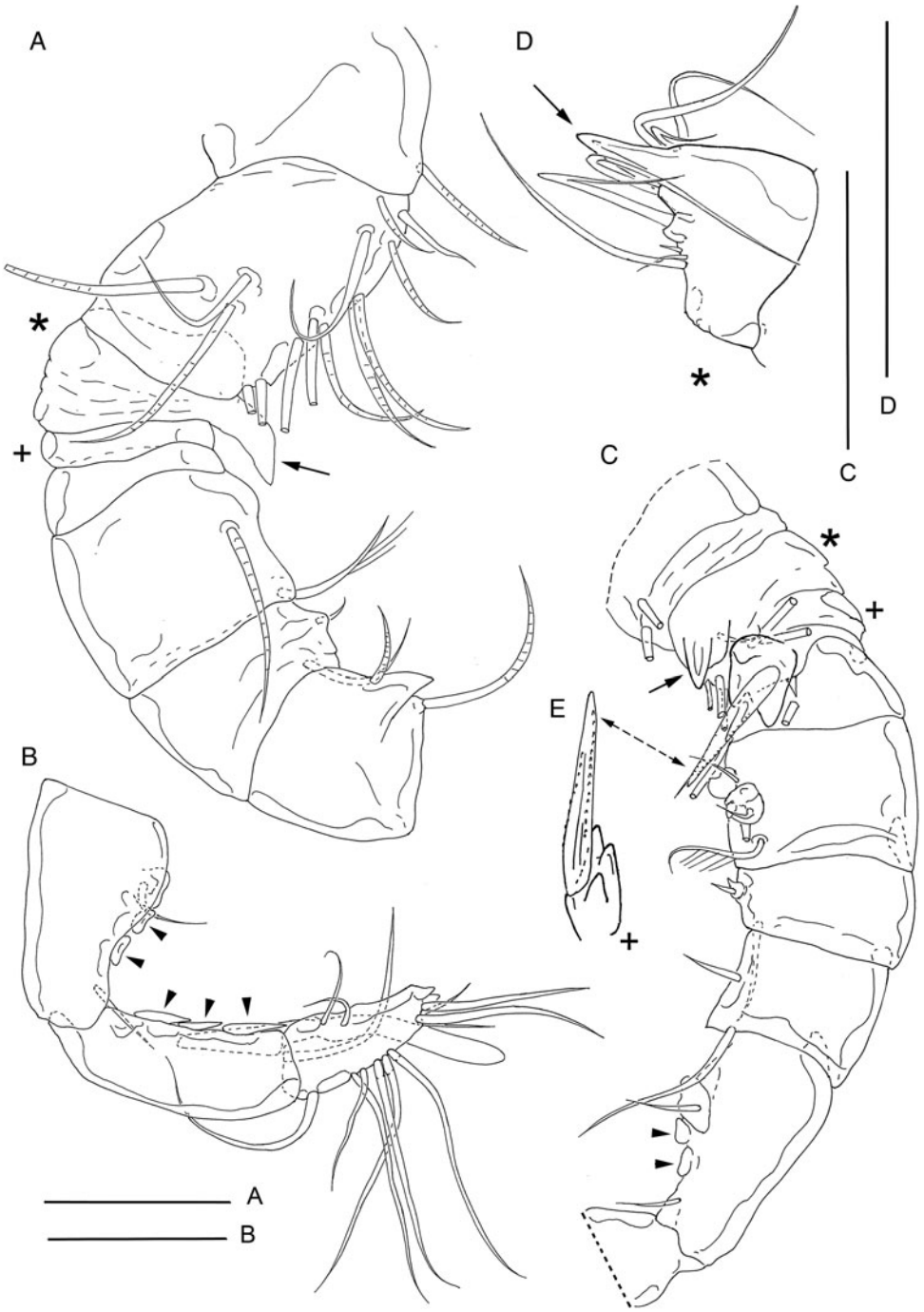

Fig. 3. *Stygiopontius senckenbergi* sp. nov., holotype ♂: (A) proximal part of antennule, segments 1–8 (segment 3 (*) subdivided on four segments; segment 4 (+) with process armed with terminal spine shown on figures C, E); (B) distal part of antennule, segments 9–11; (C) segments 3–9 of antennule, anterior; (D) segments 3 of antennule, ventral; (E) outgrowth of segment 3. Scale bars: A, B, 0.03 mm; C, D, 0.05 mm.

preservation, the dissected copepods were mounted on slides in glycerol and sealed with paraffin. The material is deposited in the collection of the Senckenberg Museum, Frankfurt am Main, Germany (SMF).

