

New species of *Stygiopontius* (Copepoda, Siphonostomatoida) from a deep-sea hydrothermal vent at the East Pacific Rise

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Three dirivultid copepods, *Stygiopontius paxillifer* sp.n. and *S. appositus* sp.n., unusual in having pegs along the ventral edges of the cephalosome, and *S. lumiger* sp.n., distinguished from congeners by the modified thorn-like seta on the second segment of the maxilliped, are described from a depth of 2616 m at 21°N in the eastern Pacific.

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Introduction

The collection of copepods from deep-sea hydrothermal vents and cold seeps has become possible in recent years by means of manned deep-sea submersibles. Many species of copepods (mostly Siphonostomatoida, with fewer Poecilostomatoida) have been reported from the Explorer Ridge off British Columbia, the Juan de Fuca Ridge off the coast of Washington, the Guaymas Basin in the Gulf of California, the East Pacific Rise, the Galapagos Rift, the West Florida Escarpment in the Gulf of Mexico and the Mid-Atlantic Ridge southeast of Bermuda (Humes & Dojiri 1980; Humes 1984, 1987, in press *a, b*).

Among the copepods previously known from hydrothermal vents are eight species of the siphonostomatoid genus *Stygiopontius* Humes, 1987 found at the East Pacific Rise, in the Guaymas Basin, on the Explorer Ridge and on the Mid-Atlantic Ridge (see Humes 1987). I now report three new species of *Stygiopontius* from one locality on the East Pacific Rise.

The new copepods were sorted from a collection (DSRV *Alvin* dive no. 1223) of more than 12,000 individuals representing a mixture of several species and including, in addition to the new species, *Ceuthoecetes cristatus*, *Nilva torifera*, *Stygiopontius cinctiger*, *S. hispidulus*, *S. sentifer* and *S. verruculatus*, all described by Humes (1987). In collections made on other *Alvin* dives (nos 1211, 1213, 1214, 1219, 1221, 1225 and 1226) at the same locality during April and May 1982 the following additional copepods were found: *Aphotopontius arcuatus*, *A. flexispina*, *A. mammillatus*, *Stygiopontius verruculatus*, *Ceuthoecetes acanthothrix*, *C. aliger*, *C. cristatus*, *C. introversus*, *Exrima singula* and *Fissuricola caritus* (see Humes 1987).

The copepods were measured, dissected and studied in lactic acid. The drawings were made with the aid of a camera lucida. The abbreviations used are: *A*₁ first antenna; *A*₂ second antenna; *MD* mandible; *MX*₁ first maxilla; *MX*₂ second maxilla; *MXP**D* maxilliped; *P*₁ leg 1. The type specimens are deposited in the National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC.

Siphonostomatoida Thorell, 1859

Dirivultidae Humes & Dojiri, 1980

Stygiopontius Humes, 1987

Stygiopontius paxillifer sp.n. (Figs. 1–3)

Type material. 77 ♂♂, in 2616 m, Clam Acres, East Pacific Rise, 20°50.0'N, 109°06.0'W, 7 May 1982. DSRV *Alvin* dive no. 1223 (Hollis, Tuttle, Arp). Holotype (USNM 233772) and 71 paratypes (USNM 233773).

Description

Male. Body (Fig. 1a) flattened with moderately broad prosome. Length (not including setae on caudal rami) 1.22 mm (1.18–1.27 mm), greatest width 0.49 mm (0.47–0.51 mm), based on 10 specimens in lactic acid. Greatest dorso-ventral thickness 0.18 mm. Segment bearing leg 1 fused with cephalosome. Epimeral areas of segments bearing legs 1–4 pointed, especially those of legs 3 and 4. Ratio of length to width of prosome 1.18:1. Ratio of length of prosome to that of urosome 1.15:1.

Segment bearing leg 5 (Fig. 1b) 88 × 138 μm. Genital segment (Figs. 1b, c) 156 × 172 μm in dorsal view, a little wider than long, subrectangular with gently rounded lateral margins. Four post-genital segments from anterior to posterior 91 × 125, 83 × 107, 57 × 90 and 52 × 81

