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A new species of *Acartia* (Copepoda, Calanoida) from the Yellow Sea

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Abstract. A new species (*Acartia hongi*) of *Acartia* (family Acartiidae) predominating in the Korean coastal waters of the Yellow Sea is described. This species closely resembles *Acartia bifilosa*, from which it can be easily distinguished by the co-occurrence of the following morphological characters: the absence of rostral filaments in both genders; the terminal spine on the female fifth leg toothed only on the inner side; the first exopodal segment of the male right fifth leg with a long seta; the distal segment of the male left fifth leg with a rod-like appendage. Its distribution was discussed in comparison with two sibling species, *Acartia omorii* and *Acartia hudsonica*.

Introduction

The Acartiidae is one of the most numerous families of copepod in estuarine and coastal environments from tropical to polar latitudes. Many acartiid species have been known as cosmopolitan species. However, recent studies show that the number of cosmopolitan species is surprisingly small (Bradford, 1976; Park, 1994; Reid, 1997/98). This needs the ongoing taxonomic reconsiderations in acartiid species of the western North Pacific.

Copepods identified as *Acartia bifilosa* (Giesbrecht, 1881) in the coastal regions of the Yellow Sea (Shen and Bai, 1956; Chen and Zhang, 1965; Kim, 1985; Kang and Lee, 1990; Yoo *et al*., 1991; Shim and Choi, 1996) have been reported from the north and temperate Atlantic, North Sea, English Channel and Baltic (Gurney, 1931; Rose, 1933; Behrends *et al*., 1997) and the Sea of Okhotsk in the North Pacific (Brodsky, 1950). As such a wide geographical distribution of this brackish and coastal species was thought highly unlikely, *A.bifilosa* from the Yellow Sea was re-examined. We conclude that specimens from the Yellow Sea differ from *A.bifilosa* from the other regions. This species is described here and its morphological and geographical relationships with allied species are discussed.

Method

Zooplankton samples were collected from the southwestern coastal waters of Korea on 25 March, 1998 with a Bongo net (mesh size: 330 μm) obliquely towed from 5 m depth to the surface. The samples were preserved immediately in 6% neutralized formalin/sea water solution. From the samples, individuals of *Acartia* species were sorted out. The body length was measured from the head to the tip of the right furcal ramous under a stereo microscope (Zeiss SV 6) using an ocular micrometer. The rostrum, posterior parts of the last pedigerous somite, urosome

and female fifth leg were further examined with a scanning electron microscope (Hitachi S-4700) to show some morphological details more clearly. The morphological terminology is based on Huys and Boxshall (1991).

Description

Acartia hongi *sp. nov. (Figures 1–12)*

Acartia bifilosa (Giesbrecht, 1881): Shen and Bai, 1956, p. 196, pl. 7, figs 52–54; Chen and Zhang, 1965, p. 112, pl. 49, figs 5–8; Kim, 1985, p. 137, pl. 46, figs f, g, pl. 47, figs a, b; Yoo *et al*., 1991, p. 257, fig. 2; Shim and Choi, 1996, figs 2–4, tables 1, 2; Yoon *et al*., 1998, figs 1–5, tables 1, 2.

Material examined. Hampyung Bay (35°10′121″N, 126°10′648″E). Type specimens are deposited in the Chonnam National University Museum (CNUM), Kwangju, Korea: one female holotype, dissected and mounted on glass slides, CNUM-ZC 1998. 0001; one female and two male paratypes, dissected and mounted on glass slides, 20 male and 20 female paratypes, CNUM-ZC 1998. 0002–0041.

Female. Body (Figure 1A, B) slender. Total length 1.03–1.19 mm (mean ± SD = 1.11 ± 0.05 mm, n = 20). Prosome–Urosome ratio 3.57:1. Prosome 5-segmented; cephalosome and first pedigerous somite completely separate; fourth and fifth pedigerous somites comprising double-somite, with posterodorsally a pair of setules and a row of spinules; posteromedial region without spinules (Figures 2A, 3A). Urosome 3-segmented: genital double-somite having common genital apparatus (Figure 4); posteroventral region furnished with hairs (Figure 4A); anterodorsal region covered with rows of fine setules; second and third segments with spinules and rows of fine setules (Figures 2A, 3B). Caudal rami each having six setae slightly asymmetrical, right ramous slightly longer. Urosomal segments and left caudal ramous with proportions 39:19:18:25 = 100.

Rostrum (Figure 5) without rostral filaments; with integumental pore between paired frontal sensilla. Nauplius eye present. Antennule 19-segmented, extending to genital double-somite (Figure 1B). Segmentation and setation patterns as follows (Figure 1C): I-1, II–VI-5 + aesthetasc, VII–VIII-2 + aesthetasc, IX–X-2, XI–XII-1 + aesthetasc, XIII, XIV–XV-2 + aesthetasc, XVI-1 + aesthetasc, XVII-1, XVIII-1 + aesthetasc, XIX-1, XX-1, XXI-1 + aesthetasc, XX-1, XXIII-1, XXIV-1+1, XXV-1+1 + aesthetasc, XXVI-1+1, XXVII–XXVIII-4 + aesthetasc. Antenna (Figure 1D): coxa with one seta; basis and first endopodal segment fused to form elongate allobasis bearing six proximal setae and one distal seta along inner margin; second endopodal segment elongate, with seven setae; third endopodal segment short, with seven setae. Exopod short, 4-segmented; setation formula 1, 2, 2, 3. Labrum large. Mandible (Figure 1E): coxa with well developed gnathobase; basis bearing one seta covered with spinules; endopod 2-segmented, with two and nine setae on first and second segments, respectively; exopod 5-segmented, with setation formula of 1, 1, 1, 1, 2. Maxillule (Figure 6A): praecoxa and coxa incompletely fused; praecoxal arthrite with nine elements; coxa with

