

Redescription of *Haloptilus caribbeanensis* (Copepoda: Calanoida) from the Pacific, with Remarks on the Morphology of Antennules in the Genus *Haloptilus*

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Haloptilus caribbeanensis Park, 1970 (Copepoda, Calanoida, Augaptilidae) is redescribed in detail on the basis of an adult female collected from Suruga Bay, Japan. This is the first record of the species from the Indo-Pacific region. Morphology of the Pacific specimen agrees well with that of the Caribbean Sea and Gulf of Mexico specimens, except for the numbers of mandibular teeth. The former has five teeth and the latter six teeth on mandible. The segmentation and segmental aesthetasc numbers of female antennules of *H. caribbeanensis* are compared with those of five species of *Haloptilus* (*H. angusticeps*, *H. fons*, *H. longicornis*, *H. ornatus* and *H. spiniceps*). These characters show morphological differentiation at the species level. *H. caribbeanensis* has no aesthetasc on the proximal segments II, IV, and VI of the female antennules.

Key words: Calanoida, Augaptilidae, *Haloptilus caribbeanensis*, the Indo-Pacific region, antennule, aesthetasc, Suruga Bay

Introduction

The genus *Haloptilus* Giesbrecht, 1898 consisting of 28 nominal species is one of the most primitive groups in the family Augaptilidae Sars, 1905 (Matthews, 1972; Soh, 1998). So far there is no report on appearance of *H. caribbeanensis* Park, 1970 in the outside of the Caribbean Sea and Gulf of Mexico, where this species was originally described. Park (1988) found that *Haloptilus* species showed variation in number of elements on oral appendages between congeners.

In the taxonomic studies on copepods from the Caribbean Sea and Gulf of Mexico, *H. caribbeanensis* was first referred as *H. furcatus* Sars, 1920 (Grice, 1969). However, Park (1970) elucidated the morphological differences between *H. caribbeanensis* and *H. furcatus*, and distinguished the former as a new species from the latter.

H. caribbeanensis also has been considered to be the primitive species of the genus (Park, 1988). Of 28 known species of genus *Haloptilus*, *H. caribbeanensis* is the sole species in the genus with the most specialized 2-segmented endopod on leg 1.

In this paper we redescribe *H. caribbeanensis* from Japanese waters in detail. Additionally, we compare the segmentation and the aesthetasc patterns on the antennule among six species of *Haloptilus* (*H. angusticeps*, *H. caribbeanensis*, *H. fons*, *H. longicornis*, *H. ornatus* and *H. spiniceps*), and discuss the phylogenetic relationships between congeners.

Material and Methods

The present study is based on the specimens deposited in the Institute of Oceanic Research & Development of Tokai University, Japan. Only one specimen of *Haloptilus caribbeanensis* Park, 1970 was found throughout 19 cruises in Suruga Bay during 1980-1992. The specimen was dissected and mounted in Gum-chloral medium, and observed

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and illustrated with a differential interference contrast microscope (Olympus BX-50) equipped with a drawing tube. Morphological terminology is adopted from Huys and Boxshall (1991).

Family Augaptilidae Sars, 1905

Haloptilus caribbeanensis Park, 1970
(Figs. 1-2 and 3E)

Systematic Account

Superfamily Arietelloidea Sars, 1902

Material examined. 1 ♀, Japan: Suruga Bay, 34° 51.06'N 138°38.01'E 34°52.09'N 138°38.00'E, depth 360~400 m, 8 Nov. 1991.