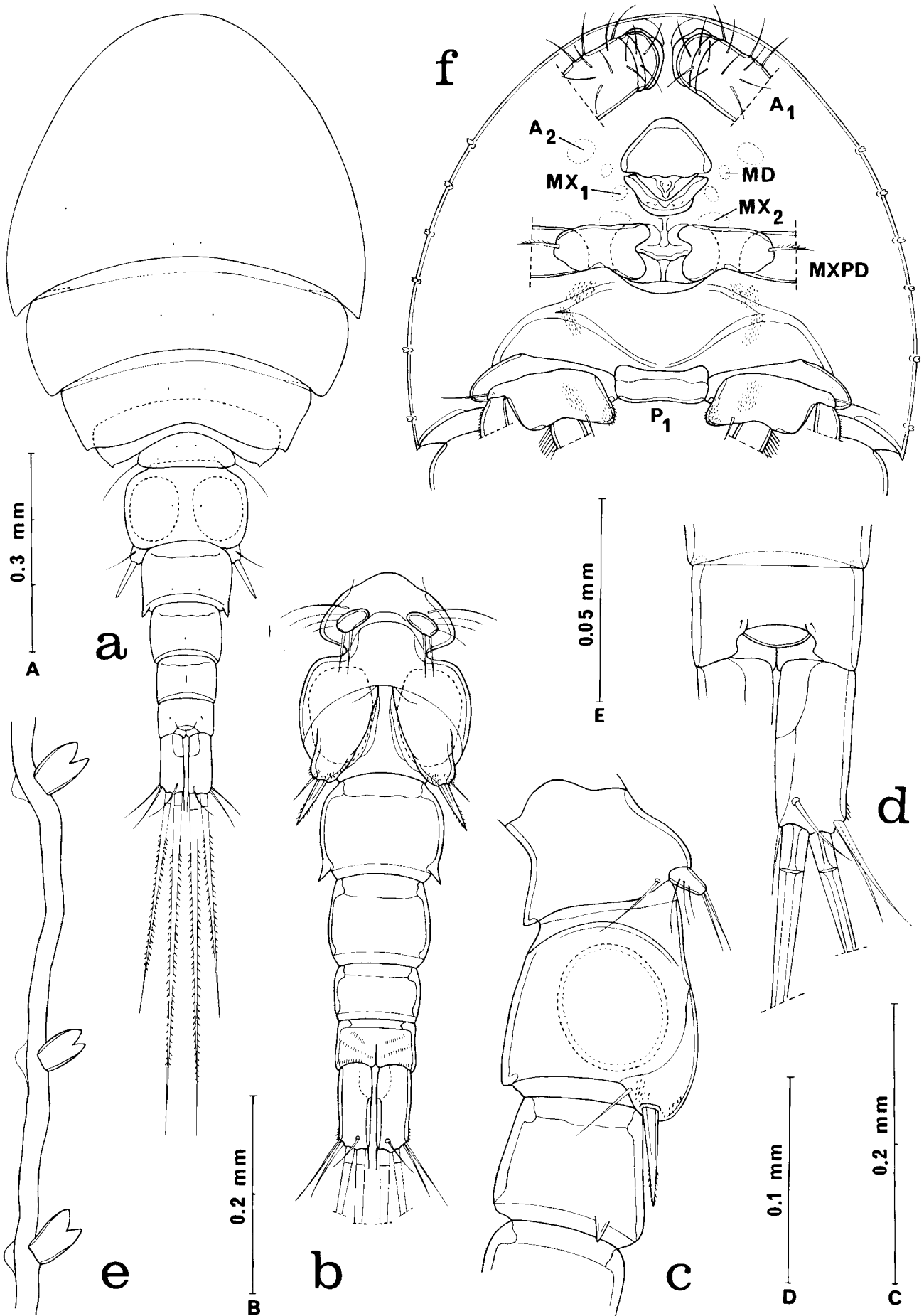


Fig. 1. *Stygiopontius paxillifer* sp. n., male.—a. Dorsal (scale A).—b. Urosome, ventral (B).—c. Segment bearing leg 5, genital segment, and first post-genital segment, lateral (C).—d. Anal segment and caudal ramus, dorsal (D).—e. Peg-like structures along edge of cephalosome, ventral (E).—f. Cephalosome, ventral (B).

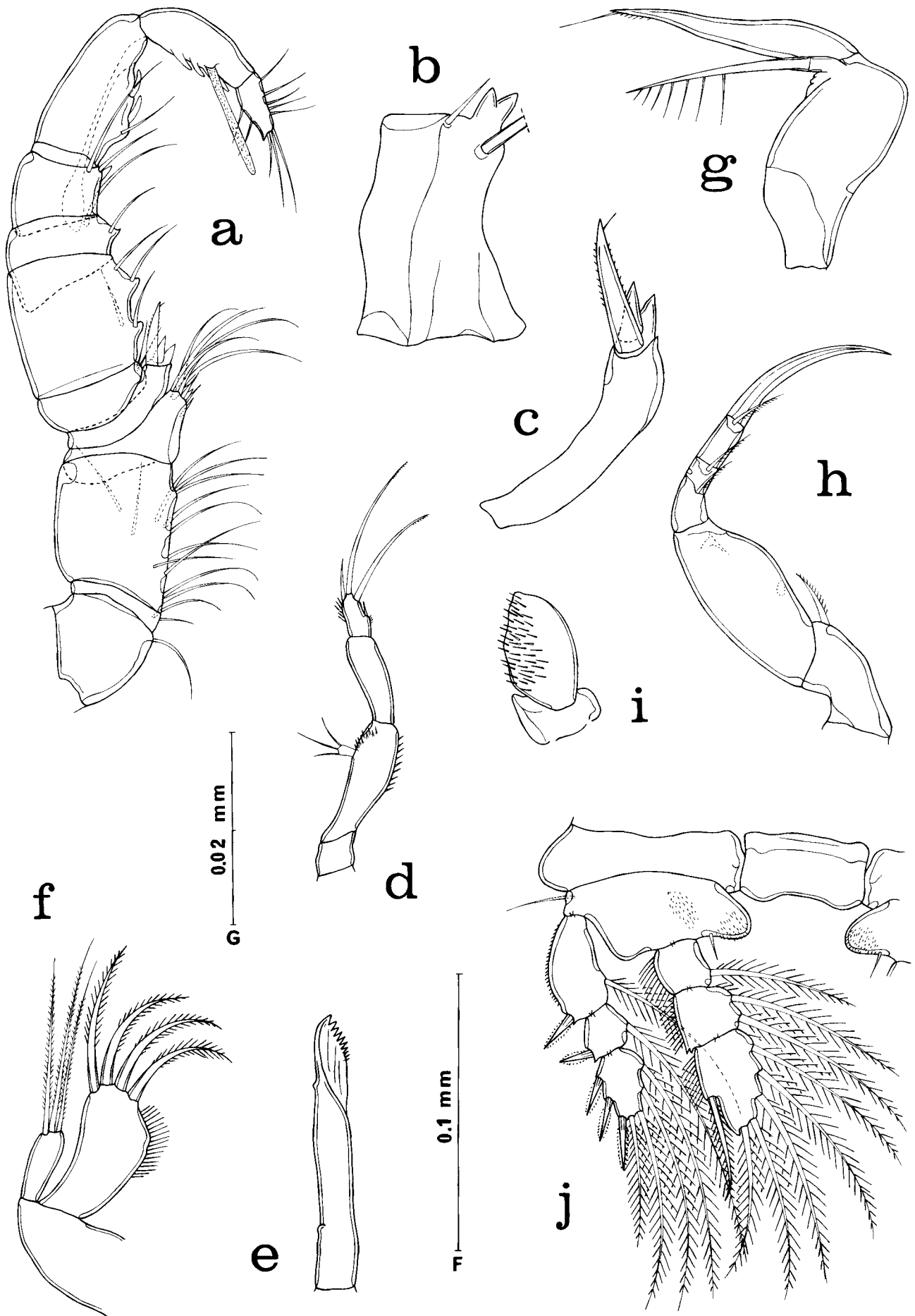


Fig. 2. *Stygiopontius paxillifer* sp.n., male.—a. First antenna, postero-ventral (scale D).—b. Segment 4 of first antenna (only 2 setae shown), antero-dorsal (E).—c. Segment 5 of first antenna, postero-ventral (E).—d. Second antenna, antero-inner (C).—e. Mandible, anterior (F).—f. First maxilla, posterior (F).—g. Second maxilla, posterior (F).—h. Maxilliped, posterior (C).—i. Modified seta on second segment of maxilliped, inner (G).—j. Leg 1 and intercoxal plate, anterior (C).

