Siphonostomatoid copepods from deep-sea hydrothermal sites on the Mid-Atlantic Ridge west of the Azores.

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Abstract: Two new siphonostomatoid copepods are described from a depth of 1688 m at a hydrothermal area on the Mid-Atlantic Ridge (37°N, 32°W). Aphotopontius temperatus n. sp. is characterized by the rectangular shape of the female genital double-somite. In legs 1-4 of copepodid V, the female has 2-segmented rami, but in the male these rami are segmented as in the adult (3-segmented except for a 2-segmented endopod in leg 4). The number of postgenital somites in copepodid V is reduced to 2 in the female and 3 in the male. Aphotopontius atlanteus is reported from very close to its type locality on Lucky Strike. Stygiopontius rimivagus n. sp., known only from the male, has 3 setae on the free segment of leg 5 and the third segment of the endopod of leg 2 has the formula IV,2.

Résumé: Deux copépodes siphonostomatoides nouveaux sont décrits d'une zone hydrothermale sur la Ride Médio-Atlantique (37°N, 32°W) à une profondeur de 1688 m. Aphotopontius temperatus n. sp. est caractérisé par la forme rectangulaire du somite génital double de la femelle. Chez la femelle, les pattes 1-4 du copépodite V ont des rames à 2 segments mais chez le mâle les rames sont segmentées comme chez l'adulte (3 segments sauf dans la quatrième patte qui a 2 segments). Le nombre de somites postgénitaux est réduit à 2 chez la femelle et à 3 chez le mâle. Aphotopontius atlanteus est signalé d'un site proche de sa localité type à Lucky Strike. Stygiopontius rimivagus, n. sp., dont on ne connaît que le mâle, a 3 soies sur le segment libre de la cinquième patte et l'endopodite de la deuxième patte a la formule IV,2.

Keywords: Aphotopontius, Stygiopontius, Siphonostomatoida, Copepoda, Mid-Atlantic Ridge, hydrothermal sites.

Introduction

Numerous species of siphonostomatoid copepods have been found, often in large numbers, at deep-sea hydrothermal vents and cold seeps (Humes & Dojiri, 1980; Humes, 1984, 1987, 1988a, b, c, 1990a, b, 1991; Humes & Nuys, 1992; Humes & Lutz, 1994; Humes, 1996). In a few cases, these siphonostomatoids are known to be associated with invertebrate hosts, for example, Stygiopontius pecinatus Humes, 1987, in the branchial chamber of the shrimp Rimicaris exoculata Williams & Rona (see Humes, 1987; Galkin & Moskalev, 1990), and Aphotopontius acanthinus Humes & Lutz, 1994, on the carapaces of brachyuran crabs and on limpets (Humes & Lutz, 1994). Members of the genus Aphotopontius are known from the eastern Pacific (East Pacific Rise, Galapagos Rift, Guaymas Basin), northeastern Pacific (Explorer Ridge, Gorda Ridge, Juan de Fuca Ridge), and the Mid-Atlantic Ridge. The 10 species are: A. acanthinus Humes & Lutz, 1994, A. arcuatus Humes, 1987, A. atlanteus Humes, 1996, A. baculigerus Humes, 1987, A. flexispina Humes, 1887, A. forcipatus Humes, 1987, A. hydromoeus Humes, 1989, A. limatulus Humes, 1987, A. mammillatus Humes, 1987, and A. probolus Humes, 1990. Two species of Aphotopontius have been reported from the Mid-Atlantic Ridge, A. forcipatus Humes, 1987,

Figure 1. Aphotopontius temperatus n. sp. Adult female: a, body, dorsal view (scale A); b, urosome, dorsal (B); c, urosome, lateral (B); d, anal somite and caudal ramus, dorsal (C); e, cephalosome, ventral (D); f, antennule, anterodorsal (B). A₁ = antennule, P₁ = leg 1.

Ventral area between maxillipeds and first pair of legs not protuberant.

Legs 1-4 (Fig. 2f,h-j) segmented and armed as in congeners. Formula for armature as follows:

- P₁: coxa 0-1 basis 1-0 exp 1-1; 1-1; II,1,4
  enp 0-1; 0-2; 1,2,3
- P₂: coxa 0-1 basis 1-0 exp 1-1; 1-1; III,1,4
  enp 0-1; 0-2; 1,2,3
- P₃: coxa 0-1 basis 1-0 exp 1-1; 1-1; III,1,5
  enp 0-1; 0-2; 1,1,1,2
- P₄: coxa 0-0 basis 1-0 exp 1-1; 1-1; III,1,4
  enp 0-1; 1,1
Figure 2. *Aphotopontius temperatus* n. sp. Adult female: a, antenna, antero-inner (scale C); b, mandible, posterior (C); c, maxillule, posterior (C); d, maxilla, posterior (C); e, maxilliped, posterior (C); f, leg 1 and intercoxal plate, anterior (E); g, detail of basis of leg 1, anterior (F); h, leg 2 and intercoxal plate, posterior (E); i, leg 3 and intercoxal plate, anterior (E); j, leg 4 and intercoxal plate, posterior (E); k, endopod of leg 4, posterior (C); l, leg 5, ventral (F).