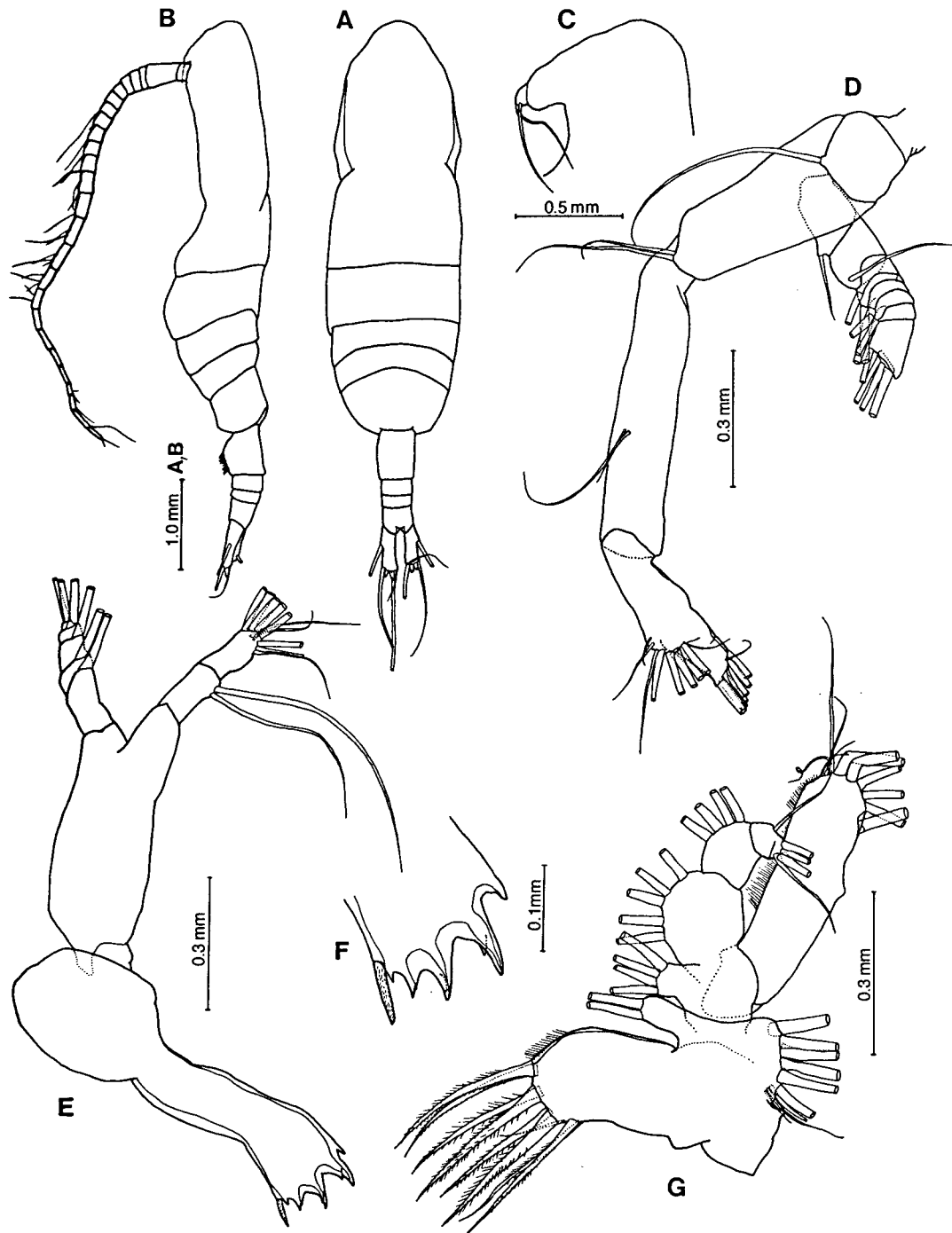


Fig. 1. *Haloptilus caribbeanensis*, female. A, Habitus, dorsal view; B, Habitus, lateral view; C, Rostrum, lateral view; D, Antenna; E, Mandible; F, Mandibular cutting edge; G, Maxillule.

Description. Female. Body (Fig. 1A, B) length 6.15 mm (prosome length 4.55 mm). Cephalosome roundly produced anteriorly. Rostrum (Fig. 1C) well developed, with two long filaments. Posterior corners of prosome widely round, symmetrical. Genital

double-somite with tuft of hairs ventrally. Left caudal ramous slightly longer than right one.

Antennule (Fig. 1B) reaching about end of caudal ramous. Ancestral segments I to III and XXVII to XXVIII completely fused. Fusion pattern and