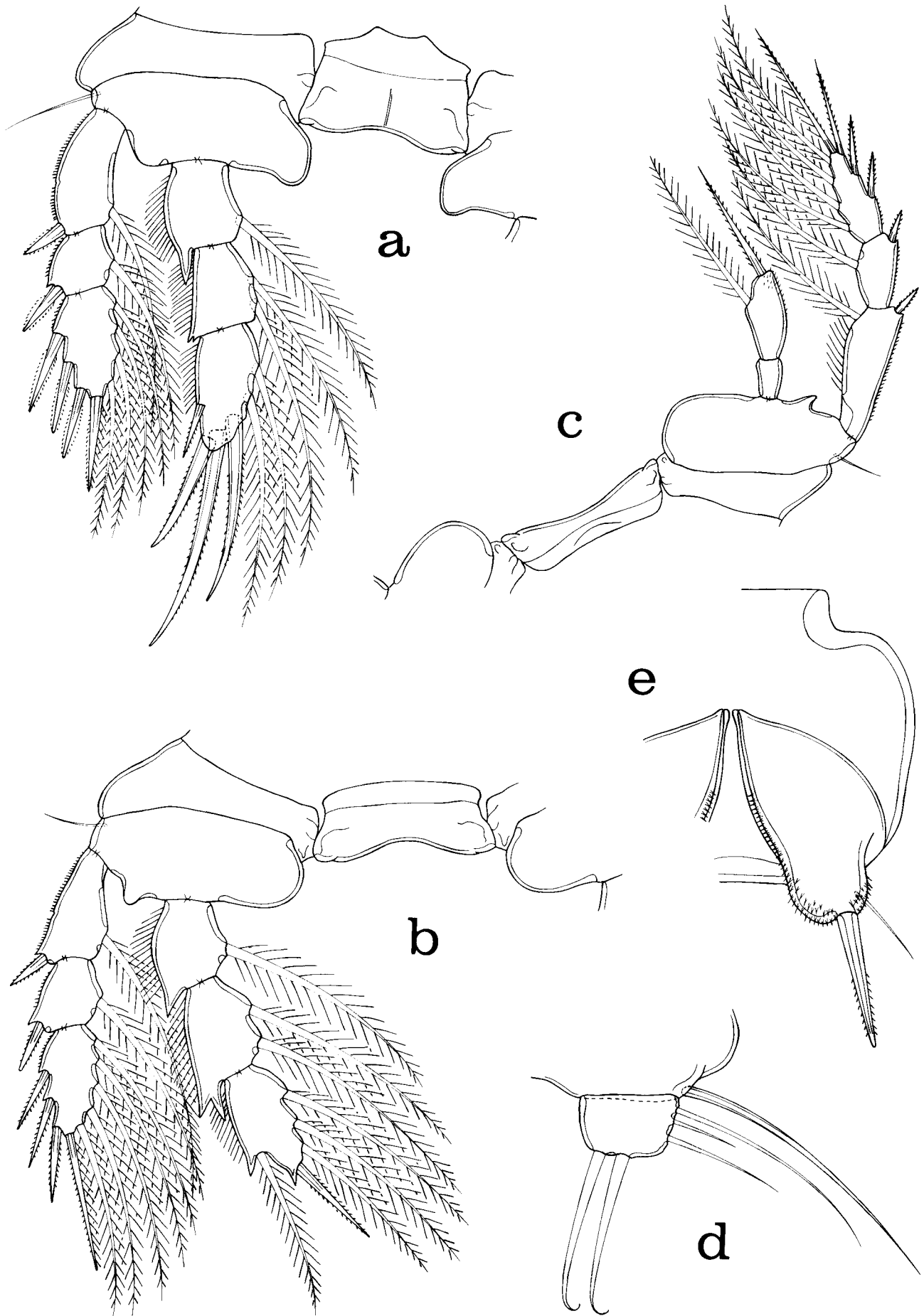


Fig. 3. *Stygiopontius paxillifer* sp.n., male.—a. Leg 2 and intercoxal plate, anterior (scale C).—b. Leg 3 and intercoxal plate, anterior (C).—c. Leg 4 and intercoxal plate, anterior (C).—d. Leg 5, ventral (F).—e. Leg 6, ventral (D).

μm . First post-genital segment with pair of posterolateral spiniform processes. Anal segment ventrally with 3 transverse rows of minute spinules on each side (Fig. 1b).

Caudal ramus (Fig. 1d) moderately elongate, $81 \times 34 \mu\text{m}$, ratio 2.38:1. Outer lateral seta, $73 \mu\text{m}$, placed adjacent to outermost terminal seta, $55 \mu\text{m}$. Dorsal seta $40 \mu\text{m}$, and innermost terminal seta short, $33 \mu\text{m}$. All these setae smooth. Two long median terminal setae barbed, outer seta $450 \mu\text{m}$, inner seta $760 \mu\text{m}$. Few minute spinules at distal outer corner of ramus. Body surface with few sensilla (Figs. 1a, d). Both sides of cephalosome with rows of 6 or 7 ventrally placed, bifurcate pegs, each approximately $13 \times 7.5 \mu\text{m}$, perhaps sensory (Figs. 1e, f). These pegs not visible in dorsal view of entire animal. Ventral surface of cephalosome lateral to rounded protuberance between maxillipeds and leg 1 with 2 patches of minute spines (Fig. 1f).

Rostral area not well defined (Fig. 1f). First antenna (Fig. 2a) $340 \mu\text{m}$ long, not including setae, geniculate. Length of its 12 segments (measured along their posterior margins): 10 ($48 \mu\text{m}$ along anterior margin), 5, 57, 13, 8, 20, 60, 47, 40, 78, 65 and $35 \mu\text{m}$, respectively. Armature: 1, 2, 12, 8, 2, 2, 4, 2, 2, 3, 1 aesthete and 10. Fourth segment with bifurcate process (Fig. 2b) in addition to setae. Fifth segment having on inner side large finely barbed spine $30 \mu\text{m}$ with small flagellum, shorter spine and spiniform process (Fig. 2c). Segment 7 with 2 small inner knobs. Segment 8 with small pointed process. Segment 9 with subconical process. Segment 10 with 1 slender seta and 2 stout hyaline short blunt setae. Segment 11 with aesthete and 3 small scale-like processes. Terminal segment with minutely uncinuate tip.

Second antenna (Fig. 2d) $177 \mu\text{m}$ long, excluding terminal setae. Basis with spinules on both sides. Exopod with 3 setae. Endopod with smooth first segment, second segment bearing 4 setae and small spinules on both sides.

Oral cone short (Fig. 1f). Mandible (Fig. 2e) $90 \mu\text{m}$ long. First maxilla (Fig. 2f) with outer lobe bearing 3 setae, inner lobe having 4 setae and row of setules along inner margin. Second maxilla (Fig. 2g) with first segment bearing 1 seta having conspicuous setules along one side. Second segment attenuated, claw-like, distally with inner minute spines and slender filament. Maxilliped (Fig. 2h) 5-segmented. First segment with inner distal unilaterally barbed seta. Second segment with modified seta $11 \times 7 \mu\text{m}$, set upon indistinct pedicel and bearing numerous spinules (Fig. 2i). Segments 3–5 with unilaterally barbed seta. Claw $117 \mu\text{m}$ long.

Legs 1–4 (Figs. 2j, 3a–c) biramous, with 3-segmented rami, except for 2-segmented endopod in leg 4. Spine and setal formula as follows (Roman numerals indicating spines, Arabic numerals representing setae.)

P₁ coxa 0–0 basis 1–1 exp I–1; I–1; II, I, 4
 enp 0–1; 0–2; I, 2, 3
 P₂ coxa 0–0 basis 1–0 exp I–1; I–1; II, II, 4
 enp 0–1; 0–2; I, II, I, 2
 P₃ coxa 0–0 basis 1–0 exp I–1; I–1; II, II, 5
 enp 0–1; 0–2; I, I, 3
 P₄ coxa 0–0 basis 1–0 exp I–1; I–1; II, II, 4
 enp 0–0; I, 1

Basis of leg 1 with inner element setiform and smooth, $15 \mu\text{m}$; anterior medial surface of basis with 2 patches of

small spinules. Outer margin of first segment of exopod in legs 2 and 3 showing slight notch. Spines on third segment of endopod of leg 2 from outer to inner 40, 87, 156 and $130 \mu\text{m}$. Endopod of leg 4 $195 \mu\text{m}$ long. First segment of endopod $27 \times 17 \mu\text{m}$. Second segment $60 \times 26 \mu\text{m}$, spine $78 \mu\text{m}$, seta $127 \mu\text{m}$; small spinules along distal outer area.