*Figure 2. Aphotopontius temperatus* n. sp. Femelle adulte : a, antenne, vue antéro-interne (échelle C) ; b, mandibule, vue postérieure (C) ; c, maxillule, vue postérieure (C) ; d, maxille, vue postérieure (C) ; e, maxillipède, vue postérieure (C) ; f, patte 1 et plaque intercoxale, vue antérieure (E) ; g, détail de la base de la première patte, vue antérieure (F) ; h, patte 2 et plaque intercoxale, vue postérieure (E) ; i, patte 3 et plaque intercoxale, vue antérieure (E) ; j, patte 4 et plaque intercoxale, vue postérieure (E) ; k, endopodite de la quatrième patte, vue postérieure (C) ; l, patte 5, vue ventrale (F).
Figure 3. *Aphotopontius temperatus* n. sp. Male: a, body, dorsal (scale A); b, epimera of metasomal somites, dorsal (E); c, urosome, dorsal (B); d, urosome, ventral (B); e, antennule, anterodorsal (C); f, segments 4, 5, and 6 of antennule, showing armature of segment 5, posteroventral (F); g, endopod of leg 2, anterior (B).

Figure 3. *Aphotopontius temperatus* n. sp. Male : a, corps, vue dorsale (échelle A) ; b, épimères des somites métasomaux, vue dorsale (E) ; c, urosome, vue dorsale (B) ; d, urosome, vue ventrale (B) ; e, antennule, vue antérodorsale (C) ; f, segments 4, 5, et 6 de l'antennule, montrant l'armature du segment 5, vue postéroventrale (F) ; g, endopodite de la deuxième patte, vue antérieure (B).

Leg 1 with inner barbed spine on basis 25 µm; expanded inner margin of basis with few minute spinules (Fig. 2g).
Leg 4 with exopod 148 µm long; endopod (Fig. 2k) with first segment 22 x 18 µm, its inner seta 53 µm; second segment 33 x 19 µm, its inner seta 55 µm and terminal barbed spine 55 µm

Leg 5 (Fig. 21) 2-segmented, in ventral view first segment incompletely set off from body somite, its outer
seta 57 µm; second segment 31 x 17 µm, its 3 setae from outer to inner 47, 51, and 52 µm. All setae with short lateral setules.

Leg 6 probably represented by seta on genital area (Fig. 1e).

Color of living specimens red.

Male: body (Fig. 3a) with length 0.63 mm (0.59-0.65 mm) and greatest width 0.28 mm (0.27-0.29 mm), based on 6 specimens. Greatest dorsoventral thickness 0.21 mm. Epimera of somites bearing legs 1-4 pointed posterolaterally, especially those of somites bearing legs 3 and 4 (Fig. 3b). Ratio of length to width of prosome 1.46:1. Ratio of length of prosome to that of urosome 1.74:1.

Somite bearing leg 5 (Fig. 3c, d) in dorsal view 36 x 81 µm, sharply pointed posterolaterally. Genital somite subquadrate, 57 x 75 µm, slightly wider than long, sides subparallel, drawn out in points posterolaterally. First postgenital somite with pair of posteralateral spiniform processes. Four postgenital somites from anterior to posterior 39 x 60, 29 x 55, 18 x 49, and 27 x 47 µm. Anal somite with row of minute posteralateral and ventral spinules (Fig. 3d).

Caudal ramus (Fig. 3c, d) similar to that of female, slightly smaller, 32 x 20 µm, ratio 1.6:1.

Body surface without sensilla.

Rostral area as in female. Antennule (Fig. 3e) geniculate, 12-segmented. Lengths of segments: 5.5 (24 µm along anterior margin), 16.5, 21, 17, 5.5, 9, 26.5, 24, 23, 43, 36, and 23 µm, respectively. Armature: 1, 2, 12, 7, 2, 2, 4, 2, 2, 3, 1 aesthetasc, and 10. Fifth segment (Fig. 3f) extended anteriorly, having spiniform process and 2 terminal elements, one spiniform and finely barbed, 30 µm, other truncated with irregular tip, 13 µm.