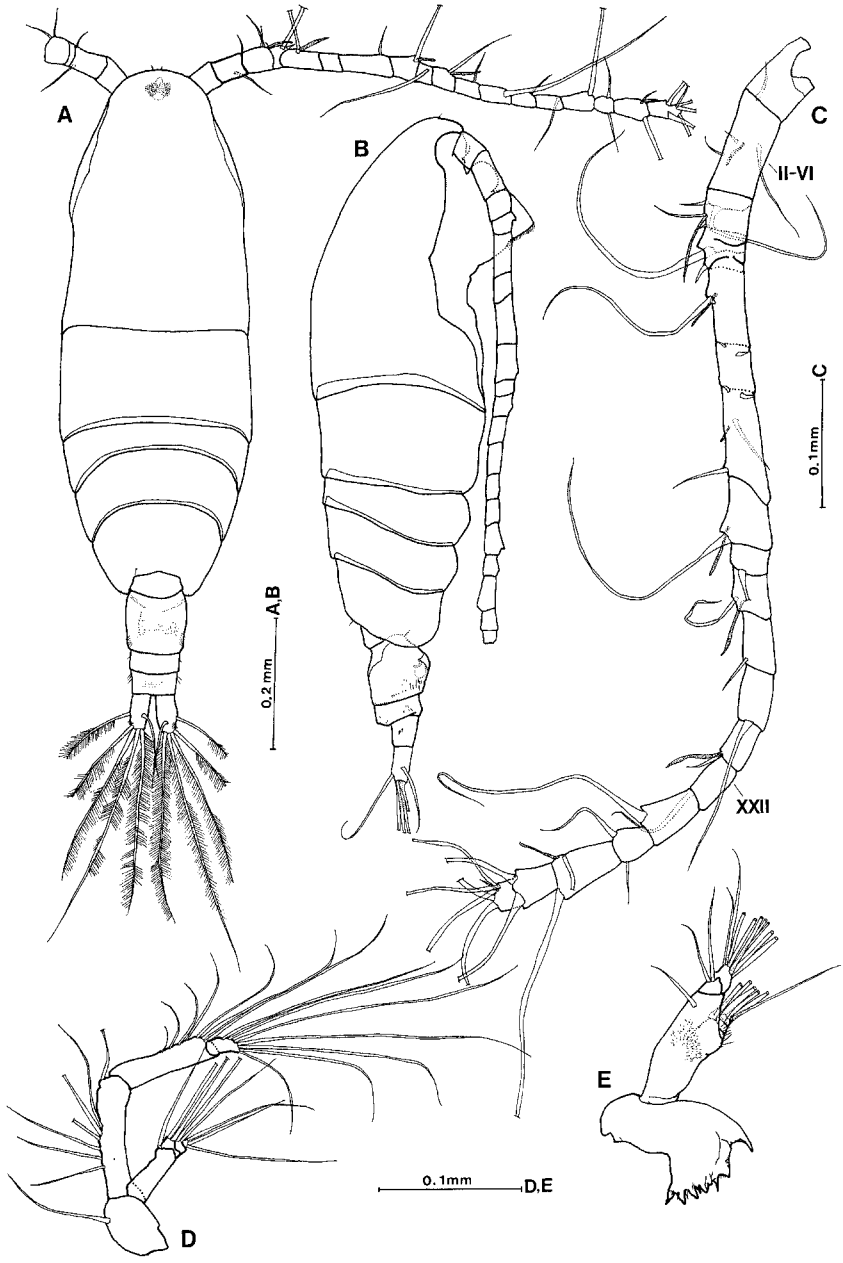

Fig. 1. *Acartia hongi* sp. nov., female (holotype): (**A**) habitus, dorsal; (**B**) habitus, lateral; (**C**) antennule; (**D**) antenna; (**E**) mandible.

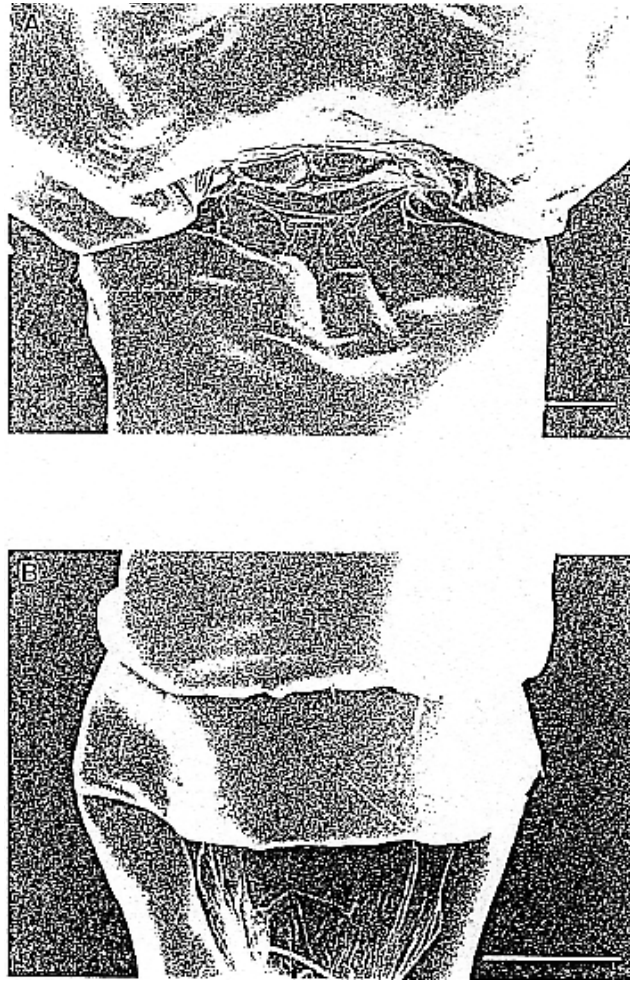

Fig. 2. *Acartia hongi* sp. nov., female: (**A**) last pedigerous somite and partial genital double somite, dorsal; (**B**) second urosomal somite, dorsal. Scale bars = 30.0 μm.

endite bearing three setae and with nine setae on epipodite; basis with one inner seta and one outer seta; endopod absent; exopod bearing seven setae furnished with hairs along inner margin. Maxilla (Figure 6B): praecoxa and coxa incompletely fused, setation formula of endites 4, 2, 2, 3; basis with one seta; endopod 4-segmented, setation formula of 1, 2, 2, 2. Maxilliped (Figure 6C) comprising robust syncoxa, basis, and 2-segmented endopod; syncoxa with setation formula of 0, 2, 2, 1; basis bearing one long seta and one short seta; first and second endopodal segments having three and two short setae.