RESULTS

SYSTEMATICS

SIPHONOSTOMATOIDA Burmeister, 1835
DIRIVULTIDAE Humes & Dojiri, 1980
Stygiopontius Humes, 1987

Stygiopontius senckenbergi sp. nov.
(Figures 1–7)

TYPE MATERIAL

Holotype: dissected ♂ mounted on three slides (SMF 37052/1-3), Edison seamount, Station 59, vicinity of 'mussel cliff' at horst structure south of the seamount, 3°19.357′S 152°35.346′E, depth 1625 m, 27 July 1998.

Paratype: dissected ♂ mounted on one slide (SMF 37053/1), Edison seamount, Station 57, horst structure south of the seamount, 3°19.369′S 152°35.312′E, depth 1610 m, 27 July 1998.

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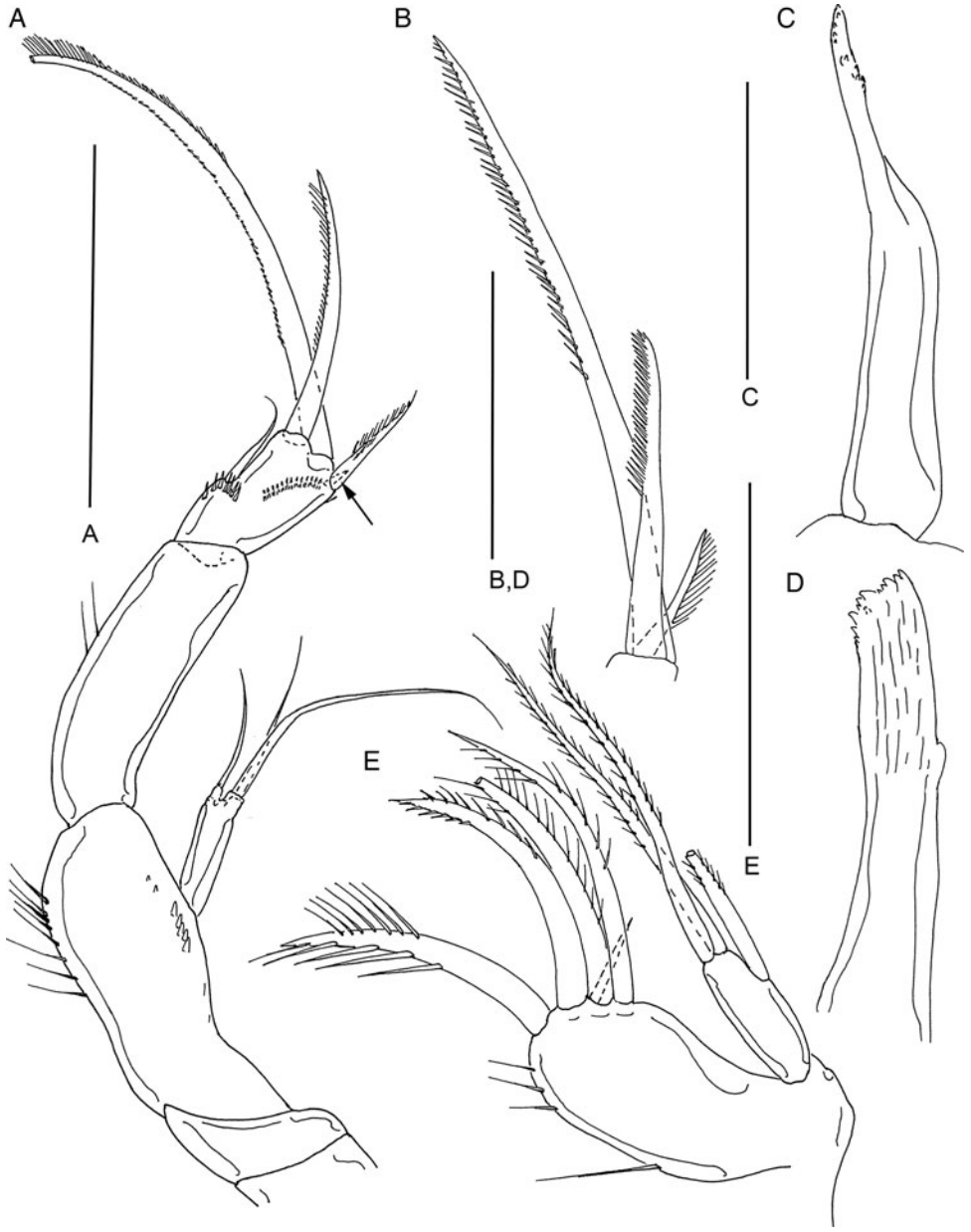