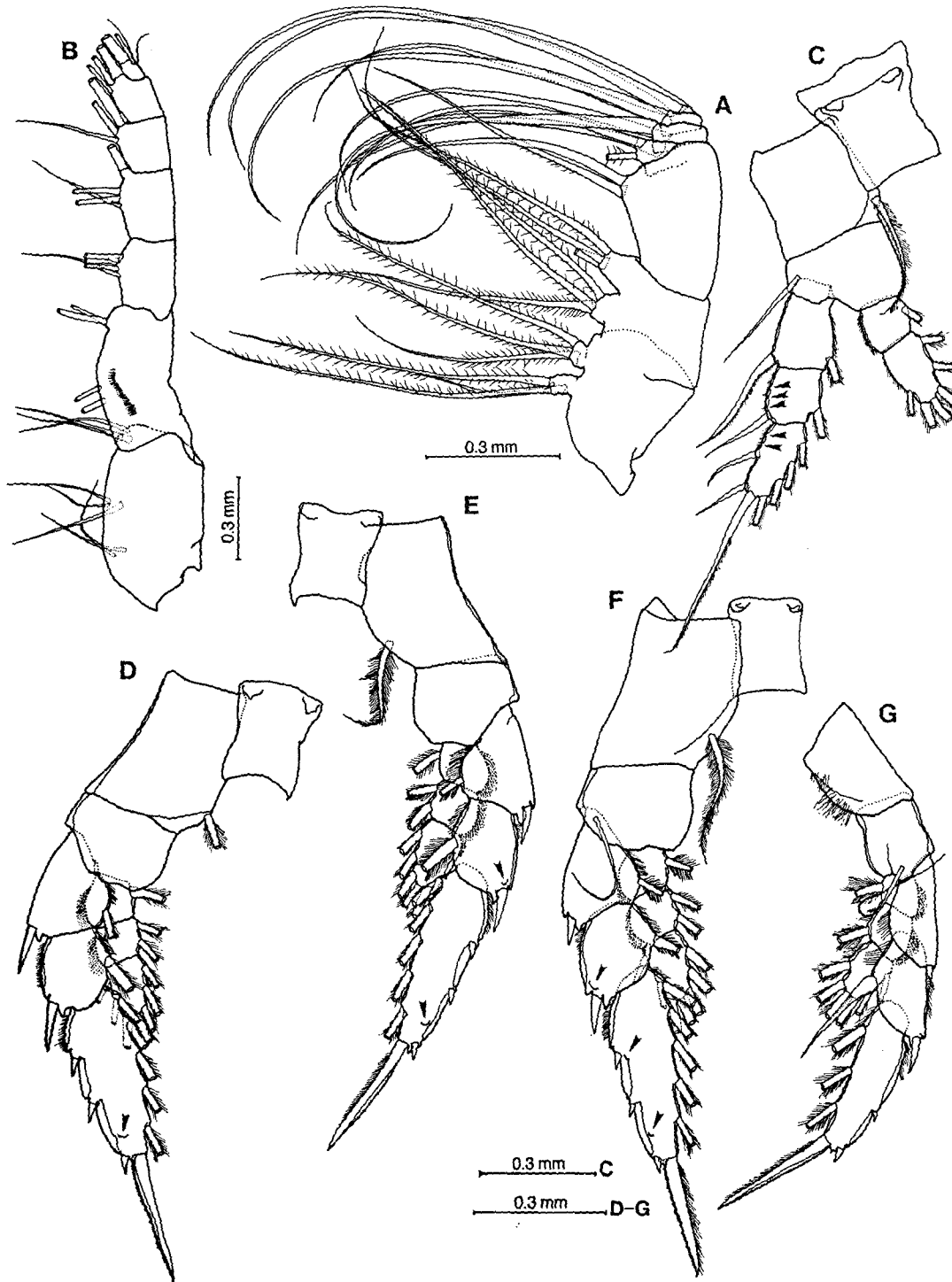


Fig. 2. *Haloptilus caribbeanensis*, female. A, Maxilla; B, Maxilliped; C, Leg 1; D, Leg 2; E, Leg 3; F, Leg 4; G, Leg 5. Arrowheads indicate positions of gland openings.

