

A New Species of *Amonardia* (Copepoda: Harpacticoida: Miraciidae) from the Cultivated Brown Alga, *Undaria pinnatifida*

Sung Joon Song¹, Hyun Soo Rho² and Won Kim*

School of Biological Sciences, Seoul National University, Seoul 151-747, Korea; ¹E & C Technology Institute, Guwol-dong 1319-3, Incheon 405-839, Korea; ²Korea Ocean Research & Development Institute, Ansan 425-600, Korea

Abstract: Both sexes of a new species of Miraciidae belonging to the genus *Amonardia* Lang, 1948 are described. All materials collected from the cultivated brown alga, *Undaria pinnatifida* of Gijang, Korea. So far only one species, *A. normani* (Brady, 1872) from the algal bed at Jindo Island was recorded in Korea. The new species can easily be distinguished from its congeners by the combination of characters as follows: (1) shape of first antennular segment in female, (2) setal formula of mandible and maxillule, (3) setae of female sixth leg in female, and (4) shape of P2 endopod and exopod of fifth leg in male.

Key words: Taxonomy, Copepoda, Harpacticoida, *Undaria pinnatifida*, *Amonardia*

The brown alga Miyok, *Undaria pinnatifida* is a representative food item and has extensively cultivated in Korea and Japan. However, some phytal harpacticoids causing pinhole disease were turned out to be thalestrid copepods (Torii and Yamamoto, 1975; Kang, 1981; Ho and Hong, 1988 and Park et al., 1990). Ho and Hong (1988) especially described two new species (*Amenophia orientalis* and *Parathalestris infestus*) from Soando Island, Korea taxonomically, and they mentioned *Thalestris* sp. reported by Torii and Yamamoto (1975) was *Parathalestris infestus*. Moreover they insisted that two species made infestation on Miyok, *Undaria pinnatifida* by their nauplii.

During an ongoing systematics and molecular marker studies on harpacticoid copepods associated with cultivated brown alga, *Undaria pinnatifida* of Gijang, Korea we found that only nauplius and copepodid of *Amenophia orientalis* (not adult copepod) caused the pinhole and also found a

new species of *Amonardia* associated with the alga. The species is described and illustrated herein as *Amonardia coreana* sp. nov.

MATERIALS AND METHODS

Materials were obtained from the cultivating farm of brown alga, *Undaria pinnatifida* at Gijang, Korea. Specimens were washed out and fixed in 95% ethyl alcohol. They were then cleared and dissected in lactic acid, and the dissected parts were mounted on slides in lactophenol mounting medium. Preparations were sealed with transparent nail varnish. All drawings were prepared using a camera lucida on a Olympus BX60 differential interference contrast microscope with Nomarski optics. The descriptive terminology was adopted from Huys et al. (1996). Abbreviations used in the text are: ae, aesthetasc exp, exopod enp, endopod P1-P6, first to sixth thoracopod exp(enp)-1(2, 3) to denote the proximal (middle, distal) segment of a ramus. The term acothek is used to denote the trifid seta complement found apically on the distal antennular segment. Type series will be deposited in the collections of The Natural Institute of Biological Resources, Korea. Scale bars in all figures are indicated in μm .

DESCRIPTION

Order Harpacticoida Sars, 1903

Family Miraciidae Dana, 1846

Genus *Amonardia* Lang, 1948

Amonardia coreana new species (Figs. 1-7)

Type locality

Off Gijang coast of Busan City, the South East Sea of Korea (35°10'42"N, 129°12'36"E); Cultivating farm of

*To whom correspondence should be addressed.