Swimming legs 1 to 4 (Figure 6D–G) biramous, with 3-segmented exopod and 2-segmented endopod. Leg 1 without basal inner seta; second endopodal segments and third exopodal segment covered with setules on anterior distal regions. Spine and seta formula as follows:

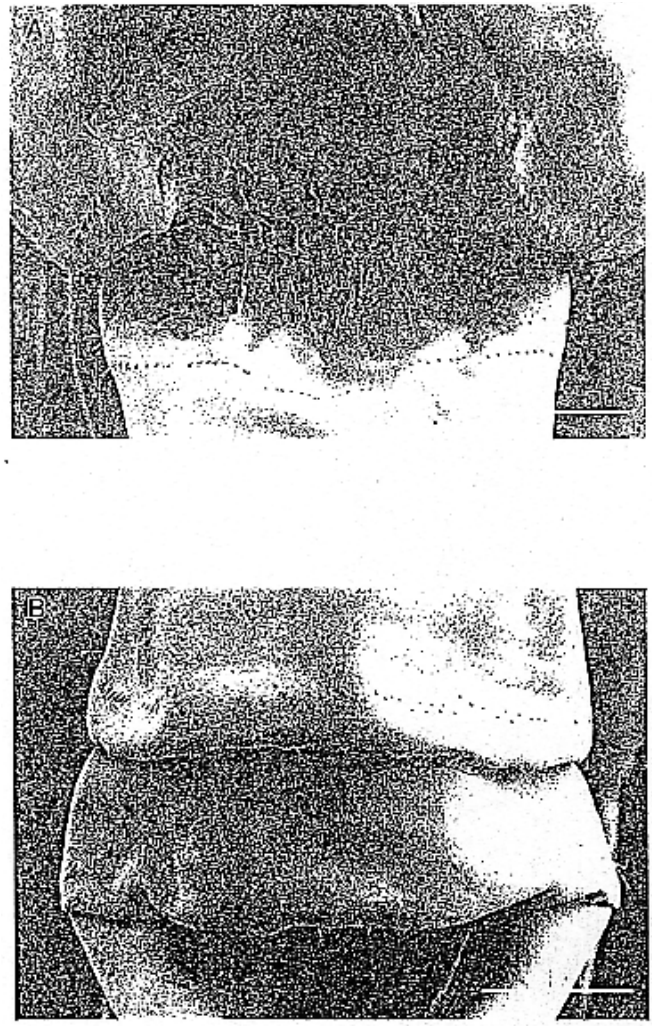

Fig. 3. *Acartia hongi* sp. nov. (different specimen to Figure 2), female: (**A**) last pedigerous somite and partial genital double somite, dorsal; (**B**) second urosomal somite, dorsal. Scale bars indicate 26.7 and 24.0 μm, respectively.

	Coxa	Basis	Exopodal segments	Endopodal segments
P 1	0–0	0–0	I-0; I-1; II, I, 4	0–1; 1, 2, 3
P 2	0–0	0–0	0–1; 0–1; 0, I, 5	0–2; 1, 2, 4
P 3	0–0	0–0	0–1; 0–1; 0, I, 5	0–2; 1, 2, 4
P 4	0–0	1–0	0–1; 0–1; 0, I, 5	0–3; 1, 2, 3

Fifth leg (Figures 6H, 7): coxae completely fused to intercoxal sclerite; basis with outer seta; exopod reduced to spine bulbous at the base; spines armed with comb-like spines along only inner margin of distal part.

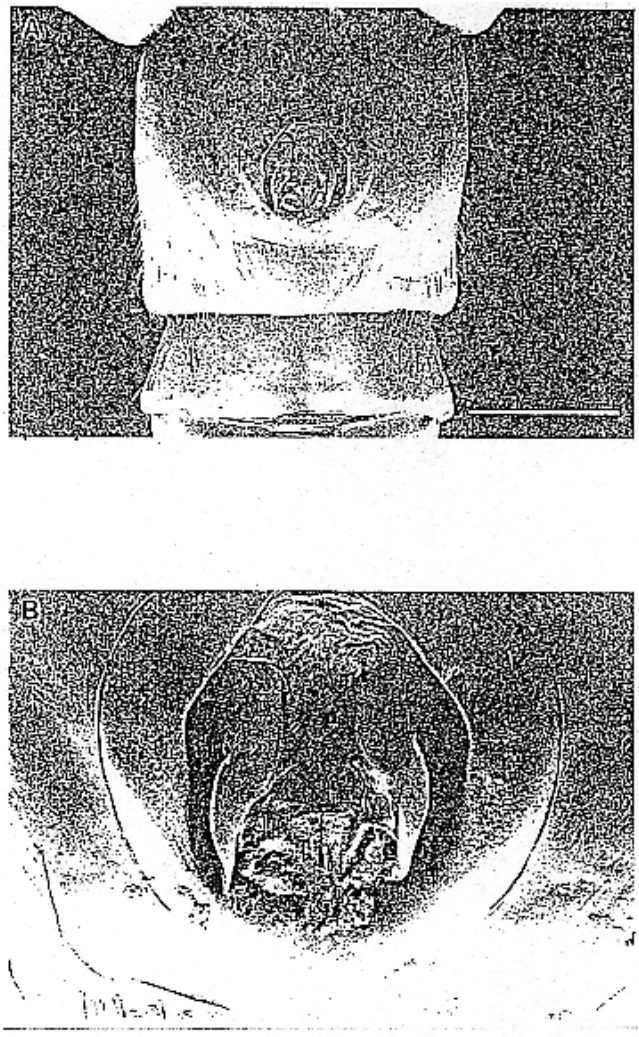

Fig. 4. *Acartia hongi* sp. nov., female: (**A**) genital double-somite, ventral; (**B**) genital aperture, ventral. Scale bars indicate 40.0 and 12.0 μm, respectively.