Fig. 4. *Stygiopontius senckenbergi* sp. nov., holotype ♂: (A) antenna; (B) terminal 3 setae of antennal endopod (short seta not shown); (C) mandible; (D) distal part of mandibular gnathobase, lateral; (E) maxillule. Scale bar: 0.05 mm.

ETYMOLOGY

The specific epithet is derived from the name of the Senckenberg Museum, the research institute and the museum of natural history. Gender masculine.

Holotype male: body (Figure 1), total length, excluding caudal setae, 1.11 mm, greatest width 0.49 mm. Body and appendages with sclerotized cuticle. Prosome 4-segmented, with ovoid anterior half, consisting of cephalothorax and three somite bearing swimming legs 2–4, posterior corners of epimeres pointed. Urosome (Figures 1A & 2B–E) 6-segmented, consisting of fifth pedigerous somite, genital somite, and four abdominal somites. First somite of urosome trapezoidal in dorsal view, with rounded posterior corners. Genital somite with pair of posterior genital flaps on ventral side. Anal opening (Figure 2E) on dorsal side, near the middle of somite.

Rostrum (Figure 2A) a slight ventral process.

Oral cone (Figure 2A): labrum robust, with pointed distal part; labium short, with notch on distal edge bearing curved barbed protuberances.

Caudal ramus (Figure 2E, F) 2.3 times longer than wide, armed with six setae of different lengths, innermost terminal seta and two dorsal setae smooth, two terminal setae with lateral setules and ventral scales.

Antennule (Figure 3) 11-segmented, geniculate between segments 9 and 10; formula of setation as follows: 1, 14, 8, 2, 2, 4, 2, 2, 4, 4 + aesthetasc, 12. Segment 3 (marked by *) with incomplete arthrodial membranes and ventro-distal process (indicated by one-sided arrow); 2 of 8 setae small (Figure 3D). Segment 4 (marked by +) with tricrotic ventral process and a stout barbed spine on it (Figure 3E) (indicated by double-sided arrow); second very small ventral seta near articulation with segments 3 and 4. Two setae on segment 9 and three setae of segment 10 modified to short flattened element.