Tel: 82-2-887-0752; Fax: 82-2-872-1993

E-mail: wonkim@plaza.snu.ac.kr

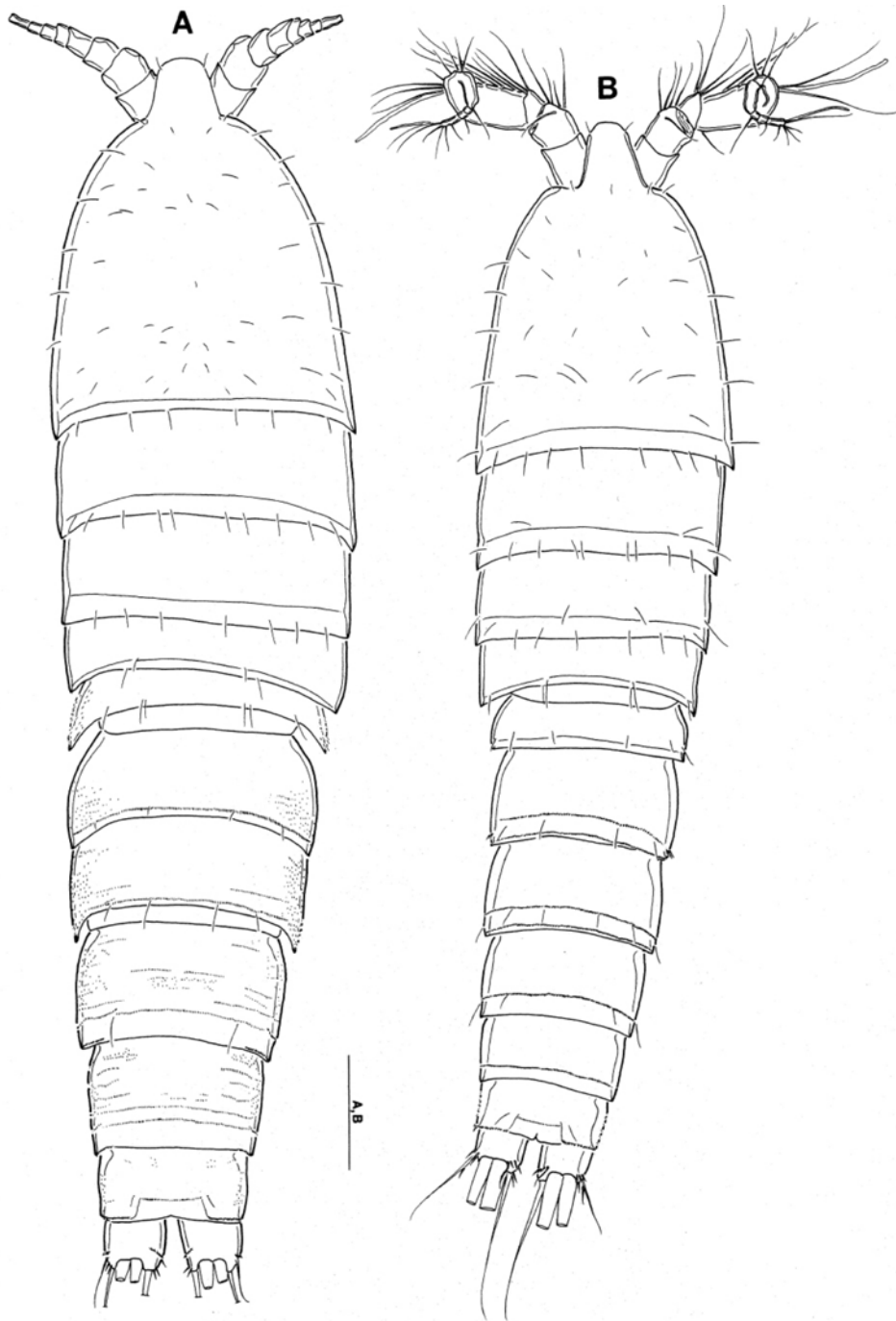


Fig. 1. *Amonardia coreana* sp. nov., A, Female habitus, dorsal; B, Male habitus, dorsal. Scale = 100 μ m.

Miyok, *Undaria finnatifida*; 5-8m depth.

Type material

Holotype: ovigerous female in alcohol collected on 29 March 2005, Coll. Sung Joon Song and Kyung Hwa Choi.

Paratypes: three females and three males preserved in alcohol, one female dissected on 15 slides and 1 male dissected on 14 slides. Coll. Sung Joon Song and Kyung Hwa Choi.

Female

Total body length 1043.6 μ m, measured from anterior margin of rostrum to posterior margin of caudal rami. Largest width measured at posterior margin of cephalic shield: 260.0 μ m. Urosome gradually tapering posteriorly, with two egg sacs attached. Cephalothorax ornamented with a few integumental sensillae as figured (Fig. 1A). Rostrum (Fig. 2A) large, triangular, directed downward, with biifid tip, with pair of subapical sensillae. Pedigerous