Male. Body (Figure 8A, B) similar to the female. Total body length 0.79–1.04 mm (mean ± SD = 0.90 ± 0.05 mm, $n = 20$). Prosome–Urosome ratio 3.15:1. Urosome 5-segmented; genital somite furnished with spinules or setules along posterior region of dorsal view; first three abdominal somites covered with spinules; caudal somite bearing setules on lateral region (Figures 8A, 9). Urosomal segments and left caudal ramous with proportions 15:26:17:9:15:18 = 100.

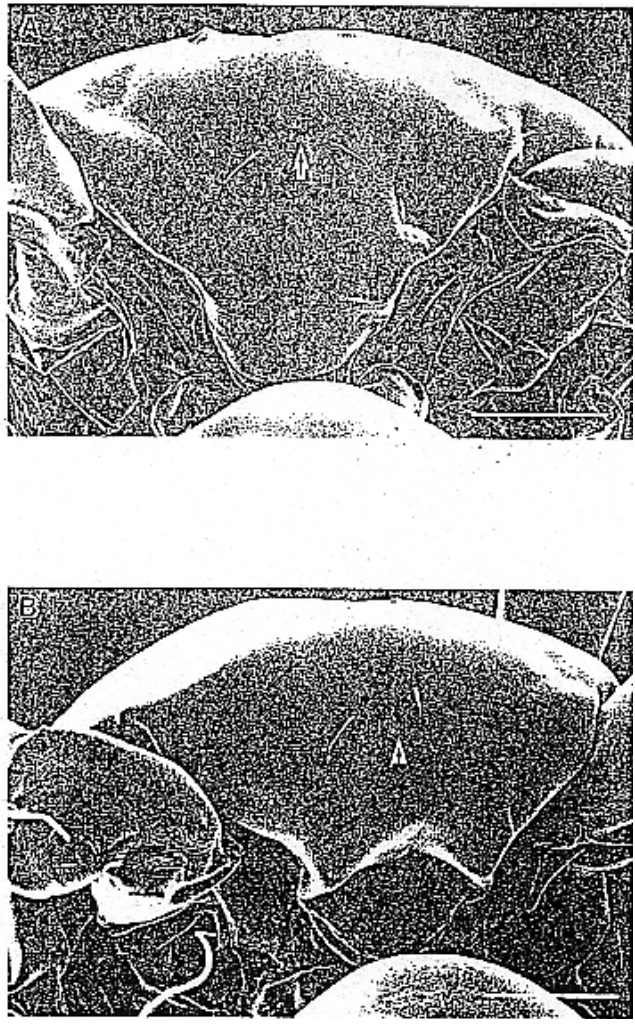

Fig. 5. *Acartia hongi* sp. nov., female: (**A, B**) variability in the rostral sensory complex of two different specimens. Arrows indicate the integumental pore. Scale bars = 30.0 μm.

Rostrum (Figure 10A) similar to the female. Antennule geniculate on right side, 18-segmented (Figure 8C). Segmentation and setation patterns as follows: I-1, II–VI-3 + aesthetasc, VII-1 + aesthetasc, VIII-1 + aesthetasc, IX–XI-4 + aesthetasc, XII, XIII, XIV-2, XV-1 (missing in Figure 8C), XVI-1 + aesthetasc, XVII-1, XVIII-1, XIX-1 + aesthetasc, XX-1, XXI–XXIII-2 + process + aesthetasc, XXIV–XXV-2 + 2 + aesthetasc, XXVI-1 + 1, XXVII–XXVII-3 + aesthetasc. Left antennule 23-segmented: segments IX–XI and XXI–XXIII and XXIV–XXV incompletely or completely separate; segment VII not having aesthetasc, while XIV bearing aesthetasc.