Leg 5 (Fig. 3d) situated ventrally (Fig. 1b). Free segment $18 \times 29 \mu\text{m}$, much wider than long, with 5 setae from outer to inner 57, 21, 39, 65 and $65 \mu\text{m}$, innermost 2 setae with recurved tips and difficult to measure accurately. Adjacent seta long, $104 \mu\text{m}$. All setae smooth.

Leg 6 (Figs. 1b, c, 3e) with spinulose flap bearing conspicuous barbed spine, $60 \mu\text{m}$, and slender smooth seta, $39 \mu\text{m}$.

Spermatophore not seen.

Color unknown.

Female. Unknown.

Etymology. The specific name *paxillifer*, Latin *paxillus* meaning a peg and *fero* to bear, alludes to the rows of small bifurcate pegs along the sides of the cephalosome.

Remarks

Among the eight currently known species of *Stygiopontius* males are known for only two, *Stygiopontius quadrispinosus* Humes, 1987 and *S. verruculatus* Humes, 1987. *Stygiopontius paxillifer* may be distinguished from *S. quadrispinosus* where the male is much smaller (average length 0.67 mm) and from *S. verruculatus* where the male is also smaller (0.84 mm) and the second segment of the maxilliped has a spherical ball instead of a seta.

The remaining six species, being known only from females, must be compared with *S. paxillifer* indirectly. However, in the genus *Stygiopontius* and related genera certain features seem to be constant in the two sexes. These characters include the armature of the second antenna, the form of the maxilliped, the formula for the inner coxal seta in legs 1–4 and the formula for the armature of the third segment of the exopod of leg 4. Using these characters, the six species may be distinguished from *S. paxillifer* as follows.

In *S. sentifer* Humes, 1987 the seta on the second segment of the maxilliped of the female (and presumably also in the male) is massive, thorn-like and spinulose, and the formula for the inner coxal seta of legs 1–4 is 1–1–0–0.

In *S. cinctiger* Humes, 1987 and *S. mucroniferus* Humes 1987 the formula for the armature of the third segment of the exopod of leg 4 is I,II,4.

In *S. flexus* Humes, 1987 the formula for the inner coxal seta of legs 1–4 is 1–1–0–0 and the inner surface of the basis is smooth; in *S. hispidulus* Humes, 1987 this formula is also 1–1–0–0, but the inner margin of the basis is spinulose.

In *S. pectinatus* Humes, 1987 the claws on the second antenna and the maxilliped are strongly pectinate.

Furthermore, in *S. quadrispinosus*, *S. cinctiger*, *S. flexus*, *S. hispidulus* and *S. pectinatus* the second segment

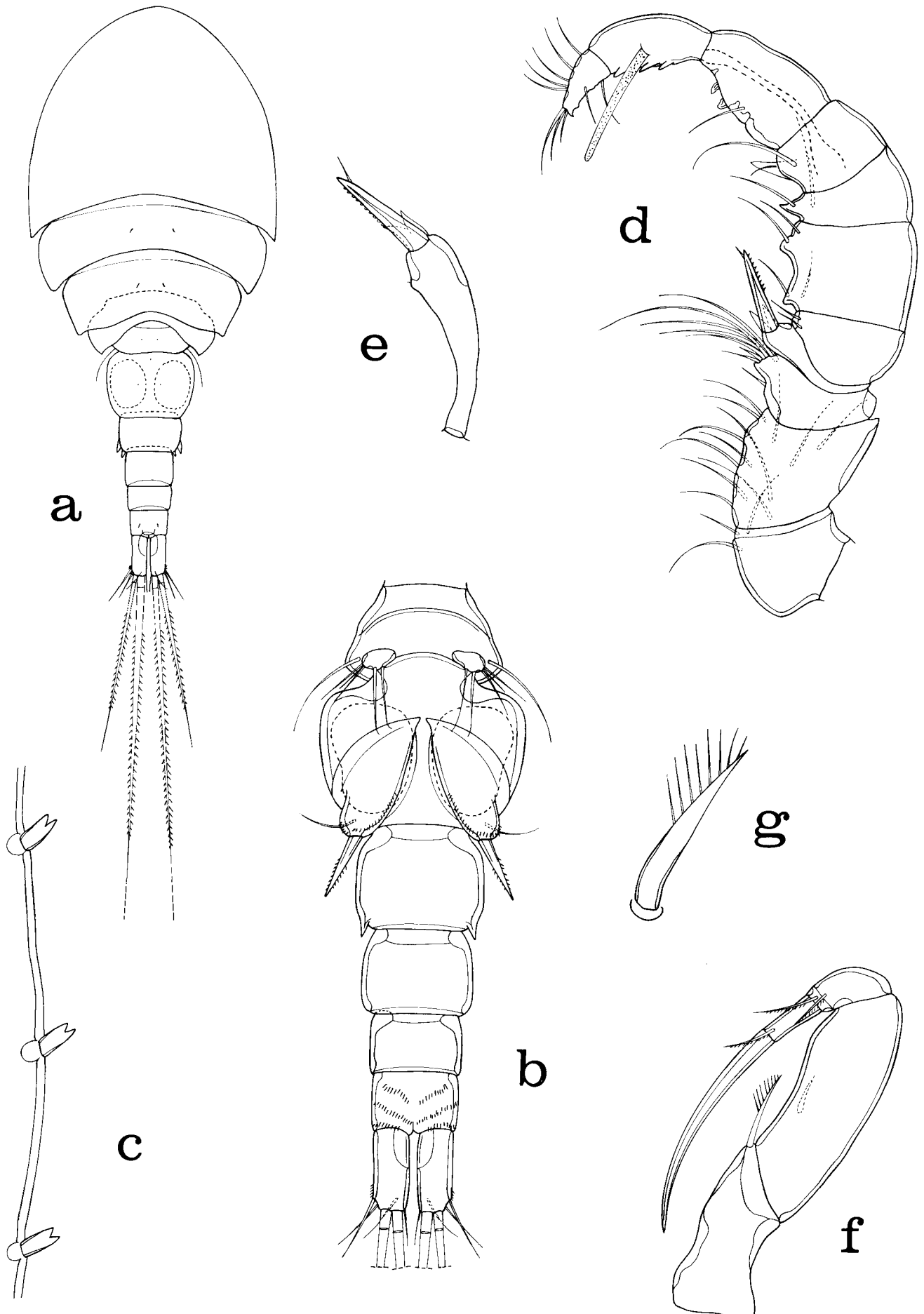


Fig. 4. *Stygiopontius appositus* sp.n., male.—a. Dorsal (scale A).—b. Urosome, ventral (C).—c. Peg-like structures along edge of cephalosome, ventral (E).—d. First antenna, postero-ventral (F).—e. Segment 5 of first antenna, postero-ventral (E).—f. Maxilliped, posterior (F).—g. Seta on second segment of maxilliped, anterior (G).

of the maxilliped bears an unmodified seta; in *S. mucroniferus* this seta is spiniform.