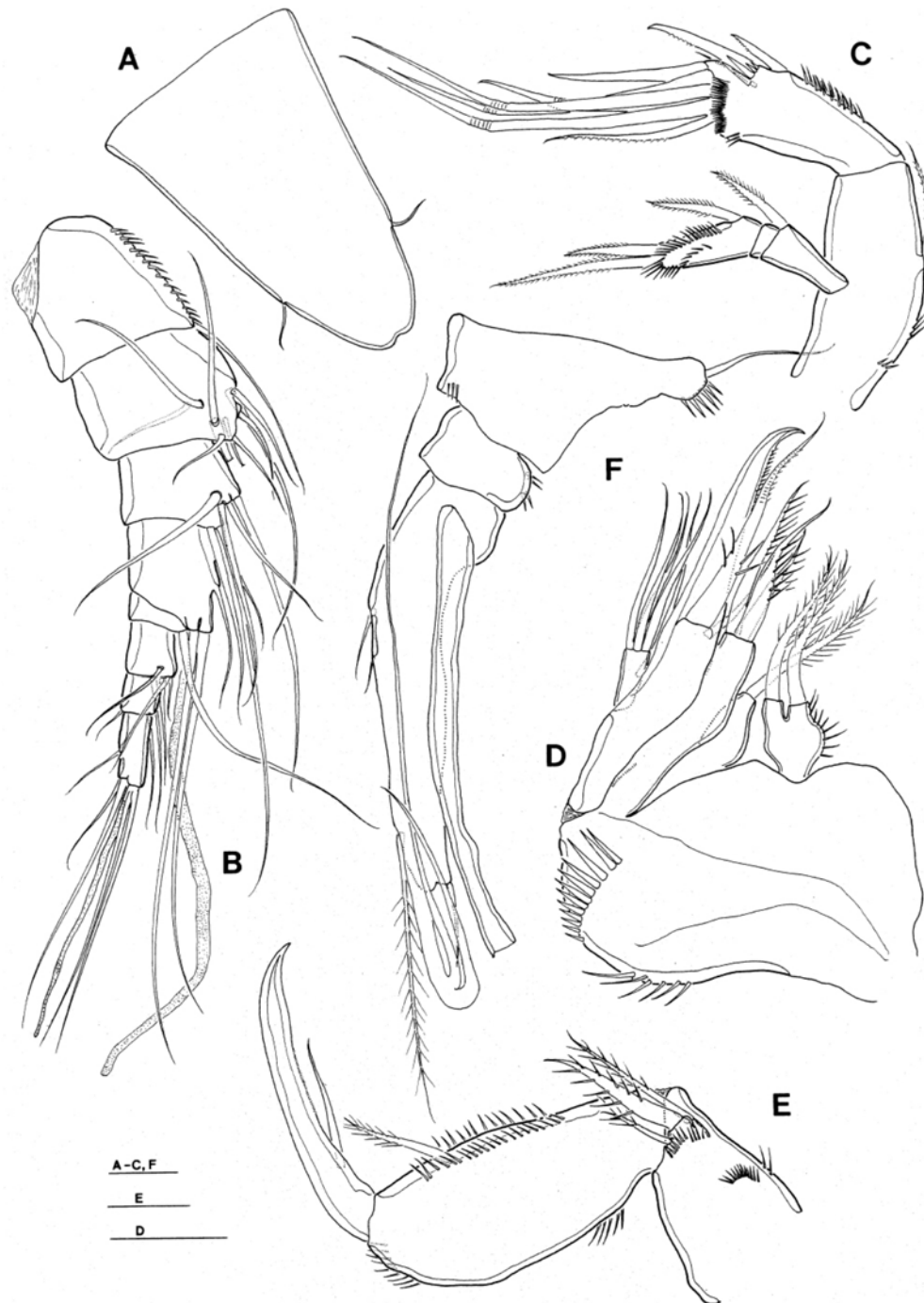


Fig. 2. *Amonardia coreana* sp. nov., female. A, Labrum and right paragnath; B, mandible; C, maxillule. Scales = 20 μ m.

somites with a few hairs along posterior margins. Urosomites (Fig. 1A) covered with a lot of tiny spinules on surface.

Urosome (Figs. 1A, 4A) 5-segmented, comprising P5-bearing somite, genital double-somite and 3 free abdominal somites. Genital double-somite (Fig. 4A) wider than long with transverse surface ridging dorsally and laterally. Genital field (Fig. 4A) positioned anteriorly with very small copulatory pore located in middle. P6 (Fig. 4A) represented

by 1 bare and 1 plumose tiny setae on small protuberance. Anal somite (Fig. 1A) with pair of sensillae dorsally, with semicircular anal operculum. Caudal rami (Figs. 1A, 4B) as long as wide; each ramus with 7 setae, seta I shortest, setae II, III and VI naked, and seta VII tri-articulate at base.

Antennule (Fig. 2B) 8-segmented; segment 1 longest with 1 seta at distal anterior corner, with spinular row on anterior margin; segment 4 with aesthetasc fused basally to 1 bare

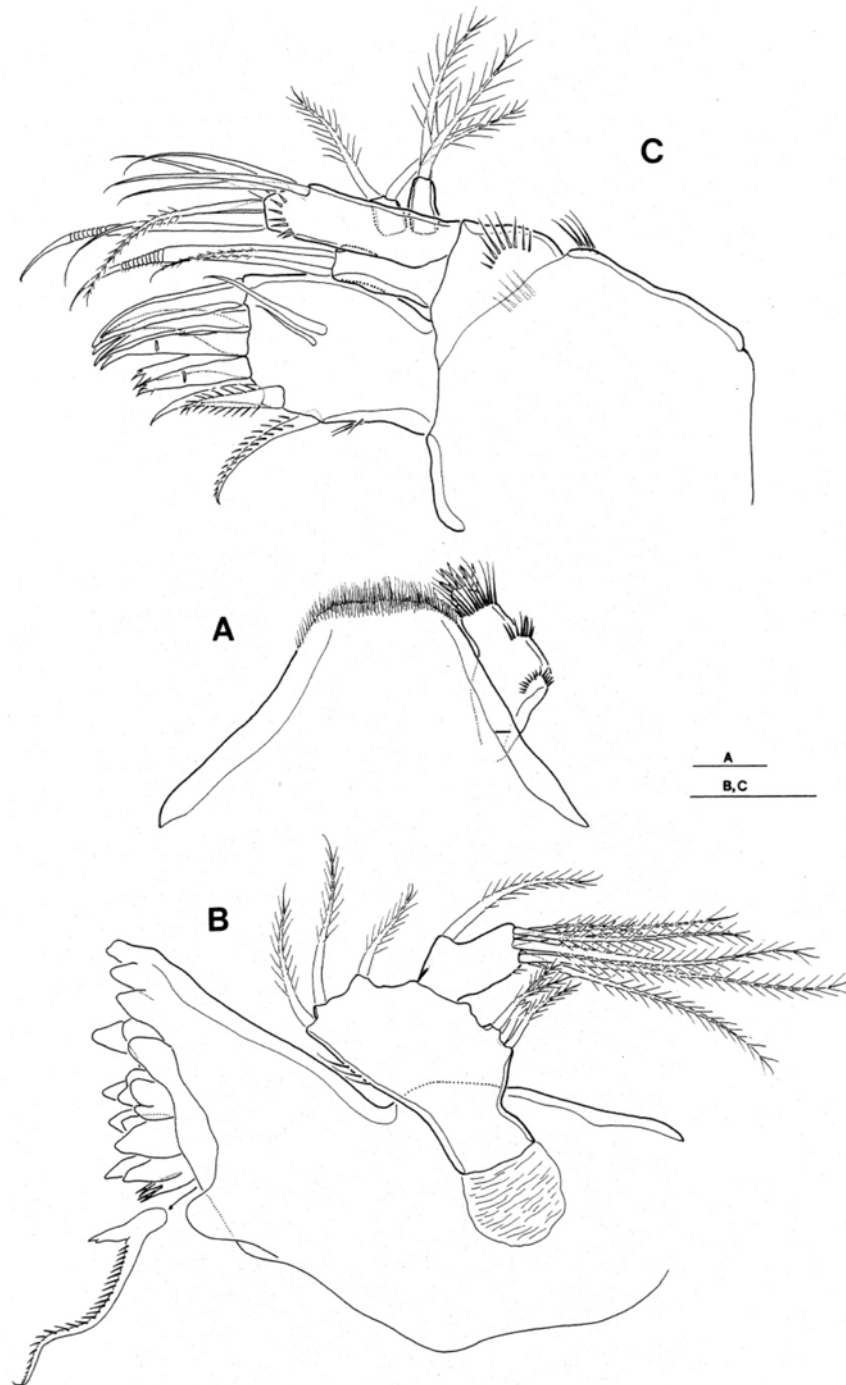


Fig. 3. *Amonardia coreana* sp. nov., female. A, Urosome (excluding somite bearing Rostrum; B, Antennule; C, Antenna; D, Maxilla; E, Maxilliped. male. F, P2 endopod. Scales = 20 μ m.