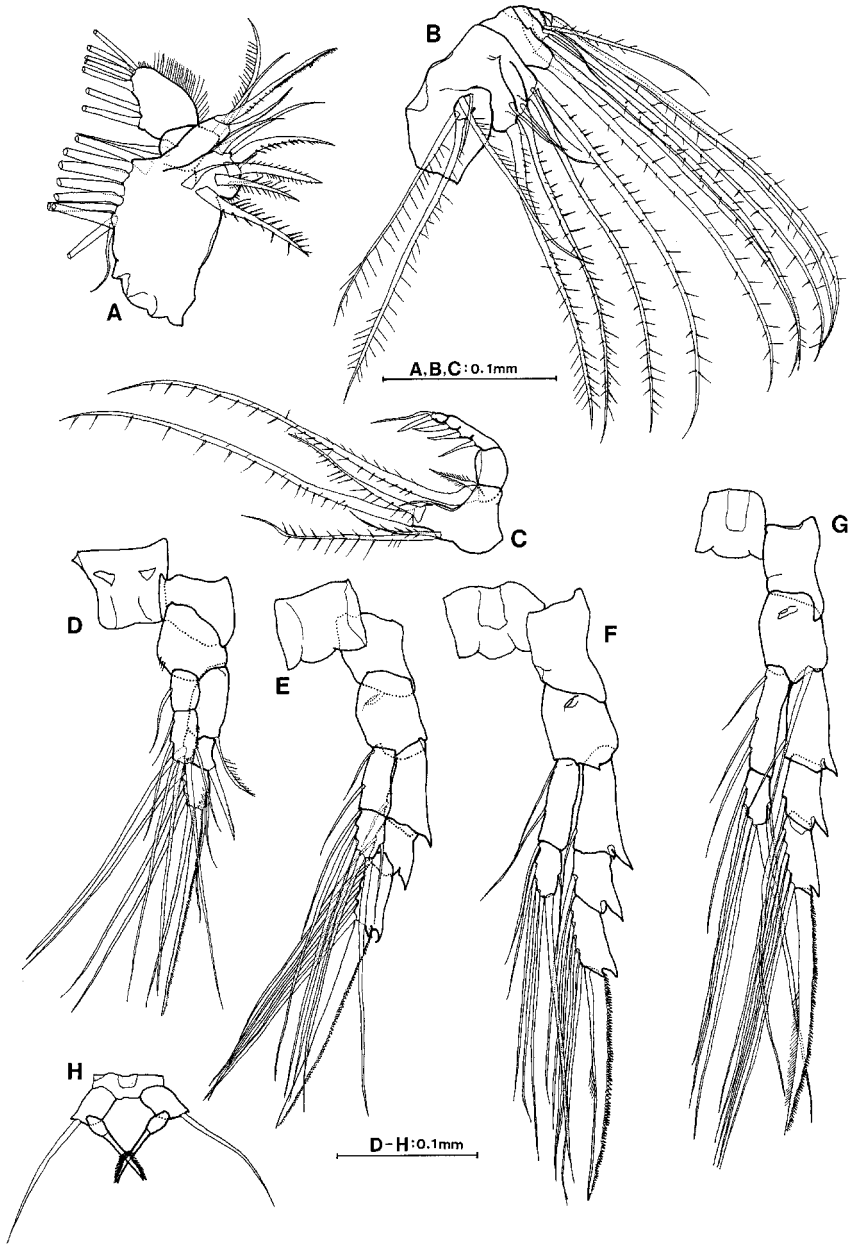

Fig. 6. *Acartia hongi* sp. nov., female (holotype): (**A**) maxillule; (**B**) maxilla; (**C**) maxilliped; (**D**) leg 1; (**E**) leg 2; (**F**) leg 3; (**G**) leg 4; (**H**) leg 5.

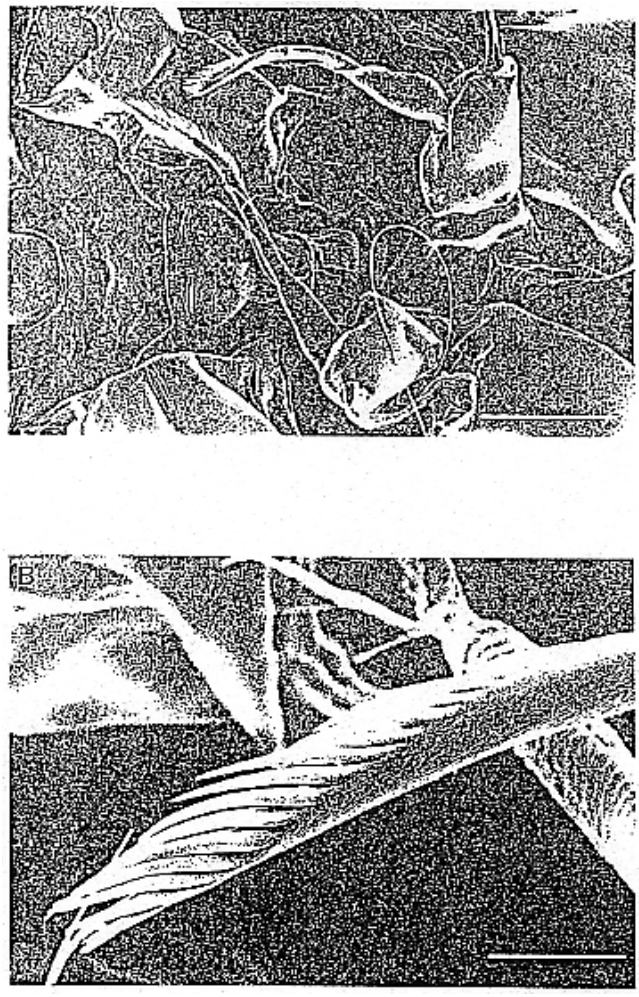

Fig. 7. *Acartia hongi* sp. nov., female: (**A**) leg 5, right spine is twisted; (**B**) spine of leg 5. Scale bars indicate 27.3 and 5.0 μm, respectively.

Fifth legs (Figures 8D, 10B) asymmetrical; intercoxal sclerite completely fused to both coxae; left leg comprising basis armed with outer seta (missing in Figure 8D) and two rows of spinules, plus 2-segmented exopod; distal exopod having a heavy spine plus a rod-like appendage covered with small spines on the tip (Figure 11); right leg comprising basis armed with outer seta, plus 3-segmented exopod; first exopodal segment with one seta, second with two spines on inner lobe and with one outer spine; third bearing two integumental pores armed with three outer spines, terminal spine, and one inner spine.