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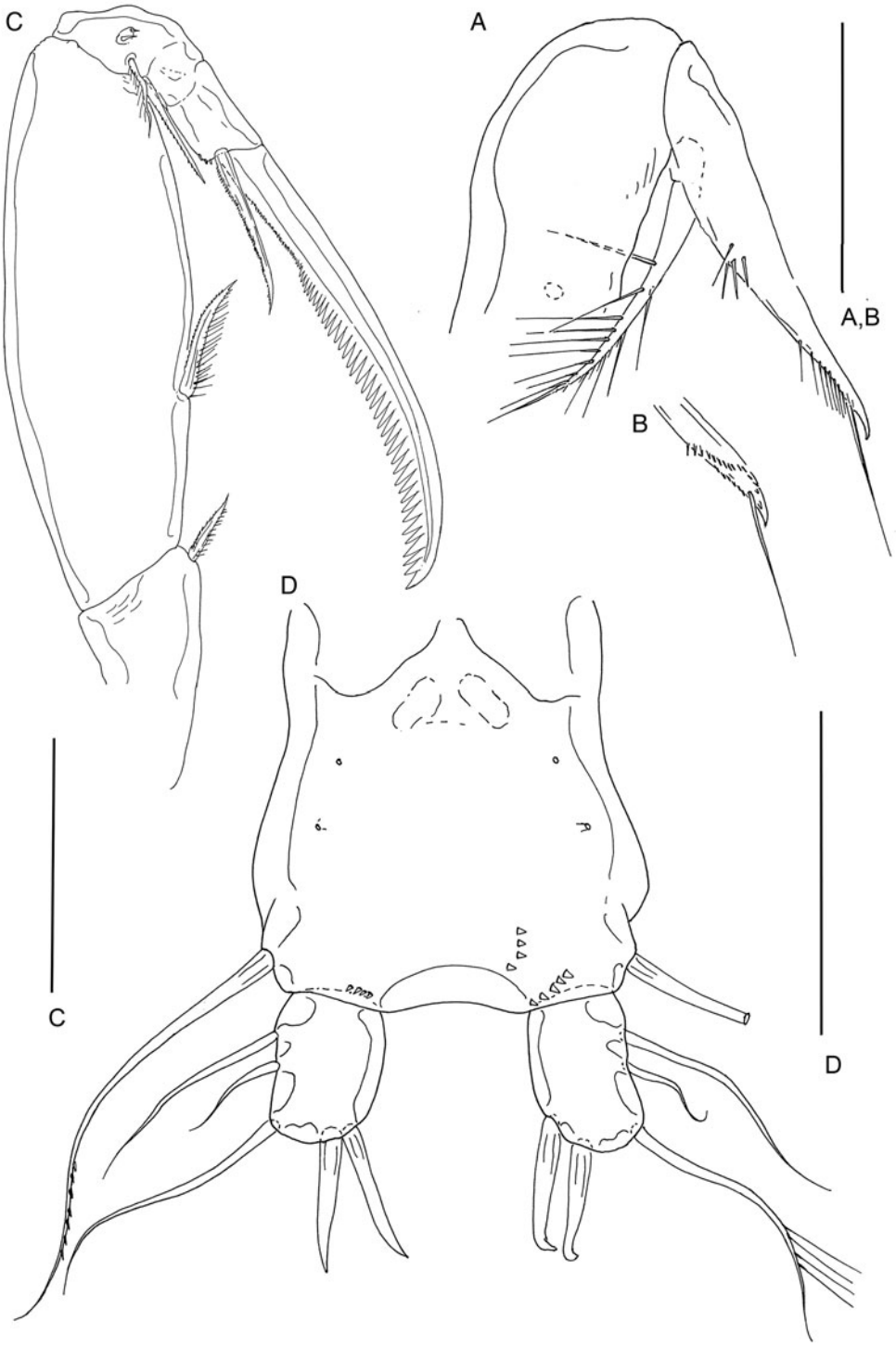

Fig. 5. *Stygiopontius senckenbergi* sp. nov., holotype ♂: (A) right maxilla, posterior; (B) tip of distal segment of maxilla, anterior; (C) right maxilliped, posterior; (D) first somite of urosome and pair of leg 5, ventral. Scale bar: 0.05 mm.

Antenna (Figure 4A, B): small coxa without ornamentation, elongate basis with long setules on outer and short setules on inner margins. Exopod small, 18 × 6 μm, 1-segmented, with three smooth setae of different lengths: two terminal, one subterminal. Endopod 2-segmented; segment 1 unarmed, as long as basis, with long setules on outer margin; segment 2 short, ornamented with rows of short setules, armed with five setae: four terminal setae (3 setae of different lengths, ornamented with short setules from one side, one seta very short) and one short slender subterminal seta.

Mandible (Figure 4C, D): represented by elongate narrow gnathobase with flattened distal part, longitudinally ribbed on one side; tip blunted, with a row of short slightly curved teeth.

Maxillule (Figure 4E): inner lobe with a few slender setules on inner margin and five terminal setae, one short and four stout long; outer lobe shorter than inner lobe, articulate, with three long setae ornamented with short setules, two terminal and one subterminal. All long setae ornamented with setules of different lengths.