The presence of pegs along the edges of the cephalosome is an unusual feature of this species.

***Stygiopontius appositus* sp.n.** (Figs. 4, 5)

Type material. 288 ♂♂, in 2616 m, Clam Acres, Eact Pacific Rise, 20°50.0'N, 109°06.0'W, 7 May 1982. DSRV *Alvin* dive no. 1223 (Hollis, Tuttle, Arp). Holotype (USNM 233774) and 283 paratypes (USNM 233775).

Description

Male. Body (Fig. 4a) smaller and with prosome less broadened than in *S. paxillifer*. Length (not including setae on caudal rami) 0.86 mm (0.78–0.95 mm), greatest width 0.36 mm (0.33–0.39 mm), based on 10 specimens in lactic acid. Greatest dorso-ventral thickness at level of postoral protuberance 0.19 mm. Ratio of length to width of prosome 1.31:1. Ratio of length of prosome to that of urosome 1.30:1.

Segment bearing leg 5 (Fig. 4b) $57 \times 99 \mu\text{m}$. Genital segment $107 \times 135 \mu\text{m}$, wider than long, in dorsal view with slightly rounded lateral margins and anterior shoulders. Four post-genital segments from anterior to posterior 56×94 , 56×81 , 46×68 and $42 \times 62 \mu\text{m}$.

Caudal ramus (Fig. 4b) $60 \times 26 \mu\text{m}$, ratio 2.31:1. Outer lateral seta, $52 \mu\text{m}$, placed close to outermost

terminal seta, $42 \mu\text{m}$. Dorsal seta $44 \mu\text{m}$, and innermost terminal seta $22 \mu\text{m}$. All these setae smooth. Two long median terminal setae barbed, outer seta $313 \mu\text{m}$, inner seta $550 \mu\text{m}$.

Body surface with few sensilla. Both sides of cephalosome with row of ventrally placed, bifurcate pegs, each approximately $7.5 \times 3.5 \mu\text{m}$ (Fig. 4c). Ventral surface of cephalosome between maxillipeds and first pair of legs lacking patches of minute spines seen in *S. paxillifer*.

Rostral area not defined. First antenna (Fig. 4d) $220 \mu\text{m}$ long as drawn. Lengths of its 12 segments (measured along their posterior margins): 13 ($34 \mu\text{m}$ along anterior margin), 4, 31, 10, 3, 18, 39, 30, 29, 49, 39 and $29 \mu\text{m}$, respectively. Armature as in *S. paxillifer*. Processes on segments 4–9 as in *S. paxillifer*. Spine on segment 5 stout, $30 \mu\text{m}$ long, with subterminal flagellum and having row of minute barbs along distal side (Fig. 4e). Second antenna as in *S. paxillifer*.

Oral cone, mandible, first maxilla and second maxilla similar to those in *S. paxillifer*. Maxilliped (Fig. 4f) elongate, 5-segmented. First segment with inner distal seta having prominent unilateral setules. Slender second segment with seta $10 \mu\text{m}$ long with unilateral distal setules (Fig. 4g). Segments 3–5 with unilaterally barbed seta. Claw $74 \mu\text{m}$.

Legs 1–4 segmented as in *S. paxillifer*, with same spine and setal formula. Spines on third segment of endopod of leg 2 (Fig. 5a) from outer to inner 23, 58, 112 and $66 \mu\text{m}$.

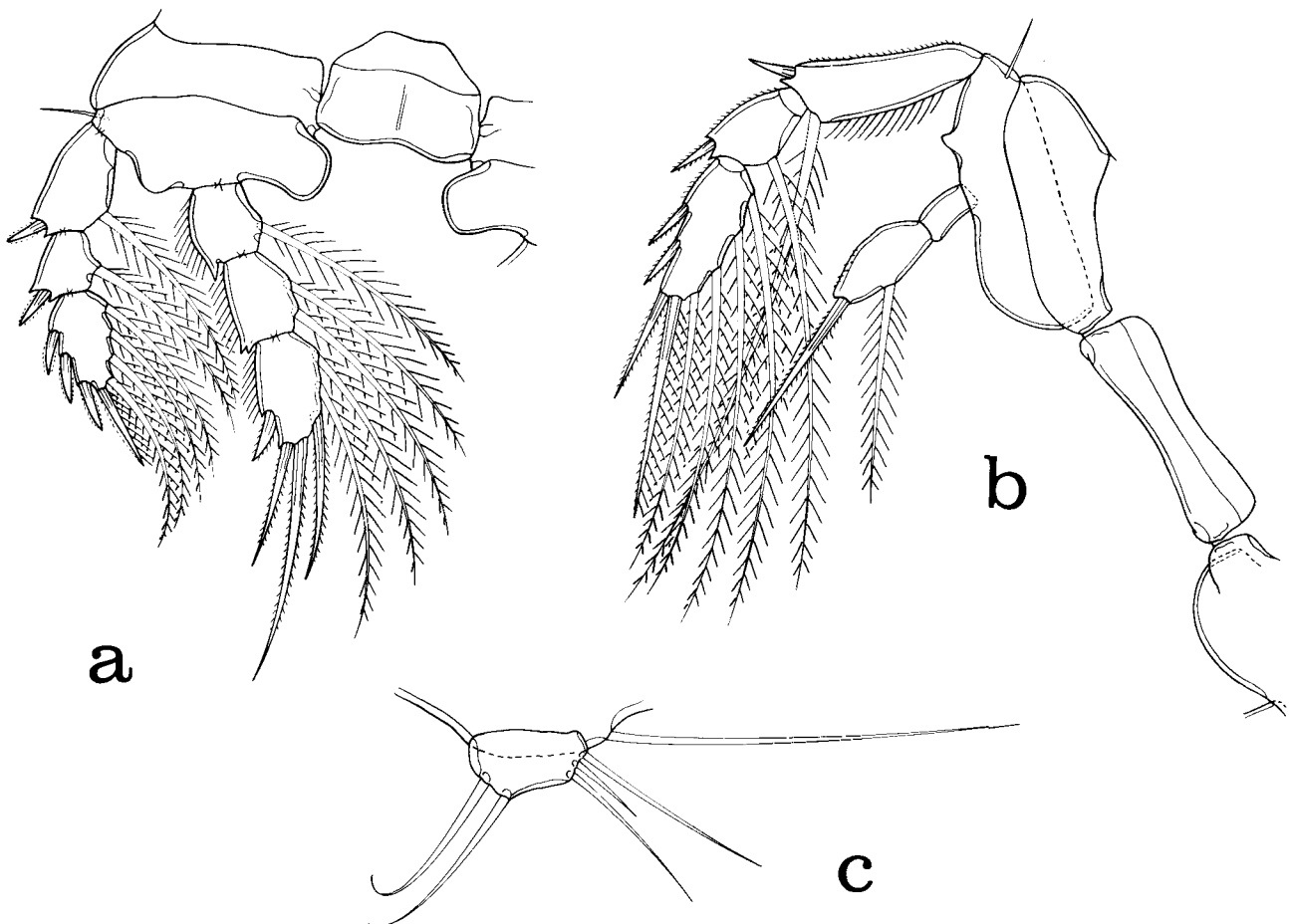


Fig. 5. *Stygiopontius appositus* sp.n., male.—a. Leg 2 and intercoxal plate, anterior (scale C).—b. Leg 4 and intercoxal plate, posterior (D).—c. Leg 5, ventral (F).