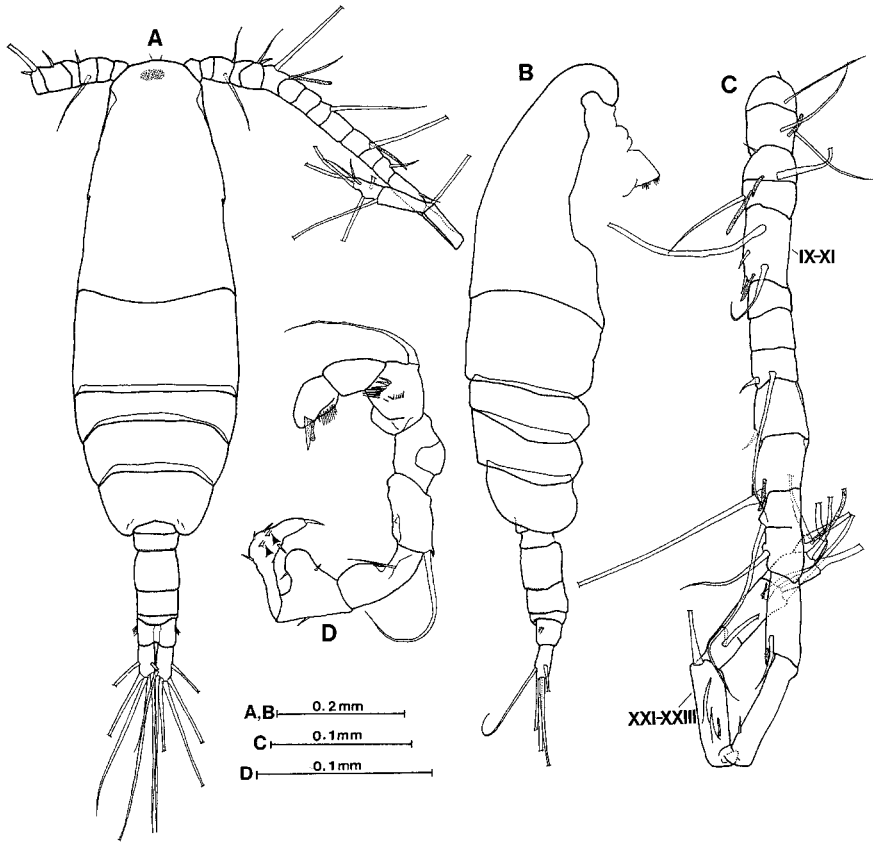

Fig. 8. *Acartia hongi* sp. nov. (paratype), male: (**A**) habitus, dorsal; (**B**) habitus, lateral; (**C**) right antennule; (**D**) leg 5. Arrowheads indicate integumental organs.

Etymology

The species name honours Dr Sung Yun Hong (Pukyung National University, Pusan) in recognition of his many contributions to the biology of marine plankton in Korea.

Remarks

A new species, *Acartia hongi*, closely resembles *A.bifilosa* Giesbrecht, 1881, but it differs from the latter in the following characteristics (Table I): (i) rostral filaments absent in both genders; (ii) female fifth leg with terminal spines toothed only on the inner side; (iii) first exopodal segment of male right fifth leg with long seta; (iv) distal segment of male left fifth leg with a rod-like appendage. Contrary to *A.hongi* being without rostral filaments, all specimens of *A.bifilosa* have rostral

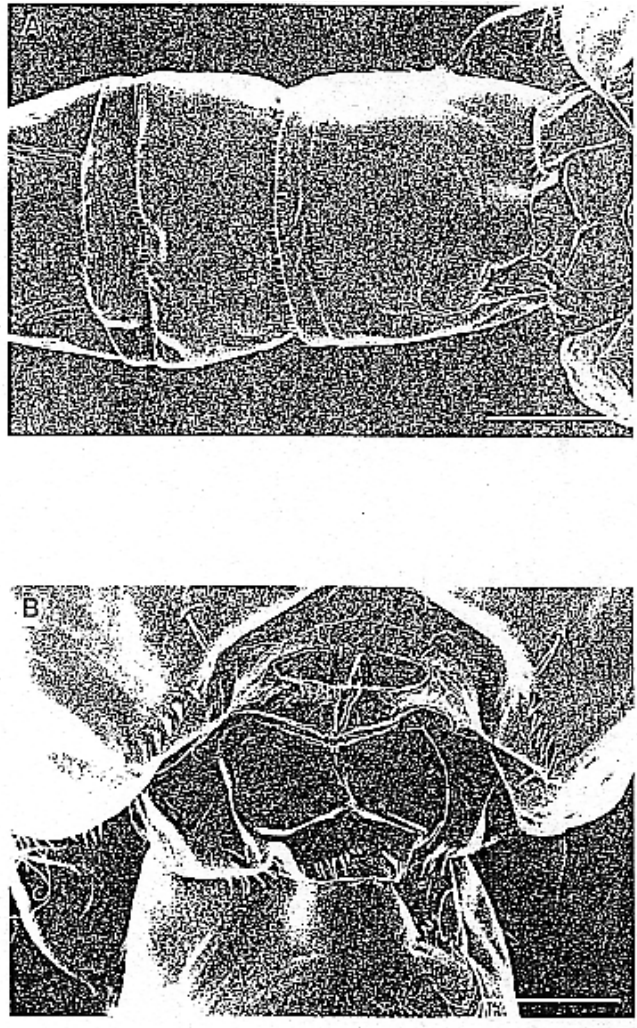

Fig. 9. *Acartia hongi* sp. nov., male: (**A**) urosome; (**B**) last pedigerous and genital somites. Scale bars indicate 30.0 and 20.0 μm, respectively.

filaments (Rose, 1933; Brodsky, 1950; Castro-Longoria and Williams, 1999). Several illustrations of female fifth leg spines of *A.bifilosa* have shown small teeth-like spines on the internal side (Gurney, 1931) of both internal and external sides (Rose, 1933; Brodsky, 1950; Crisafi and Crescenti, 1972). However, Hirst and Castro-Longoria confirmed that the female fifth leg of *A.bifilosa* has both internally and externally toothed spines through morphological comparisons between the original descriptions and the varieties (Hirst and Castro-Longoria, 1998). The male fifth leg of *A.bifilosa* is slightly different from that of *A.hongi*. The former has a triangular appendage on the distal segment of the left leg, while

Table I. Comparisons of distinctive characters of *Acartia* species closely related to each other