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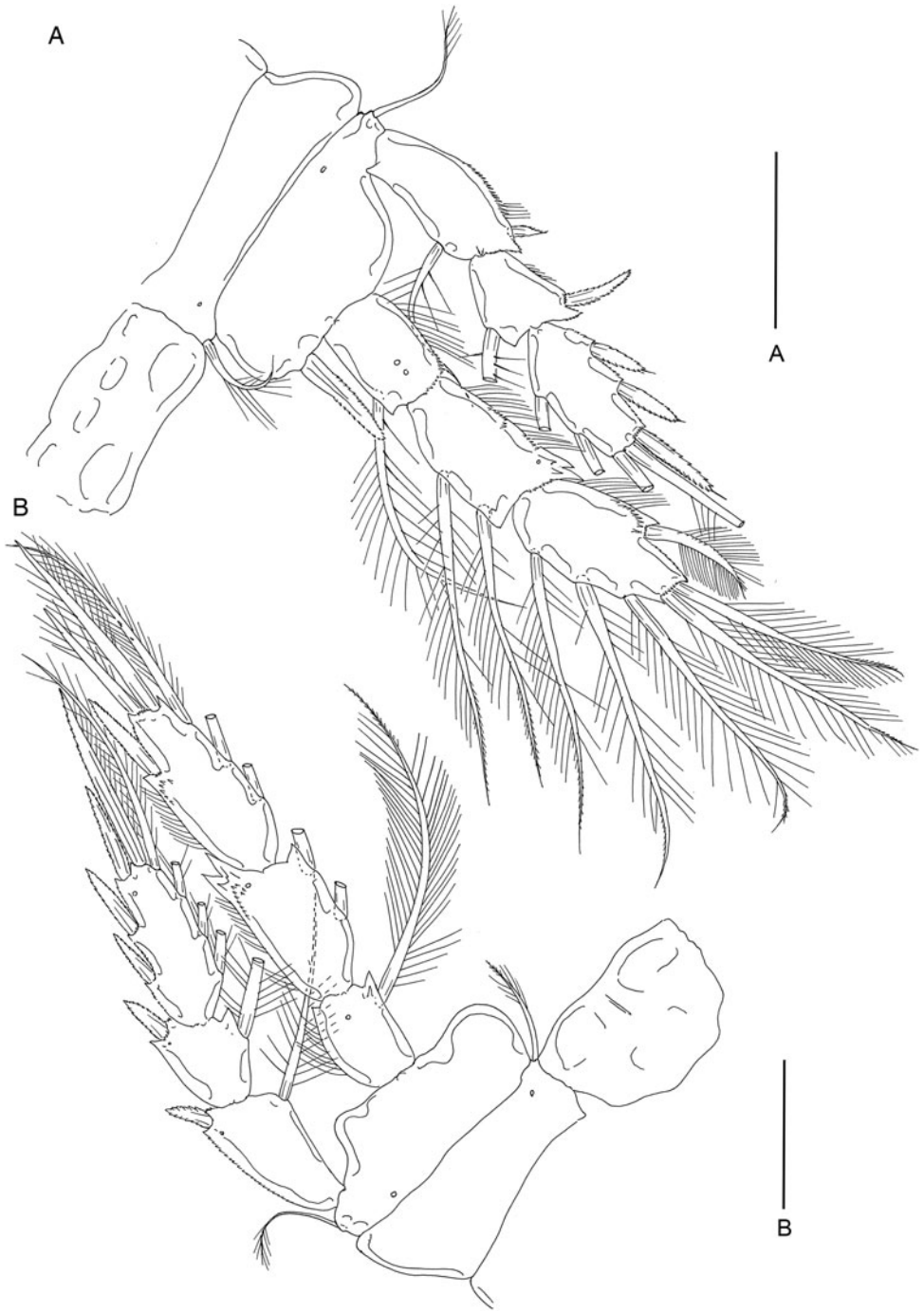

Fig. 6. *Stygiopontius senckenbergi* sp. nov., holotype ♂: (A) left swimming leg 1, anterior; (B) left swimming leg 2, anterior. Scale bar: 0.05 mm.

Maxilla (Figure 5A, B) 2-segmented: syncoxa wide, proximal part with pore; basis elongate, distal part ornamented by setules, tip pointed and slightly curved; one needle-like setula situated near the tip, elongate and pointed distally. Long inner seta near juncture of segments (representing distal lobe of coxa); its distal part ornamented from both sides with long setules.