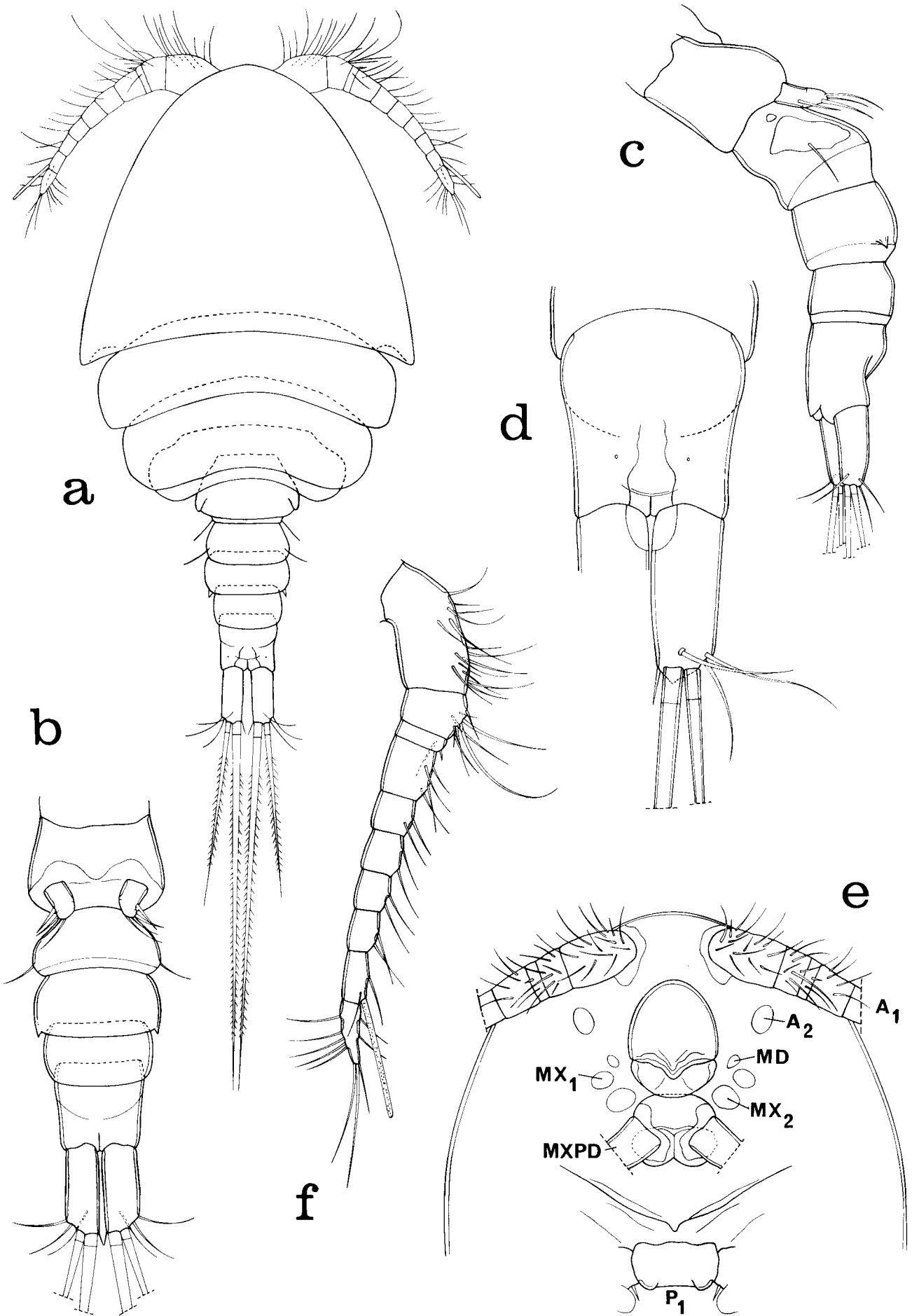


Fig. 6. *Stygiopontius lumiger* sp.n., female.—a. Dorsal (scale A).—b. Urosome, ventral (B).—c. Urosome, lateral (B).—d. Anal segment and caudal ramus, dorsal (D).—e. Cephalosome, ventral (B).—f. First antenna, postero-ventral (C).