	A.hongi	*A.omorii*	*A.hudsonica*	*A.bifilosa*
Female				
Rostral filament	Absent	Absent	Absent	Present
Last pedigerous somite posterodorsally with spines	Yes or no	No	No	No
Proportion of length to width of genital double somite	0.85–1.00	0.99–1.07[a]	1.24–1.34[a]	0.87–0.9[b]
Posterodorsal margin of genital double somite	With rows of fine setules	Naked	Naked	Naked or with rows of fine setules
Fifth legs	Toothed on inner edge	Toothed on inner and outer edges	Toothed on inner and outer edges	Toothed on inner and outer edges
Male				
Last pedigerous somite posterodorsally with spines	Yes	No	No	No
First exopodal segment of right 5th leg	With a long seta	With a long seta	With a long seta	With a heavy spine
Inner lobe of 3rd exopodal segment of right 5th leg	With posteriorly directed projection	With two very unequal distal processes	With posteriorly directed projection	With posteriorly directed projection
Appendage on distal segment of left fifth leg	Rod-like	Rod-like	Rod-like	Triangular

[a]Was referred from Ueda (1986).
[b]Was based on Giesbrecht (1892) and Brodsky (1950).

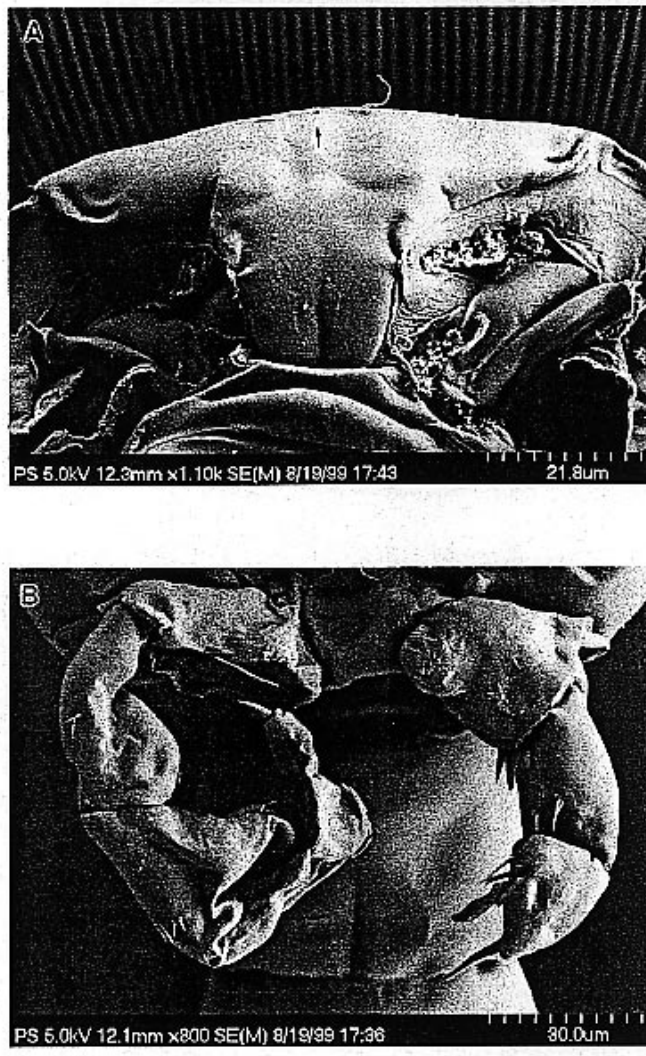

Fig. 10. *Acartia hongi* sp. nov., male: (**A**) rostrum; (**B**) fifth leg. Arrow indicates the integumental pore.

the latter has a rod-shaped appendage armed with small spines on the tip (see Figure 11). Therefore, *A.hongi* should be easily distinguishable from *A.bifilosa* based on a combination of the above characters.

Acartia hongi is also closely related to *A.hudsonica* and *A.omorii* from Korean waters, but it can be distinguished by co-occurrence of the following characters (Table I): (i) the last pedigerous somite posterodorsally with spines; (ii) the allobasis of the antenna with six plus one setae; (iii) the abdominal somites covered with fine spinules; (iv) the last two abdominal somites nearly equal in adult females; (v) the spines of the female fifth leg toothed only on inner edge;

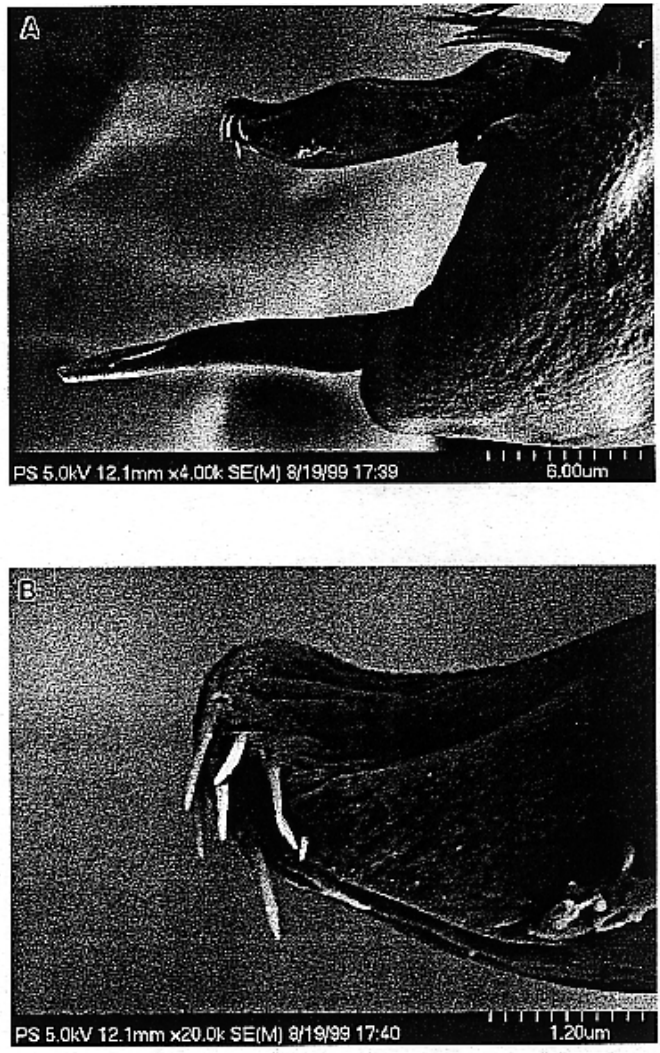

Fig. 11. *Acartia hongi* sp. nov., male: (**A**) partial distal segment of left fifth leg; (**B**) appendage on distal segment of left fifth leg.