armature as follows: I-III-7+2 aesthetascs, IV-2, V-2 + aesthetasc, VI-2, VII-2 + aesthetasc, VIII-2 + aesthetasc, IX-2 + aesthetasc, X-2 + aesthetasc, XI-2 + aesthetasc, XII-2 + aesthetasc, XIII-2 + aesthetasc, XIV-2 + aesthetasc, XV-2 + aesthetasc, XVI-2 + aesthetasc, XVII-2 + aesthetasc, XVIII-2 + aesthetasc, XIX-2 + aesthetasc, XX-2 + aesthetasc, XXI-2 + aesthetasc, XXII-1, XXIII-1 + aesthetasc, XXIV-1+1, XXV-1+1 + aesthetasc, XXVI-1+1, XXVII-XXVIII-6 + aesthetasc. Antenna (Fig. 1D) with coxa bearing 1 inner seta; basis with 2 setae of unequal length; endopod about 1.9 times as long as exopod; first endopodal segment bearing 2 setae of unequal length nearly twice as long as second segment carrying 9 setae on inner lobe and 7 setae on outer lobe; exopod 8-segmented and segmental fusion: I-1, II-1, III-1, IV-1, V-1, VI-1, VII-1, VIII-X-4. Mandible (Fig. 1E, F) with coxal gnathobase bearing 5 subequal teeth and strongly chitinized dorsalmost seta; first and second central teeth elongate; mandibular palp lacking basal seta, with both rami nearly equal in length; endopod 2-segmented, first endopodal segment with 2 setae, second with 10 setae; exopod 5-segmented, with setation formula of 1, 1, 1, 1, 2. Maxillule (Fig. 1G) with 9 spiniform setae on praecoxal arthrite; coxa with 2 setae on endite and 9 setae on epipodite; basis bearing 4 and 5 setae on first and second endites, respectively; endopod with 2 free segments, first segment with 4 setae, second segment with 1 subterminal seta and 4 terminal setae; exopod very elongate, with 11 setae. Maxilla (Fig. 2A): praecoxa and coxa incompletely separate; proximal endite of praecoxa with 3 setae and 1 vestigial element, distal endite with 3 setae; 2 endites of coxa each with 3 setae; basis with 2 setae; endopod 4-segmented, setal formula of endopod: 3, 3, 2, 2. Maxilliped (Fig. 2B): syncoxa with first to fourth endites bearing 0, 2, 3, and 3 setae, respectively; basis with 2 medial setae, armed with minute spinules or setules along inner margin; endopod with 5 free segments plus first endopodal segment completely incorporated into basis; setation formula of endopod 2, 4, 4, 3, 3, 4.

Leg 1 (Fig. 2C) with 2-segmented endopod bearing setal formula of 0-1; 1, 2, 3. Second and third exopodal segments of leg 1 with 3 and 2 gland openings on outer margin, respectively (indicated by arrowheads in Fig. 2C). Leg 2 (Fig. 2D) with 1 gland opening on third exopodal segment (indicated by arrowhead in Fig. 2D). Leg 3 (Fig. 2E) with 1 gland opening on second and third exopodal

segments, respectively (indicated by arrowheads in Fig. 2E). Leg 4 (Fig. 2F) with 1 and 2 gland openings on second and third exopodal segments (indicated by arrowheads in Fig. 2F). Leg 5 (Fig. 2G) with tuft of setules on inner margin of coxa, lacking inner coxal seta; second exopodal segment with large spiniform inner seta.

Male. unknown.

Remarks. *Haloptilus caribbeanensis* Park, 1970 was originally described as *H. furcatus* Sars, 1920 by Grice (1969). However, Grice's specimen was easily distinguished from Sars' (1920, 1924, 1925) one: 1) 5 setae on second endopodal segment of maxillule (4 setae in *H. furcatus*); 2) 3 setae on second proximal endite on syncoxa (2 setae in *H. furcatus*); 3) 2-segmented endopod of leg 1 (3-segmented endopod in *H. furcatus*). Park (1970) established *H. caribbeanensis* as a separate species from *H. furcatus* Sars, 1920 on the basis of morphological differences between them. *H. caribbeanensis* collected from Suruga Bay is 6.14 mm long and it corresponds to the intermediate size of Grice's (1969) (5.83 mm) and Park's (1970) (6.42 mm) females from the Caribbean Sea and Gulf of Mexico. In this study, *H. caribbeanensis* is its first record from the Pacific. The present specimen from Suruga Bay slightly differs from the specimens of the Caribbean Sea and Gulf of Mexico: the former has 5 teeth on mandibular cutting edge, but the latter 6 teeth. Three inner setae on the right third endopodal segment of leg 5 are considered as abnormal, since the present specimen bears 2 inner setae on the left third endopodal segment of leg 5 as in most of augaptilids.