Maxilliped (Figure 5C): syncoxa with one short inner bipinnate seta; basis with longer bipinnate inner seta. Endopod indistinctly 3-segmented: segment 1 with two very short and one long posterior setae; segment 2 with one posterior seta ornamented with spinules; segment 3 bearing one seta, and one large claw with pectinate inner margin.

Swimming legs 1–4 (Figures 6 & 7) with 3-segmented rami, except for leg 4, with 2-segmented endopod. Formula for the armature of legs 1–4 in Table 1. Leg 1: inner seta of basis

Table 1. *Stygiopontius senckenbergi* sp. nov., holotype male, armature formulae of the swimming legs 1–4. Roman numerals indicate spines, Arabic numerals, setae.

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

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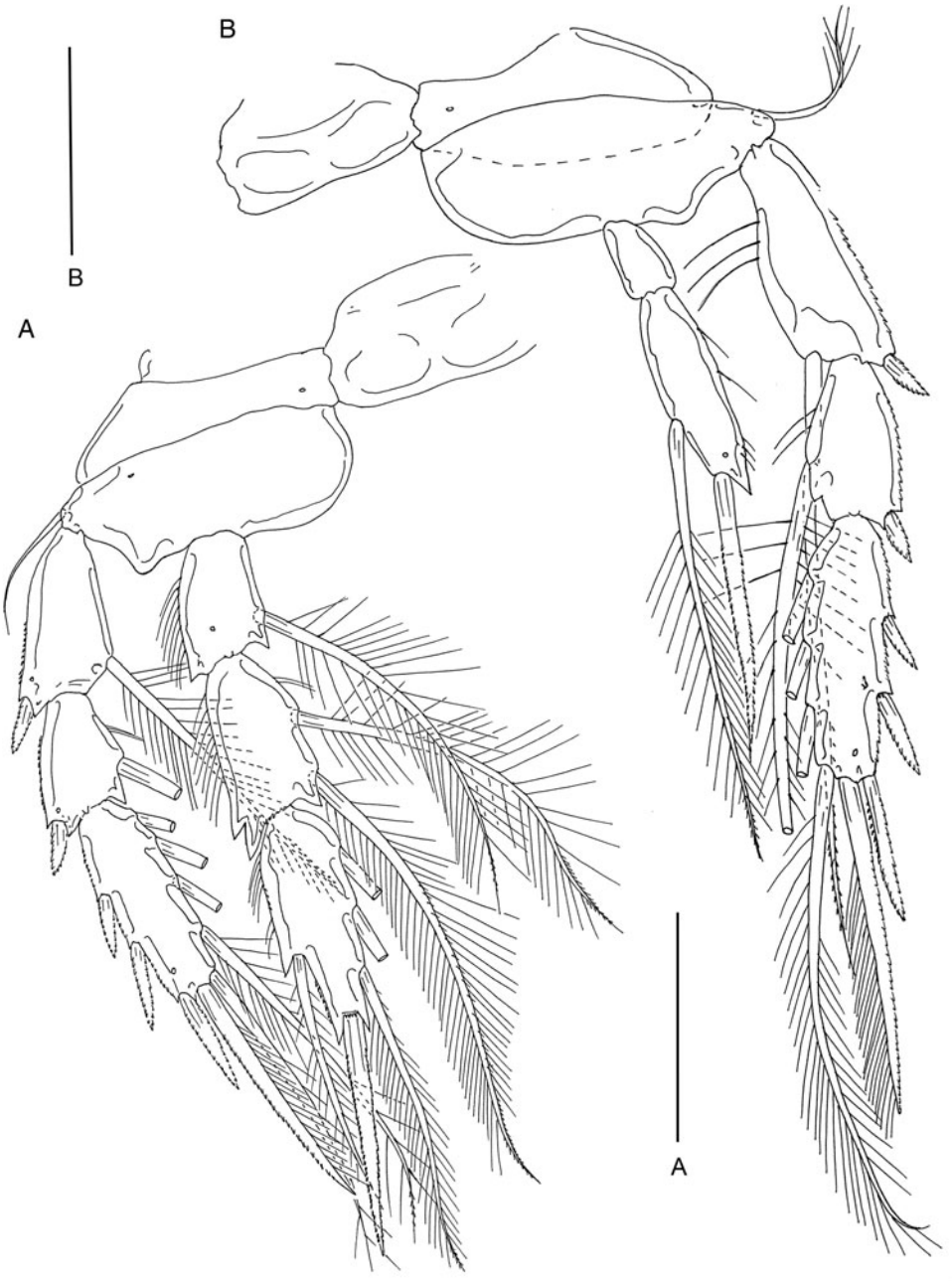