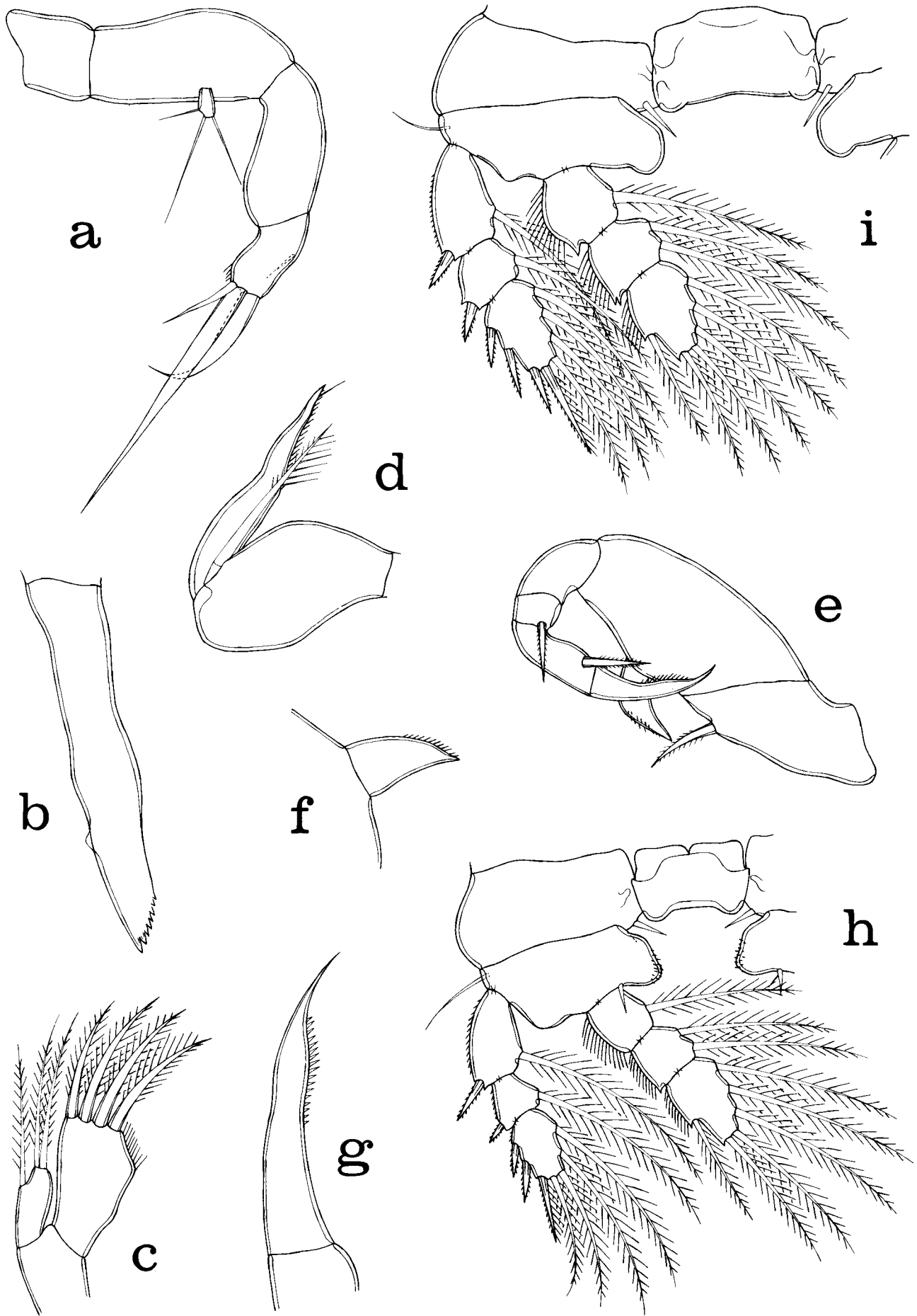


Fig. 7. *Stygiopontius lumiger* sp. n., female.—a. Second antenna, anterior (scale F).—b. Mandible, posterior (E).—c. First maxilla, posterior (F).—d. Second maxilla, posterior (F).—e. Maxilliped, posterior (D).—f. Modified seta on second segment of maxilliped, anterior (E).—g. Claw of maxilliped, anterior (E).—h. Leg 1 and intercoxal plate, anterior (C).—i. Leg 2 and intercoxal plate, anterior (C).

Leg 4 (Fig. 5b) exopod 140 μm long. First segment of endopod 18 \times 13 μm . Second segment 44 \times 20 μm , spine 56 μm , seta 86 μm .

Leg 5 (Fig. 5c) situated ventrally. Free segment 16 \times 29 μm , much wider than long, with 5 setae from outer to inner 42, 16, 37, 50 and 50 μm . Adjacent seta 78 μm . All setae smooth.

Spermatophore not seen.

Other detailed features similar to *S. paxillifer*.

Color unknown.

Female. Unknown.

Etymology. The specific name *appositus*, Latin meaning placed near, alludes to the close relationship of this species with *S. paxillifer*.

Remarks

While many similarities between *S. appositus* and *S. paxillifer*, among them the peglike structures along the ventral edges of the cephalosome, indicate their close relationship, the two species may be easily separated by careful examination. *Stygiopontius appositus* is distinctly smaller, its length being 0.86 mm (0.78–0.95 mm), while *S. paxillifer* is larger, with a length of 1.22 mm (1.18–1.27 mm). The nature of the element on the second

segment of the maxilliped differs in the two species. In *S. appositus* it is a slender seta with unilateral setules, as in Fig. 4g, while in *S. paxillifer* it is a modified broad seta with a patch of spinules, as in Fig. 2i. Other more subtle and less obvious differences may be found in the lengths of spines on the endopod of leg 2 and the presence or absence of patches of spinules on the post-maxillipedal area.

Stygiopontius lumiger sp.n. (Figs. 6–8)

Type material. 112 ♀♀, in 2616 m, Clam Acres, East Pacific Rise, 20°50.0'N, 109°06.0'W, 7 May 1982. DSRV *Alvin* dive no. 1223 (Hollis, Tuttle, Arp). Holotype (USNM 233776) and 107 paratypes (USNM 233777).

Description

Female. Body (Fig. 6a) lightly sclerotized with moderately broad prosome. Length (excluding setae on caudal rami) 1.02 mm (0.88–1.18 mm), greatest width 0.47 mm (0.45–0.49 mm), based on 10 specimens in lactic acid. Greatest dorso-ventral thickness in front of first pair of legs 0.26 mm. Leg-bearing segments overlapping in dorsal view and having rounded epimera. Ratio of length to