Antenna, oral cone, mandible, maxillule, maxilliped, and ventral area between maxillipeds and first pair of legs as in female.

Legs 1-4 resembling those of female, except sexual dimorphism in third segment of endopod of leg 2 (Fig. 3g) with formula 1,II,3.

Leg 5 (Fig. 3d) situated ventrally. Free segment 18 x 13 µm, with 5 setae, 3 outer slender, 2 inner stout and hyaline.

Leg 6 (Fig. 3d) posteroventral flap on genital somite, bearing 2 long setae 45 and 52 µm.

Spermatophore not seen.

Color as in female.

Etymology: the specific name temperatus, Latin meaning having proper limits, temperate, alludes to the relatively slight modification in the shape of the genital double-somite of the female, as compared with congeners.

Remarks: Aphotopontius temperatus may be distinguished from its 10 congeners by the form of the rectangular genital double-somite in the female, possessing only a pair of small anterolateral rounded expansions.
thickness 0.19 mm. Epimera of somites bearing legs 1-4 pointed as in adult. Ratio of length to width of prosome 1.3:1. Ratio of length of prosome to that of urosome 1.54:1.

Somite bearing leg 5 (Fig. 5f) 44 x 75 µm. Genital somite 52 x 68 µm with pair of prominent posterolateral spiniform processes. First postgenital somite with pair of small
Figure 5. *Aphotopontius temperatus* n. sp. Copepodid V, female: a, leg 2 and intercoxal plate, anterior (scale B); b, leg 3 and intercoxal plate, posterior (B); c, leg 4 and intercoxal plate, anterior (B); d, endopod of leg 4, anterior (F). Copepodid V, male: e, dorsal (A); f, urosome, ventral (B); g, antennule, ventral (B).

*Caudal ramus (Fig. 5f) 39 x 20 µm, ratio 1.95:1, resembling that of female.*

Body surface without visible sensilla.
Rostral area like that of adult. Antennule (Fig. 5g) 220 µm long, 11-segmented, but segments 1 and 2 only partially separated and 5 and 6 weakly separated. Armature: 10, 4, 1, 2, 2, 2, 2, 2, 2 + 1 aesthetasc, and 12. Antenna as in adult.

Oral cone, mandible, maxillula, maxilla, and maxilliped like those in adult.

Legs 1-4 (Fig. 6a-d) with 3-segmented exopods and endopods, except 2-segmented endopod in leg 4. Armature:

<table>
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<tr>
<th>p1</th>
<th>coxa 0-1</th>
<th>basis 1-1</th>
<th>exp 1-1;</th>
<th>I-1;</th>
<th>II, I, 4</th>
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<tr>
<td></td>
<td>exp 0-1;</td>
<td>0-2;</td>
<td>1, 2, 3</td>
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<tr>
<td>p2</td>
<td>coxa 0-1</td>
<td>basis 10</td>
<td>exp 1-1;</td>
<td>I-1;</td>
<td>III, I, 4</td>
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<tr>
<td>p3</td>
<td>coxa 0-1</td>
<td>basis 14</td>
<td>exp 1-1;</td>
<td>I-1;</td>
<td>III, I, 5</td>
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<tr>
<td></td>
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<td>0-2;</td>
<td>1, 1, 3</td>
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<td></td>
</tr>
<tr>
<td>p4</td>
<td>coxa 0-0</td>
<td>basis 14</td>
<td>exp 1-1;</td>
<td>I-1;</td>
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Leg 5 (Fig. 5f) similar to that of adult.

Leg 6 incomplete flap on genital somite bearing 2 setae as in adult.

Color as in adult.

Remarks: the most notable features of copepodid V, when compared with the adult, are the reduction in the number of postgenital somites to 2 in the female and 3 in the male, the incompletely separated segments in the antennule of both sexes, the 2-segmented rami on legs 1-4 in the female, and the nongeniculate nature of the antennule in the male.

While the specimens described here as copepodid V were obviously not obtained by rearing, they are considered as copepodid V of *Aphotopontius temperatus* on the basis of (1) their similarities in external anatomy to the adults, (2) their occurrence in large numbers along with adults of the new species, and (3) their size range falling just below but not overlapping that of the adult. (A few younger
copepodids were also present in the samples, but are not described here because of their uncertain linkage to *A. temperatus*.

Information on the copepodid stages of siphonostomatoid copepods is scarce. Although developmental stages are known for certain siphonostomatoids living on fishes, for example, *Caligus* (see Kabata, 1972), *Lepeophtheirus* (see Boxshall, 1974), the larval development of those siphonostomatoids associated with hosts other than fishes is very incomplete (Ferrari, 1988). Nothing is known of the copepodid development of the Dirivulidae.