seta on pedestal at distal end; segment 5 shortest. Armature formula: 1-[1], 2-[10], 3-[7], 4[2 + (1 + ae)], 5-[1], 6-[5], 7-[2], 8-[3 + acrothek]. Apical acrothek consisting of 2 long setae and aesthetasc.

Antenna (Fig. 2C) with allobasis and free 1-segmented endopod. Allobasis elongate with several spinules and bipinnate abexopodal seta in distal two fifth. Endopod shorter than allobasis, ornamented with spinules along

outer margin and 1 transverse hyaline frill subapically. Lateral armature consisting of 2 spines and 1 slender seta. Distal armature consisting of 1 spine, 4 geniculate setae and 1 serrated seta. Exopod 3-segmented; exp-1 with 1 bipinnate seta, exp-2 shortest and exp-3 ornamented with lots of setules laterally and apically, and bearing 1 lateral bipinnate seta and 2 apical bipinnate setae.

Labrum and right paragnath with elaborate spinular

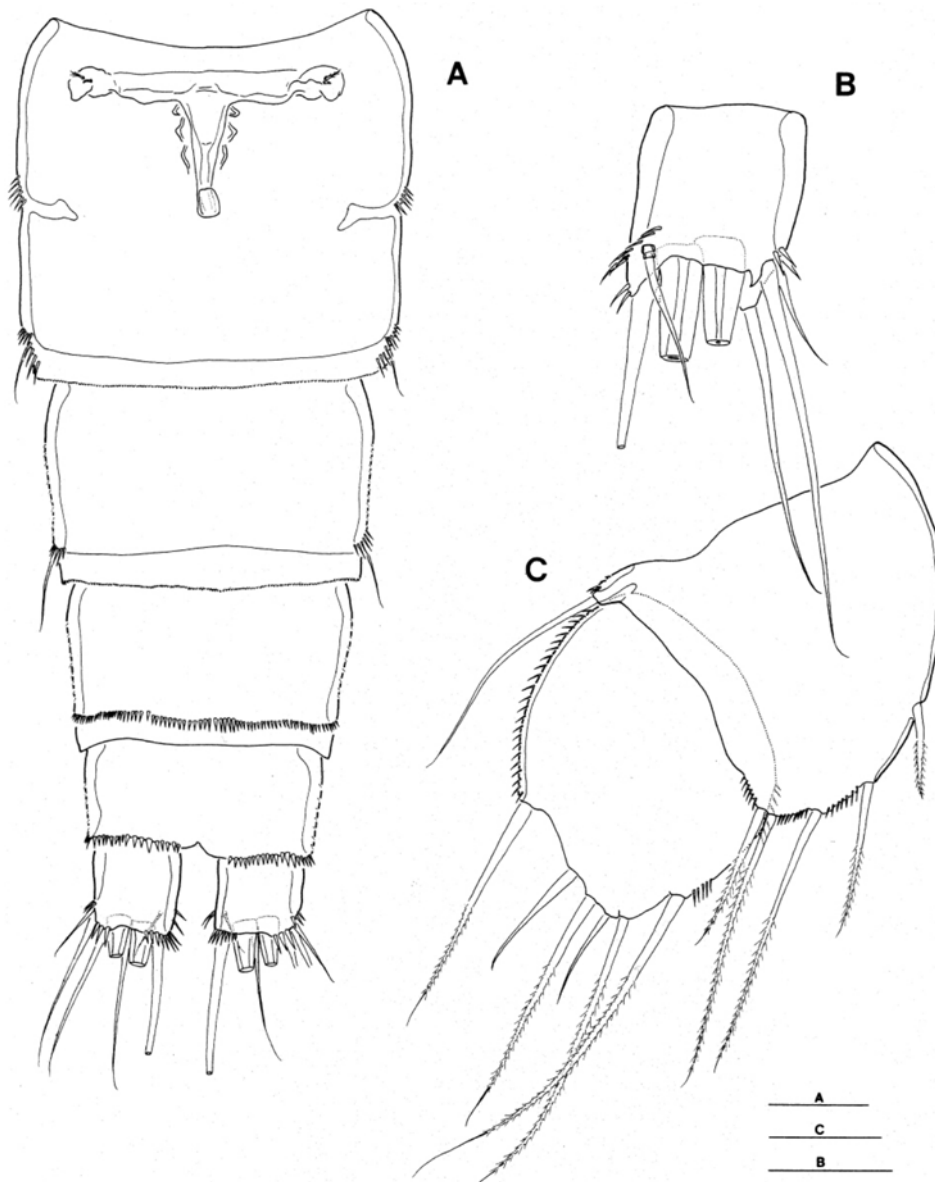


Fig. 4. *Amonardia coreana* sp. nov., female. A, Urosome (excluding somite bearing P5), ventral; B, Caudal ramus, dorsal; C, P5. Scales = 50 μ m.

ornamentation as in Fig. 3A.