Discussion

The genus *Haloptilus* Giesbrecht, 1898 has many primitive states on oral appendages and legs (Park, 1988; Soh, 1998). Park (1988) redefined the genus *Haloptilus*, with a key to the species of the Antarctic and Subantarctic waters. He also divided the genus into three groups based on the numbers of teeth on the mandibular cutting edge, endopodal segments, and setae on the maxillule and the maxilla: 1) primitive group (*H. angusticeps*, *H. caribbeanensis*, *H. fons*, *H. furcatus* and *H. major*); 2) specialized group (*H. acutifrons*, *H. longicirrus*, *H. longicornis*, *H. mucronatus*, *H. ocellatus*, *H. ornatus*, *H. oxycephalus*, *H. paralongicirrus*, *H. plumosus*, *H. pseudooxycephalus*, *H. spiniceps* and

H. tenuis); 3) neither primitive nor specialized group (*H. austini*, *H. chierchiaie* and *H. validus*). Soh (1998) reported that the species carrying 3-segmented endopod on the maxillule also retain many primitive setations on other oral appendages whereas species bearing uni-segmented endopod show diminished setation and segmentation on those. In addition to the characters described by Park's (1988), therefore, the segmentation of maxillular endopod can be important to analysis the phylogenetic relationships between the congeners (Soh, 1998).

In the Park's (1988) primitive group *H. caribbeanensis* is the sole species having 2-segmented endopod on leg 1. According to Hulsemann (1991), the proximalmost inner seta on the distal endopodal segment of leg 1 probably corres-

ponds to the inner seta on the second endopodal segments of the congeners and separation of the second endopod might be suppressed in the ontogenetic development of leg 1 in *H. caribbeanensis*. Like the other primitive species *H. angusticeps* and *H. fons*, *H. caribbeanensis* lacks aesthetasc on the proximal segments II, IV, VI of the female antennules (see Fig. 3), indicating synapomorphy. On the other hand, additional aesthetascs are present in the proximal segments VIII to X and XII and XIII of the primitive species, *H. angusticeps* and *H. fons* as well as the specialized species, *H. spiniceps*. All males of *Haloptilus* also have additional aesthetascs on the proximal segments of the antennules (see Fig. 4). Boxshall and Huys (1998) suggested that the aesthetasc patterns should be considered with

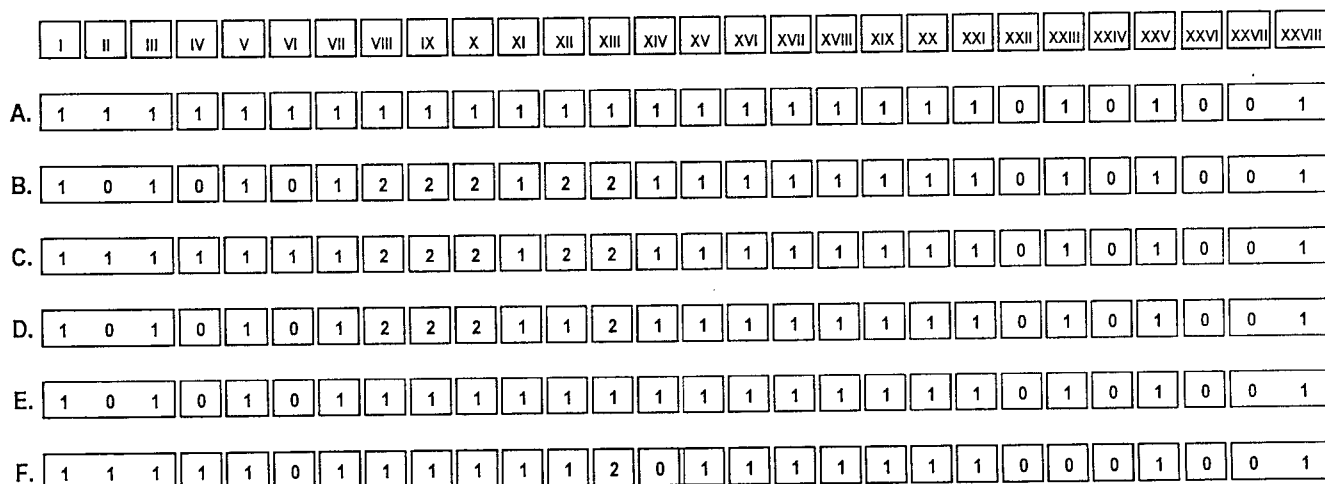


Fig. 3. Schematic comparison of segmentation and segmental aesthetasc numbers of female antennules between six species of *Haloptilus*. A, *H. ornatus*; B, *H. angusticeps*; C, *H. spiniceps*; D, *H. fons*; E, *H. caribbeanensis*; F, *H. longicornis*.