Fig. 7. *Stygiopontius senckenbergi* sp. nov., holotype ♂: A, right swimming leg 3, anterior; B, swimming left leg 4, anterior. Scale bar: 0.05 mm.

very stout. Leg 2: distal endopodal segment with one outer and two terminal spines. Leg 4: inner seta of exopodal segment 1 smooth in proximal part and with small setules in distal part; distal exopodal segment with three outer spines; second endopodal segment pointed and armed with long serrated spine.

Leg 5 (Figures 1A & 5D) located ventrally, articulating segment 1.5 times longer than wide, segment bearing five setae: two flattened and curved inner setae, one long terminal seta; and two slender outer setae of different lengths; long seta joined to segment represents protopodal segment fused with somite.

Leg 6 (Figure 2B, D) represented by genital flap bearing one long stout serrated spine reaching middle of the third abdominal somite and two smooth setae, long and small.

Colour of living specimens unknown.

Female: unknown.

REMARKS

Stygiopontius Humes, 1987 is distinguished from other genera of Dirivultidae by the combination of the following characters states: first segment of maxilla with inner sinuous seta; endopod of leg 1 3-segmented on both male and female; and leg 4 with 2-segmented endopod, its first segment unarmed, second segment is armed with terminal spine and inner seta. Like males of many genera of Dirivultidae (except *Dirivultus spinigulatus*, *Ceuthoecetes, Chasmatopontius, Nilva* and *Rhogobius*), males of *S. senckenbergi* sp. nov. possesses antennules with ventral process having a stout spine on it (see Figure 3, marked by +). The new species belongs to a group of eight species (*S. brevispina* Humes, 1991; *S. flexus* Humes, 1987, male unknown; *S. hispidulus* Humes, 1987, male unknown; *S. lauensis* Humes, 1991; *S. mirus* Humes,

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1996, female unknown; *S. pectinatus* Humes, 1987, male unknown; *S. senckenbergi* sp. nov.; and *S. sentifer* Humes, 1987, male unknown) that are separated from their remaining congeners on the basis of setation of legs 1 and 4: the coxa of leg 1 has an inner seta (absent from the others) and the third exopodal segment of leg 4 has three outer spines (instead of two outer spines). The new species shares with *S. pectinatus* Humes, 1987 (found in the Mid-Atlantic Ridge and Lau Basin) a pectinate maxilliped but differs from it in lacking two pectinate terminal claw-like setae on the endopod of the antenna. Among species of *Stygiopontius* with known males (*S. cladarus* Humes, 1996; *S. quadrispinosus* Humes, 1987; *S. regius* Humes, 1996; *S. serratus* Humes, 1996; *S. lomonosovi* Ivanenko & Martínez Arbizu, 2006; *S. rimivagus* Humes 1997; *S. verruculatus* Humes, 1987 *S. brevispina* Humes, 1991; *S. lauensis* Humes, 1991; and *S. mirus* Humes, 1996) only *S. senckenbergi* and *S. mirus* Humes, 1996 from the Mid-Atlantic Ridge possess a ventro-distal process on the third segment of the antennules (see Figure 3, marked by *). *Stygiopontius mirus* differs from *S. senckenbergi* in many details: second segment of antennules (with two setae) articulates with the following segment instead of being fused to it; first segment of maxilliped with extended ventral process; distal endopodal segment of leg 2 with four stout spines and two setae (formula I,II,I,2) instead of three stout spines and three setae (formula I,II,3); middle endopodal segment of leg 2 with two inner spines instead of two setae; and exopodal segment of leg 5 fused with somite and bearing three setae instead of articulating and having five setae.

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