Mandible (Fig. 3B) with well-developed gnathobase bearing several multicuspidate teeth on distal margin and 1 unipinnate long seta on distal corner; 3 spinular rows on surface. Palp well-developed and consisting of exopod and exopod fused to basis; basis with 3 plumose setae; exopod consisting of 1 lateral and 6 apical plumose setae; endopod represented by small peduncle on basis bearing 3 plumose setae.

Maxillule (Fig. 3C). Praecoxa with few spinules on outer distal corner and posteriorly. Arthrite strongly developed, with 1 bipinnate seta on inner margin, 2 subequal naked setae on anterior surface, and 8 spines (5 naked spines 1 bipinnate spine and 2 spines with serrated tip). Coxa with

cylindrical process bearing 1 bipinnate and 1 geniculate setae. Basis longer than coxa bearing 1 bipinnate, 1 naked and 1 geniculate setae on distal and 4 bare setae on subdistal. Exopod and endopod 1-segmented, bearing 2 plumose setae, respectively.

Maxilla (Fig. 2D) with several spinules on outer margin, and strong spinular row on anterior surface and 3 endites on syncoxa. Proximal endite bilobed and spinules on inner margin, with 2 setae. Middle one shortest with 1 setae. Distal one with 3 unipinnate setae. Allobasis drawn out into unipinnate claw; accessory armature consisting of 2 setae on anterior and posterior surface respectively. Endopod represented by small protuberance bearing 1 subdistal and 4 distal bare setae.

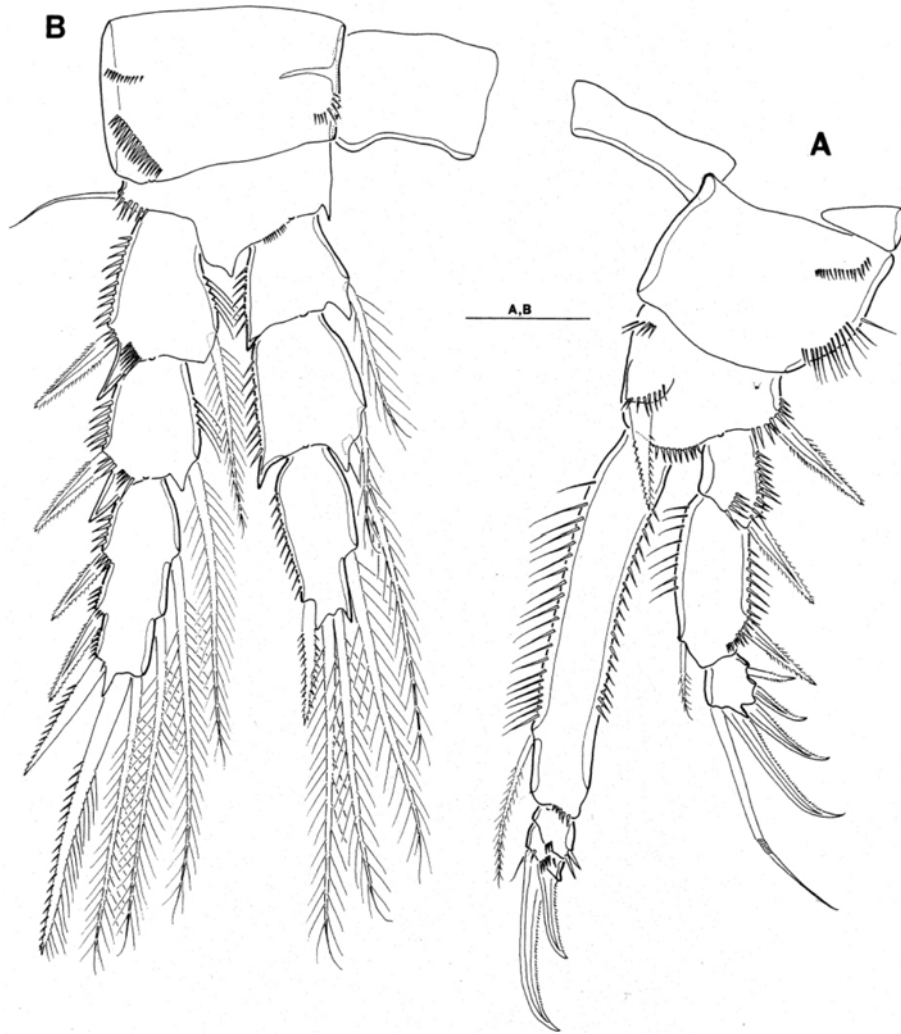


Fig. 5. *Amonardia coreana* sp. nov., female. A, P1; B, P2. Scales = 50 μ m.

Maxilliped (Fig. 2E) with 3 pinnate seta subdistally and 2 rows of setules on syncoxa. Basis with 1 seta and 2 rows of spinules along inner margin, and 2 clusters of spinules on outer margin. Endopod drawn out into long unipinnate claw, with 1 long bare seta.

P1 (Fig. 5A). Praecoxa and intercoxal sclerite bare. Coxa with 2 rows of spinules on anterior surface. Basis with 2 anterior surface spinular rows; additional spinules present around bases of inner and outer spines; inner and outer spines bipinnate. Exopod 3-segmented and much shorter than endopod; exp-1 ornamented with spinules on outer surface and 1 bipinnate spine outerodistally; exp-2 elongated with strong spinules along inner and outer margin, with 2 subdistal setae on inner and outer margin; exp-3 shortest and consisting of 1 bipinnate small seta, 3 unipinnate setae and 1 geniculate seta. Endopod 3-segmented; enp-1 ornamented with strong setule rows along inner and outer margin, and small spinules posteriorly, and with 1 inner seta in a fourth distally; enp-2 with small surface spinules and 2 inner setules

distally; enp-3 with several spinules on surface, with 1 tiny seta and 2 subequal unipinnate spines.