(vi) the basis of the male left fifth leg with two rows of spines; (vii) the first exopodal segment of the male left leg 5 slightly longer than the second plus third exopodal segment.

Discussion

In the Yellow Sea, *Acartia bifilosa* sp. nov. has been misidentified as *A.bifilosa* so far, from the coastal waters of China (Shen and Bai, 1956; Chen and Zhang, 1965)

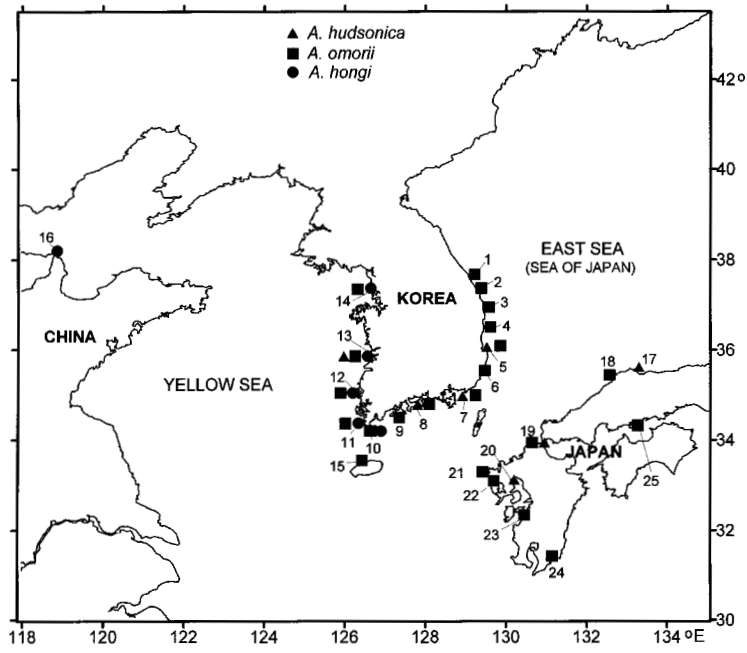

Fig. 12. Distribution of *Acartia hongi* sp. nov., *A.omorii*, and *A.hudsonica* in the coastal waters of East Asia: (1) coast of Kangneung; (2) Samchuk Harbor; (3) coast of Uljin; (4) Kanggu Harbor; (5) Yongil Bay; (6) Ulsan Harbor; (7) Pusan Harbor; (8) Dolsando; (9) Koheung; (10) Wando; (11) Jindo; (12) Hampyung Bay; (13) Mankyung-Dongjin River mouth; (14) Kyunggi Bay; (15) Cheju Isalnd; (16) the Yellow River mouth; (17) Naka-umi; (18) off Etomo; (19) Dokai Bay; (20) Chikugo River mouth; (21) Shijiki Bay, Hirado Island; (22) Omura Bay; (23) near Amakusa-matsushima; (24) Shibushi Bay; (25) an artificial fish pond on Momoshima Island. Numbers 4 and 16 are referred from Kang and Lee (1990) and Chen and Zhang (1965), respectively. Numbers 17–25 are partially cited from Ueda (1986).

and Korea (Kim, 1985; Yoo *et al*., 1991; Shim and Choi, 1996; Yoon *et al*., 1998). Such misidentification could be due mainly to the lack of details and illustrations in the original description of *A.bifilosa*, particularly of the rostral filaments and the female fifth leg (Giesbrecht, 1881, 1882). Steuer classified the genus *Acartia* into two major groups, Rostratae with rostral filaments and Arostratae without rostral filaments (Steuer, 1923). Bradford stated that 'arostrate *Acartia* (*Acanthacartia*) *tonsa* have been apparently found at Woods Hole . . . (T.E.Bowman, Smithsonian Institution, in litt. 1974)', although *A.tonsa* has been originally placed in the rostrate group [(Bradford, 1976) pp. 163–164]. If Bradford's statement is correct, *A.tonsa* can fall into rostrate and/or arostrate group(s), and may be the exceptional case in the genus *Acartia*.

Acartia hongi shows variations in the position of paired small sensilla on the rostrum (see Figure 5), as well as in the ornamentation of setules posterodorsally on the last pedigerous somite and the urosome of females (see Figures 2 and 3), as reported for other species of *Acartia* (Ueda, 1986; Garmew *et al*., 1994; Hirst and Castro-Longoria, 1998).

Acartia hongi occurs only in the brackish waters and/or the coastal waters of the Yellow Sea (Figure 12). It is also the most abundant in the copepod community in the winter and spring seasons (Chung, Soh and Suh, unpublished data). According to Shim and Choi it is the most abundant species of the inner bay characterized by low salinity, low temperature and high eutrophication (Shim and Choi, 1996). However, it dominates all coastal regions of southwestern Korea numerically. On the other hand, *A.omorii*, which usually occurs together with *A.hongi*, is widespread in the coastal waters and bays of East Asia, while *A.hudsonica* is strictly confined to brackish waters (Chen and Chang, 1965; Ueda, 1986; Kang and Lee, 1990) (Figure 12). However, in contrast to *A.hongi*, *A.omorii* is more abundant in offshore waters (Chung, Soh and Suh, unpublished data). These facts suggest that *A.hongi* is endemic to the Yellow Sea.

Acknowledgements

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