The sexual difference in segmentation of the rami of legs 1-3, such as that seen in the fifth copepodid of *Aphotopontius temperatus*, with the endopod of the female 2-segmented but that of the male 3-segmented, is remarkable. A sexual difference in segmentation occurs in the fifth copepodid of the notodelphyid copepod *Pygodelphys aquilonaris* Illg, where the endopod of leg 4 is 2-segmented but in the male 3-segmented (Dudley, 1966, fig. 28h, j). However, in certain poecilostomatoid copepods where the fifth copepodid is known, for example, *Lichomolgus canui* G. O. Sars, in Costanzo (1968); *Leptinogaster major* (Williams), in Humes (1986); and *Pseudanthessius gracilis* Claus, in Costanzo *et al.* (1996), the endopod is 3-segmented in both sexes.

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**Table 1.** Siphonostomatoid copepods at hydrothermal vent sites on the Mid-Atlantic Ridge.

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**Table 1.** Siphonostomatoid copepods at hydrothermal vent sites on the Mid-Atlantic Ridge.

**Tableau 1.** Copépodes siphonostomatoides des sites hydrothermaux de la Ride Médio-Atlantique.

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Mid-Atlantic Ridge by examining the formula for the endopod of leg 4, which is 0-0; 1 in Rimipontius Humes, 1996, and 0-0; 1 in Stygiopontius Humes, 1987.

Thirteen siphonostomatoid copepods occur at hydrothermal sites on the Mid-Atlantic Ridge (Table 1). Ten species live at 23° and 26°N in depths of 3490-3650 m. The remaining three species are found at 37°N in depths of 1635-1688 m. Van Dover et al. (1996) considered the Lucky Strike fauna, at 37° in a depth of approximately 1636 m, to be a biogeographic hydrothermal province, with a characteristic hydrothermal community. However, explanations for the distribution of the siphonostomatoid copepods known from the Mid-Atlantic Ridge, and for whether a barrier truly exists between 23°-26°N and 37°, remain unknown.

Stygiopontius Humes, 1987
Stygiopontius rimivagus, new species (Figs. 7-9)

Type material: 7 d d from Jason mussel samples (Sintra 2), Lucky Strike, 37°17′N, 32°16′W, west of the Azores (location shown on map in Van Dover et al., 1996), 1688 m, 28 July 1996. Cindy Lee Van Dover collector. Holotype (USNM 285473) and 4 paratypes (USNM 285474) deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. Remaining paratypes (dissected) in the collection of the author.

Male: body (Fig. 7a) with prosome moderately broadened, rostral region denoted by pair of slight indentations in contour. Length 0.79 mm (0.72-0.87 mm) and greatest width 0.43 mm (0.42-0.45 mm), based on 7 specimens. Greatest dorsoventral thickness 0.28 mm. Somite bearing leg 1 fused with cephalosome. Epimera of somites bearing legs 3 and 4 pointed posteriorly (Fig. 7b). Ratio of length to width of prosome 1.28:1. Ratio of length of prosome to that of urosome 1.54:1.

Somite bearing leg 5 (Fig. 7c) 52 x 125 µm. Genital somite in dorsal view 68 x 127 µm, wider than long with gently rounded lateral margins. Four postgenital somites from anterior to posterior 52 x 101, 52 x 94, 34 x 83, and 34 x 83 µm.

Caudal ramus (Fig. 7d) 47 x 34 µm, slightly longer than wide, ratio 1.38:1. Outer lateral seta 52 µm, dorsal seta 50 µm, and outermost terminal seta 52 µm, all smooth. Innermost terminal seta 156 µm, and 2 median terminal setae 242 (outer) and 418 µm (inner), all with lateral setules (innermost seta with setules on medial side only).

Body surface with few sensilla (Fig. 7a,c).

Rostral area (Fig. 7e) not developed. Antennule (Fig. 7f) 210 µm long in geniculate condition as in figure. Approximate lengths of its 12 segments: 39, 10, 31, 15, 13, 13, 34, 23, 26, 50, 42, and 18 µm, respectively. All setae smooth, except modified stout sclerotized element on segment 5 with subterminal setule and tip with minute knobs (Fig. 7g). Antenna (Fig. 8a) with short smooth coxa, elongated basis with inner and outer marginal setules. Exopod 1-segmented, 8 x 5 µm, bearing 3 setae, middle seta very long. Endopod 2-segmented, first segment unarmed, second segment with 1 inner marginal seta (few minute setules near base), 1 subterminal outer seta 18 µm (few minute setules near base), and 2 long terminal finely barbed setae 78 µm and 39 µm.