P2-P4 (Figs. 5B, 6A-B) with wider intercoxal sclerites lacking ornamentation. Coxae with 1 spinular row of P2 and 2 spinular row on anterior surfaces of P3-4. Bases transversely elongated; with fine setules on anterior surface; outer distal setae bare. Exopod and Endopod 3-segmented; armature formula of P2-P4 as follows:

	Exopod	Endopod
P2	1, 1, 223	1, 2, 121
P3	1, 1, 323	1, 2, 321
P4	1, 1, 223	1, 1, 221

Fifth pair of legs (Fig. 4C) not fused to supporting somite; rami separate. Baseoendopod as long as wide, with a few setules on inner and distal margins, Endopodal lobe extending to distal half of exopod, with 5 bipinnate setae.

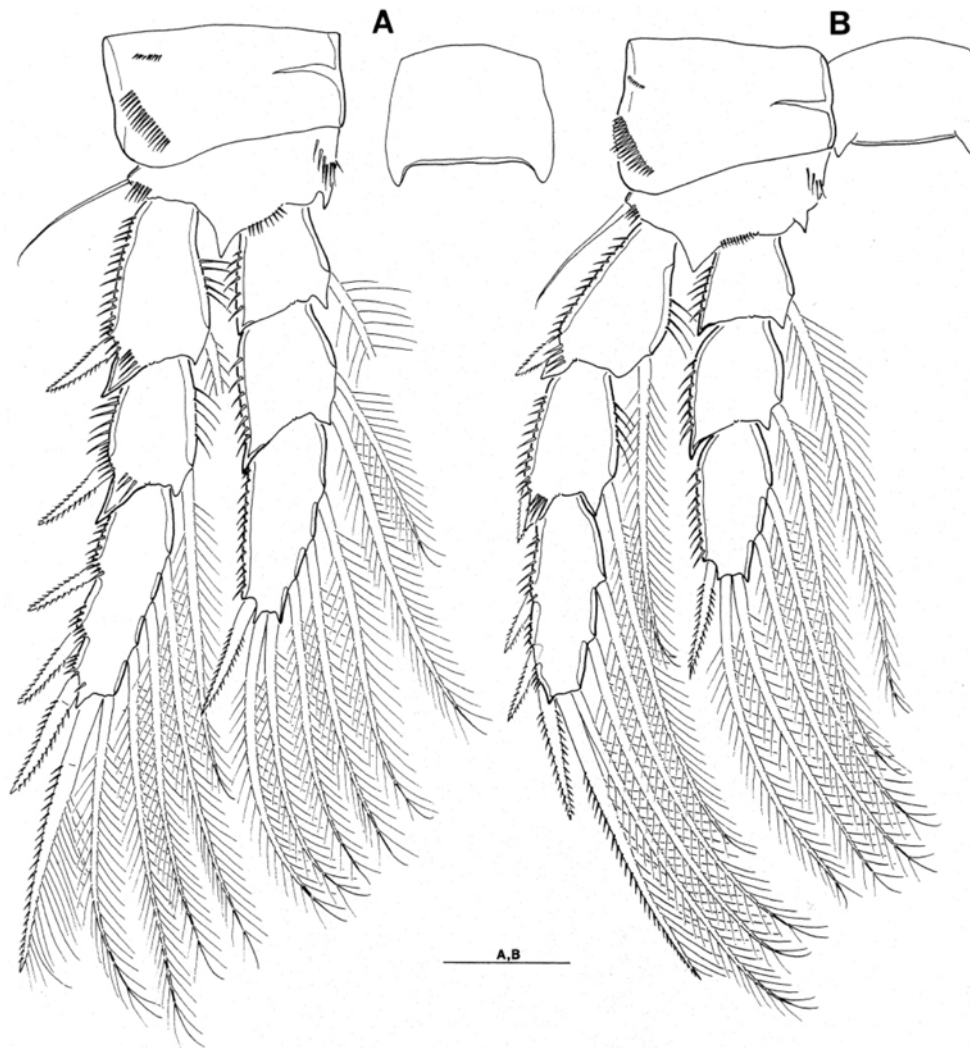


Fig. 6. *Amonardia coreana* sp. nov., female. A, P3; B, P4. Scales = 50 μ m.

Exopod longer than wide, with setules along inner and outer margins; with 4 bipinnate setae and 2 short bare setae.

Male

Total body length 914.3 μ m measured from anterior margin of rostrum to posterior margin of caudal rami. Largest width measured at middle margin of cephalic shield: 220.0 μ m.

Prosoma (1B) 4-segmented, comprising cephalothorax and 3 free pedigerous somites. Cephalothorax and pedigerous somites (Fig. 1B) with smooth posterior margin; ornamented with a few integumental sensillae as figured. Rostrum as in female.

Urosome (Fig. 7A) 6-segmented, comprising P5-bearing somite, genital somite and 4 abdominal somites. All somites ornamented with spinule row dorsally, first 3 abdominal somites with spinular row and small denticulate line along posterior margin ventrally. Caudal rami (Fig. 1B,

7A) similar to female in appearance;

Antennule (Fig. 7B) 10-segmented; subchirocer, with geniculation between segment 6 and 7. Segment 1 ornamented with spinules on outer surface and hyaline frill subapically. Segment 4 longest and swollen. Armature formula: 1-[1 bipinnate], 2-[1 bipinnate + 12 bare], 3-[8 + ae], 4-[4 bare + 2 tiny bipinnate + 1 small process + (1 + ae)], 5-[1 tiny pinnate + 2 bare], 6-[1 pinnate + 1 bare], 7-[1 bare], 8-[2 bare], 9-[1 bare], and 10-[5 bare + acrothekk]. Apical acrothekk consisting of 2 long setae and aesthetasc.