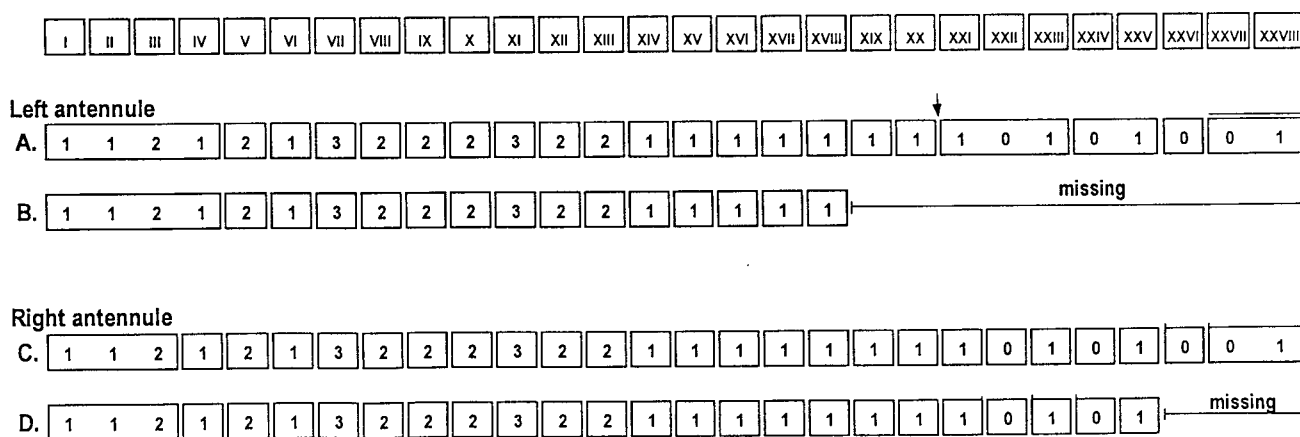


Fig. 4. Schematic comparison of segmentation and segmental aesthetasc numbers of male geniculate antennules between *Haloptilus fertilis* and *H. chierchiaie*. A, C, *Haloptilus fertilis*; B, D, *H. chierchiaie*. Arrow indicates position of geniculation.

caution in phylogenetic analysis, because aesthetasc can be easily lost and regained within well-defined lineage.

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References

- Boxshall, G.A. and R. Huys. 1998. The ontogeny and phylogeny of copepod antennules. *Phil. Trans. R. Soc. Lond. B*, 353, 765~786.
- Grice, G.D. 1969. Calanoid copepods from the Caribbean Sea and Gulf of Mexico. 1. New species and new records from midwater trawl samples. *Bull. Mar. Sci.*, 19, 446~455.
- Hulsemann, K. 1991. Tracing homologies in appendages during ontogenetic development of calanoid copepods. *Bull. Plankton Soc. Japan, Spec. Vol.*, 105~114.
- Huys, R. and G.A. Boxshall. 1991. *Copepod Evolution*. Ray Society, London, 468 pp.
- Matthews, J.B.L. 1972. The genus *Euaugaptilus* (Crustacea, Copepoda). New descriptions and a review of the genus in relation to *Augaptilus*, *Haloptilus* and *Pseudaugaptilus*. *Bull. Br. Mus. Nat. Hist. Zool.*, 24, 1~71, figs. 1~13, tables 1~7.
- Park, T. 1970. Calanoid copepods from the Caribbean Sea and Gulf of Mexico. 2. New species and new records from plankton samples. *Bull. Mar. Sci.*, 20, 472~546, figs. 1~402.
- Park, T. 1988. Calanoid copepods of the genus *Haloptilus* from Antarctic and Subantarctic waters. *Biology of the Antarctic Seas XIX, Antarct. Res. Ser.*, 47, 1~25.
- Sars, G.O. 1920. Calanoides recueillis pendant les campagnes de S.A.S. le Prince Albert de Monaco (Nouveau supplément). *Bull. Mus. Oceanogr. Monaco* No. 377, 20pp.
- Sars, G.O. 1924. Copépodes particulièrement bathypélagiques provenant des campagnes scientifiques du Prince Albert I^{er} de Monaco. *Planches. Result. Camp. Scient. Prince Albert I*, 69, 46pp., 127 pls.
- Sars, G.O. 1925. Copépodes particulièrement bathypélagiques provenant des campagnes scientifiques du Prince Albert I^{er} de Monaco. *Texte. Result. Camp. Scient. Prince Albert I*, 69, 408 pp.
- Soh, H.Y. 1998. Phylogenetic studies of the calanoid copepod superfamily Arietelloidea, with notes on distribution and feeding habits. Ph.D. thesis, Hiroshima University, 260 pp.