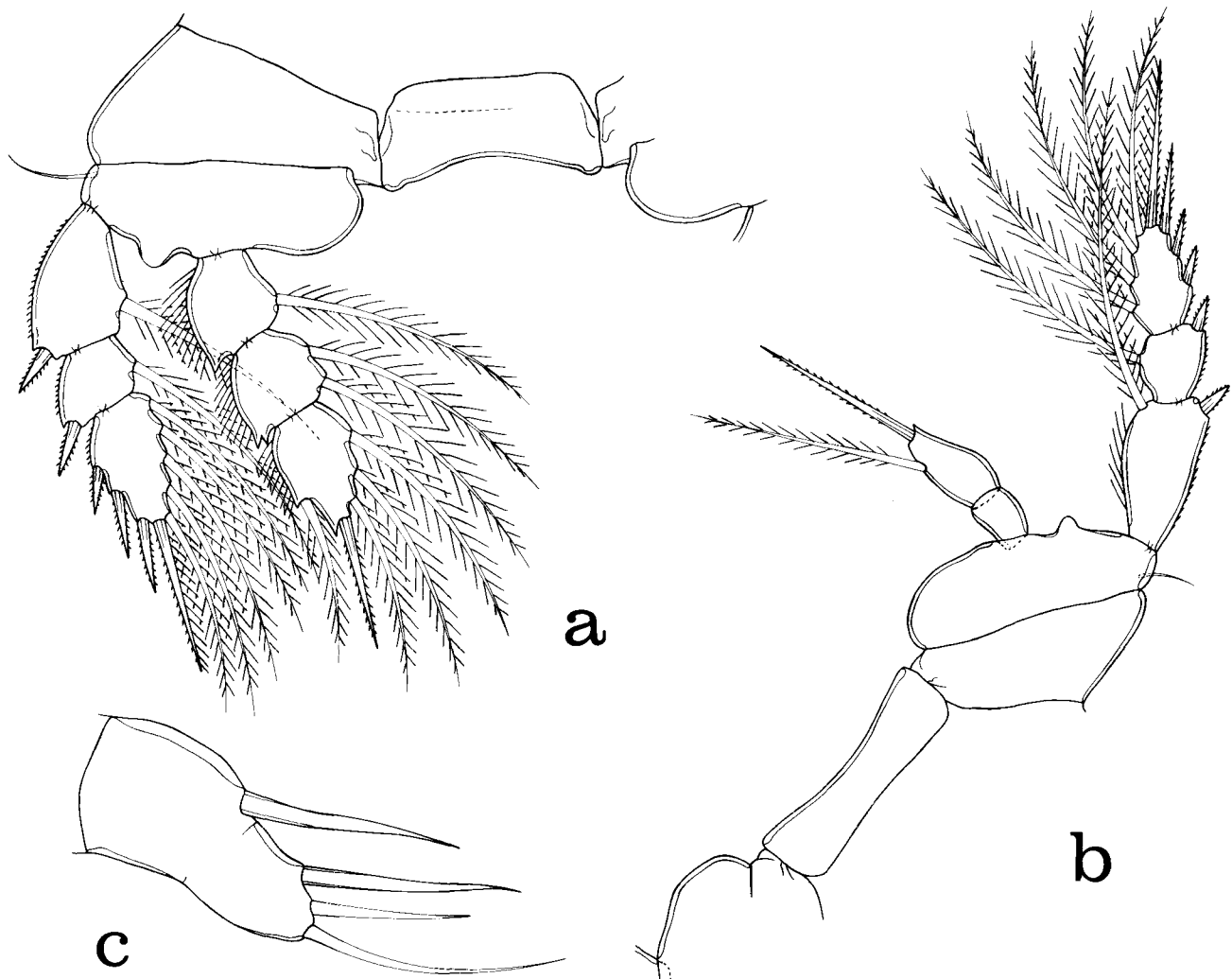


Fig. 8. *Stygiopontius lumiger* sp.n., female.—a. Leg 3 and intercoxal plate, anterior (C).—b. Leg 4 and intercoxal plate, anterior (C).—c. Leg 5, ventral (E).

width of prosome 1.26:1. Ratio of length of prosome to that of urosome 1.56:1.

Segment bearing leg 5 (Fig. 6b) $107 \times 140 \mu\text{m}$. Genital segment $70 \times 120 \mu\text{m}$, much wider than long and broadest in posterior half. Genital areas located dorso-laterally and weakly sclerotized, carrying 1 seta $40 \mu\text{m}$ long (Fig. 6c). Three post-genital segments from anterior to posterior 65×120 , 65×101 and $86 \times 88 \mu\text{m}$. Anal segment with ventral indentation (Fig. 6c). First post-genital segment with pair of small postero-lateral spiniform processes (Figs. 6b, c).

Caudal ramus (Fig. 6d) $81 \times 34 \mu\text{m}$, ratio of length to width 2.38:1. Outer lateral seta $77 \mu\text{m}$, placed far distally. Dorsal seta $57 \mu\text{m}$. Outermost terminal seta $50 \mu\text{m}$. Innermost terminal seta $18 \mu\text{m}$. All these setae smooth. Two long median setae barbed, inner seta $528 \mu\text{m}$, outer seta $242 \mu\text{m}$.

Body surface with very few sensilla.

Egg sac unknown.

Rostral area (Fig. 6e) not defined. First antenna (Fig. 6f) $350 \mu\text{m}$. Lengths of its 10 segments (measured along their posterior non-setiferous margins): 52 ($99 \mu\text{m}$ along anterior margin), 21 , 13 , 39 , 26 , 26 , 26 , 30 , 35 and $40 \mu\text{m}$, respectively. Armature: 15 (representing 1, 2, 12 on 3 fused segments), 8, 2, 4, 2, 2, 2, 2, 2 + 1 aesthete and 20. All setae smooth. Second antenna (Fig. 7a) with exopod having 3 setae. Endopod with first segment smooth; second segment having 1 small outer hyaline seta and 3 terminal smooth setae (1 small and 2 large and stout in proximal half); few spinules at distal inner corner of segment.

Oral cone short (Fig. 6e), no true siphon. Mandible (Fig. 7b) $94 \mu\text{m}$ long. Paragnath not seen. First maxilla (Fig. 7c) with outer lobe bearing 3 setae, inner lobe with 4 setae and row of setules distal to angle on inner margin. Second maxilla (Fig. 7d) with second segment stout, slightly undulating, attenuated, with minute inner spinules and subterminal flagellum. Maxilliped (Fig. 7e) 5-segmented. First segment with inner distal seta. Second segment with stout seta minutely spinulose along one side (Fig. 7f). Claw (Fig. 7g) $71 \mu\text{m}$, with swelling bearing row of spinules distal to mid-region, and having attenuated tip. All setae finely barbed.

Legs 1–4 (Figs. 7h, i, 8a, b) biramous, with 3-segmented rami, except for 2-segmented endopod in leg 4. Spine and setal formula as follows (Roman numerals indicating spines, Arabic numerals representing setae).

P₁ coxa 0–I basis 1–I exp I–1; I–1; II,I,4
 enp 0–1; 0–2; 1,2,3
 P₂ coxa 0–I basis 1–0 exp I–1; I–1; II,II,4
 enp 0–1; 0–2; 1,2,3
 P₃ coxa 0–0 basis 1–0 exp I–1; I–1; II,II,5
 enp 0–1; 0–2; 1,1,3
 P₄ coxa 0–0 basis 1–0 exp I–1; I–1; II,II,4
 enp 0–0; 1,1

Coxa of leg 1 with inner element smooth, $24 \mu\text{m}$ (Fig.

7h). Basis with inner element spiniform, smooth $18 \mu\text{m}$ (Fig. 7h). Leg 4 (Fig. 8b) with exopod $170 \mu\text{m}$ long. Endopod with first segment $29 \times 31 \mu\text{m}$. Second segment $49 \times 26 \mu\text{m}$, spine $78 \mu\text{m}$, seta $104 \mu\text{m}$.

Leg 5 (Fig. 8c) situated ventrally (Fig. 6b), $50 \times 27 \mu\text{m}$, composed of 2 incompletely separated segments. First segment with stout seta $42 \mu\text{m}$. Second segment with 3 setae from outer to inner $39 \mu\text{m}$ and $50 \mu\text{m}$. All setae smooth.

Leg 6 (Fig. 6c) represented by seta on genital area.

Male. Unknown.

Etymology. The specific name *lumiger* is formed from Latin *luma*, a kind of thorn, and *gero*, to carry, alluding to the thorn-like setae on the second segment of the maxilliped.

Remarks

Stygiopontius lumiger may be distinguished from the other 10 species in the genus by the modified thorn-like seta on the second segment of the maxilliped. Only *Stygiopontius sentifer* Humes, 1987 has a somewhat similar seta, but this species differs from the new species in the genital segment of the female having an anterior pair of linguiform lobes and a posterior pair of spiniform processes. Other distinctive features of *S. lumiger* are the ventrally indented anal segment, two stout terminal setae on the second antenna, the relatively short claw swollen distal to its mid-region on the maxilliped and the inner area of the coxa of legs 1–4 with I,I,0,0.

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