Antenna, mouth appendages, and P1, P3, P4 same as in female.

P2 (Fig. 2F). Basis widened with spinules on inner lobe; outer distal seta bare with strong spinules around basis. Exopod 3-segmented as in female. Endopod modified and consisting of 2-segmented; enp-1 much shorter than wide bearing several setules on outer margin; enp-2 deeply

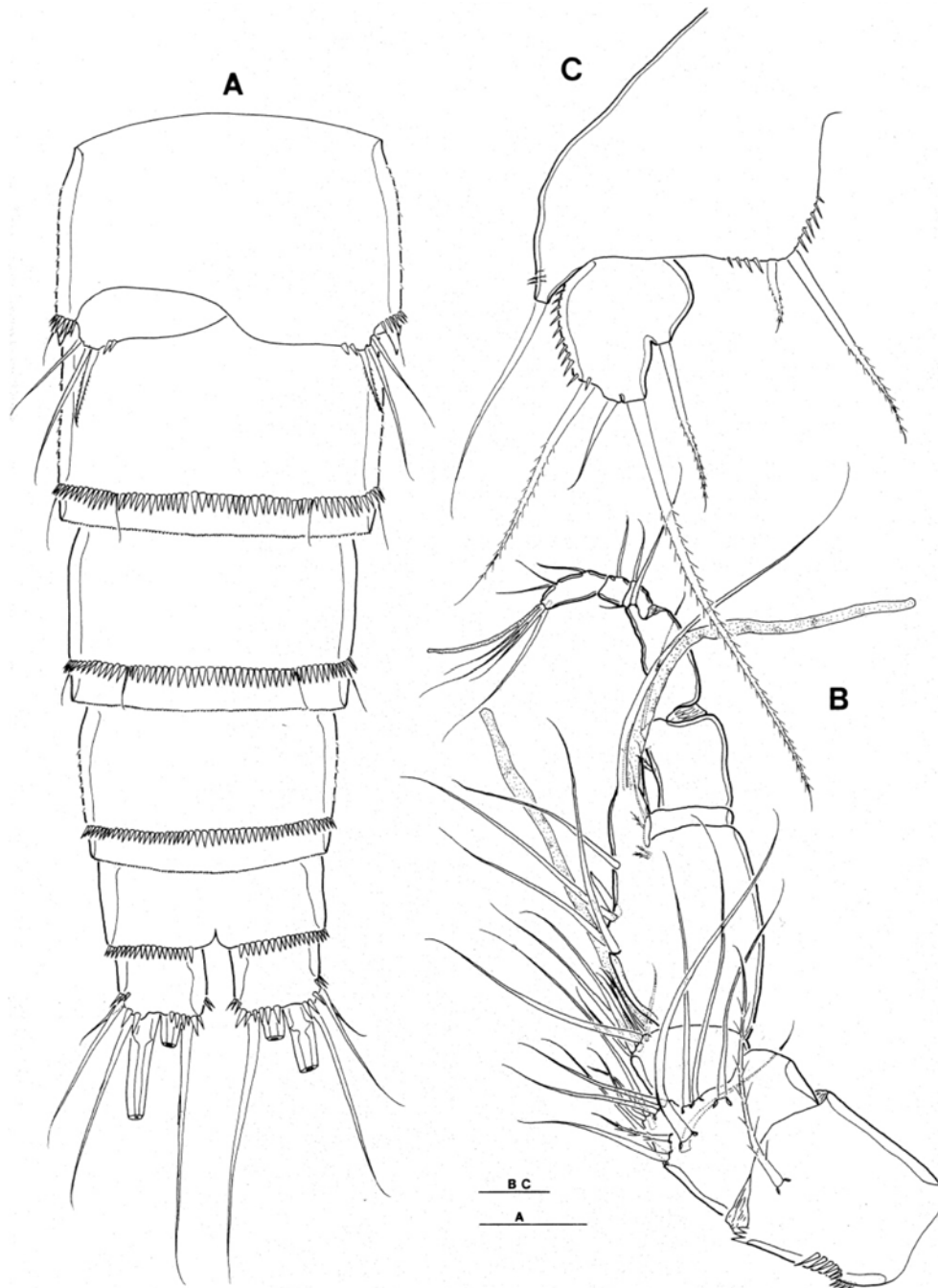


Fig. 7. *Amonardia coreana* sp. nov., male. A, Urosome (excluding somite bearing P5), ventral; B, Antennule; C, P5. Sclaes: A = 50 μ m; B, C = 20 μ m.

modified, with 2 subequal small setae on inner margin, 1 bipinnate seta subdistally and 1 distal seta; tip divided into 2 slender setae as figure, and with seriously modified strong and curved apophysis proximally and extending beyond end of endopodal segment.

Fifth pair of legs (Fig. 7C) not fused to supporting somite; rami separate. Baseoendopod confluent, with 2 bipinnate setae, of which inner one about 3 times longer than outer one. Exopod slightly longer than wide, with setules along

outer margins; with 3 bipinnate setae and 1 short bare seta.

Sixth pair of legs (Fig. 7A) asymmetry, fused to genital somite, armature consisting of 1 bipinnate and 2 bare seta distally.

ETYMOLOGY

The species name “*coreana*” refers to the occurrence of this species in Korea.