Oral cone short resembling that of Stygiopontius cladarus Humes, 1996. Mandible (Fig. 8b) slender blade 100 µm long with few minute subterminal teeth. Maxillule (Fig. 8c) and maxilla (Fig. 8d) as illustrated. Maxilliped (Fig. 8e) similar to that of S. cladarus, but second segment with few outer marginal setules.

Ventral area between maxillipeds and first pair of legs resembling that in S. cladarus.

Legs 1-4 (Figs. 8f-h, 9a) segmented and armed as in congeners. Formula for armature as follows:

- P1: coxa 0-1 basis I-1 exp I-1; I-1; II,4,3
- P2: coxa 0-0 basis I-0 exp I-1; I-1; III,4,3
- P3: coxa 0-0 basis I-0 exp I-1; I-1; III,5,3
- P4: coxa 0-0 basis I-0 exp I-1; I-1; III,4,3

Leg 1 (Fig. 8f) with coxa having inner plumose seta and basis bearing inner setiform spine 27 µm. Third segment of endopod of leg 2 (Fig. 8g) with 4 stout finely barbed spines and 2 plumose setae. Endopod of leg 4 (Fig. 9b) with small unarmed first segment 16 x 13 µm. Elongate second segment 47 x 15.5 µm, bearing terminal barbed spine 60 µm and subterminal plumose seta 90 µm.

Leg 5 (Fig. 9c-e) located ventrally, with free segment oval, 17 x 13 µm, bearing 3 setae 52, 23, and 44 µm; setae on body adjacent to free segment 60 µm, with swollen base. All setae smooth.

Leg 6 (Fig. 9c) posteroventral flap on genital somite bearing 2 smooth setae 65 µm and 47 µm.

Spermatophore seen only inside genital somite, as in Figs. 7a, c, 9e.

Color uncertain but presumably red as in Aphotopontius temperatus, above.

Female unknown.

Etymology: the name rimivagus is a combination of the Latin words rima, meaning a fissure or cleft, and vagus, wandering, alluding to the habitat near vents.

Remarks: at present the genus Stygiopontius contains 22 species, including the new species described here. In 10 species only females are known. Stygiopontius rimivagus can be compared with 11 congeners in which males are known. Seven of these species differ from the new species
Figure 7. *Stygiopontius rimivagus* n. sp. Male: a, body, dorsal (scale A); b, outline of epimera of metasomal somites, dorsal (B); c, urosome, dorsal (B); d, anal somite and caudal ramus, dorsal (B); e, rostral area, ventral (E); f, antennule, anterodorsal (C); g, segment 5 of antennule, posteroventral (F).

Figure 7. *Stygiopontius rimivagus* n. sp. Mâle : a, corps, vue dorsale (échelle A) ; b, contour des epimères des somites métasomaux, vue dorsale (B) ; c, urosome, vue dorsale (B) ; d, somite anal et rame caudale, vue dorsale (B) ; e, région du rostre, vue ventrale (E) ; f, antennule, vue antérodorsale (C) ; g, cinquième segment de l’antennule, vue postéroventrale (F).
Figure 8. *Stygiopontius rimivagus* n. sp. Male: a, antenna, postero-outer (scale C); b, mandible, flat view (C); c, maxillule, posterior (C); d, maxilla, posterior (C); e, maxilliped, posterior (B); f, leg 1 and intercoxal plate, anterior (C); g, leg 2 and intercoxal plate, anterior (E); h, leg 3 and intercoxal plate, anterior (E).

Figure 8. *Stygiopontius rimivagus* n. sp. Mâle : a, antenne, vue postérieure externe (échelle C) ; b, mandibule, vue à plat (C) ; c, maxillule, vue postérieure (C) ; d, maxilla, vue postérieure ; e, maxillipède, vue postérieure (B) ; f, patte 1 et plaque intercoxale, vue antérieure (C) ; g, patte 2 et plaque intercoxale, vue antérieure (E) ; h, patte 3 et plaque intercoxale, vue antérieure (E).
in having the free segment of leg 5 armed with five elements (instead of three as in S. rimivagus): S. appositus, S. cladarus, S. paxillifer, S. quadrispinosus, S. regius, S. serratus, and S. verruculatus. Of the remaining four species, two may be distinguished from the new species by the formula for the third segment of the endopod of leg 2, with S. brevispina having 1,II,3 and S. lauensis having 1,III,2. The other two species, S. mirus and S. latulus, have the formula IV,2, as in the new species, but the four spines are very unequal in length, with one being much longer than the others.

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References