REMARKS

The new species can be assigned to the genus *Amonardia* according to the features within the family Diosaccidae Sars, 1906 given by Lang (1965) as follows: (1) antennule without any plumose seta, (2) antenna exopod with more than 3 setae, (3) first segment of P2 exopod with inner seta, (4) third segment of P3 endopod with 6 setae, (5) P4 endopod 3-segmented and third segment exopod with 3 outer spines and (6) P5 exopod of male with 4 setae. However, the genus *Amonardia* was moved by Willen (2002) to the older family Miraciidae Dana, 1846 as mentioned in Surez-Morales and Avils-Torres (2003) the genus *Amphiascoides* belongs to the Miraciidae now.

The genus *Amonardia* Lang, 1948 presently includes 10 valid species: *A. similis* (Claus, 1866), *A. normani* (Brady, 1872), *A. arctica* (T. Scott, 1898), *A. phyllopus* (Sars, 1906), *A. subnasuta* (Willey, 1935), *A. pentasetosa* Noodt, 1954, *A. pelophila* Por, 1964, *A. tristanensis* Wiborg, 1964, *A. perturbata* Lang, 1965, and *A. magna* Chislenko, 1978. Of these, only 2 species were recorded from the Far East: *A. magna* Chislenko, 1978 from Japan and *A. normani* (Brady, 1872) from Korean waters by Song and Chang (1995). In general, the genus *Amonardia* is divided into two groups based on the number of seta (4 or 5 setae) on distal segment of P1 exopod (Lang, 1948; 1965). The new species is most closely related to *A. perturbata* Lang, 1965 from the Californian Pacific Coast, but differs in the following characteristics: (1) first segment of antennule with spinular row (without spinular row in *A. perturbata*), (2) endopod of mandible with 3 setae (2 setae in *A. perturbata*); exopod with 6 setae (7 setae in *A. perturbata*), gnathobasis having a well-developed long seta (small seta in *A. perturbata*), (3) maxillule bearing 2 setae on anterior surface (1 seta *A. perturbata*), (4) exp-2 of P1 with short inner seta (long seta extending far beyond end of exp-3 in *A. perturbata*), (5) female sixth leg represented by tiny two setae (1 long and 1 small setae in *A. perturbata*) and (6) in male P2 endopod, enp-1 without inner seta, modified enp-2 more straight and comparatively long. On the other hand, *A. arctica* (T. Scott, 1898) is also similar to *A. coreana* sp. nov., but there are major discrepancies between the two species as follows: *A. arctica* possesses 9-segmented antennule in female, exopodal setae of antenna are slender and long, P5 exopod is about 1.7 times longer than wide (1.3 time in new species), and enp-1 of male have inner setae and a straight apophysis with sharp tip (see Mielke, 1974, p. 26, Fig. 12-C).

ACKNOWLEDGMENTS

We thank Dr. Kyung Hwa Choi of Busan Dong Middle School, Korea for her support in collecting samples. We are also grateful to 3 anonymous reviewers who made valuable suggestions for improving the manuscript. This work was supported by the Korea Research Foundation Grant funded by the Korean Government (KRF-2004-003-C00173).

REFERENCES

- Chislenko, LL (1978) New species of copepod harpacticoids (Copepoda, Harpacticoida) from the Possjet Bay of Japan. *Tr Zool Inst A N SSSR* 61: 161-192. (in Russian).
- Ho, J-S and Hong, J-S (1988) Harpacticoid copepods (Thalestridae) infesting the cultivated Wakame (brown alga, *Undaria pinnatifida*) in Korea. *J Nat Hist* 22: 1623-1637.
- Huys, R, Gee, JM, Moore, CG and Hamond, R (1996) Marine and brackish water harpacticoid copepods. *Part 1. Synopses of the British fauna (New Series)* 51: 1-352.
- Kang, J-W (1981) Some seaweed diseases occurred at seaweed farms along the south-eastern coast of Korea. *Bull Korean Fish Soc* 14: 165-170.
- Lang, K (1948) Monographie der Harpacticiden. *H. Ohlsson, Lund* 2 vols. 1-1682.
- Lang, K (1965) Copepoda Harpacticoida from the California Pacific coast. *Kungliga Svenska Vetenskapsakademiens Handlingar, Fjrdje Serien* 10: 1-560.
- Mielke, W (1974) Eulitorale Harpacticoida (Copepoda) von Spitzbergen. *Microfauna Meeresboden* 37: 1-52.
- Park T-S, Rho, Y-G, Gong, Y-G and Lee, D-Y (1990) A harpacticoid copepod parasitic in the cultivated brown alga *Undaria pinnatifida* in Korea. *Bull Korean Fish Soc* 23: 439-442.
- Song, SJ and Chang, CY (1995) Marine harpacticoid copepods of Chindo Island, Korea. *Korean J Syst Zool* 11: 65-77.
- Surez-Morales, E and Avils-Torres, S (2003). A new species of *Amphiascoides* Nicholls, 1941 (Crustacea, Copepoda, Harpacticoida) from the Caribbean coast of Mexico. *Zootaxa* 227: 1-16.
- Torii, S and Yamamoto, H (1975) *Thalestris* sp. a parasitic Copepoda on *Undaria pinnatifida* (a preliminary report). *Hokusuishi Geppo* 32: 29-34.
- Willen, E (2002) Notes on the systematic position of the Stenheiliinae (Copepoda, Harpacticoida) within the Thalestridimorpha and description of two new species from Motupore Island, Papua New Guinea. *Cah Biol Mar* 43: 27-42.

[Received May 1, 2007; accepted June 8, 2007]