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NOTE

A Review on the Microstructures and Taxonomy of the *Acartia bifilosa* (Crustacea: Copepoda) in Kyeonggi Bay, Yellow Sea

MOON BO SHIM AND JOONG KI CHOI
Department of Oceanography, Inha University, Inchon, 402-751, Korea

Acartia bifilosa has been classified as Rostratae group of *Acartia* by the characteristic of having the rostral filament. However, we have found that *A. bifilosa* does not have any rostrum. Therefore, *A. bifilosa* should be classified as Arostratae group. For the first time, we have observed that this species has only one genital pore in the genital segment. Two spermathecal canals are looped in lateral view as well as ventral view. We have also observed two thin, very short filaments and minute apertures on the anterio-ventral part of the top of the head. The function of the filaments need to be investigated.

These revisions on the classification of subgenera *Acanthacartia* and *Acartiura* are focused on the *Acartia bifilosa* and *Acartia clausi* (*omorii*) in Kyeonggi Bay, Yellow Sea which is located in the western coastal areas of Korea. *Acartia bifilosa* is the most abundant species at the inner bay (Fig. 1: ST. 1), which has lower salinity, low temperature and high eutrophication conditions, while *A. clausi* (*omorii*) is dominant in the outer bay (Fig. 1: ST. 2). *A. bifilosa* dominates more than 90% of the copepod community in the spring season. This genus comprises more than 50 species, most of which are neritic and abundant in inshore waters (Bowman, 1965; Razouls 1983: cited from Brylinski 1984). Geographical separation of *A. clausi* has been known to be distinctive. However, morphologically indistinguishable populations of *A. clausi* may be of interest in relation to earlier observations on separate races and varieties of the zooplankton (Raymont, 1983). There is no doubt that numerous new species will be established, since the existing species are poorly defined (Kim, 1985). However, the small (about 1mm), soft and semi-transparent body makes it difficult to examine the fine structure even with any improved methods such as SEM (scanning electron microscope) and CM (conforcal microscope).

Thus, we summarized key characters of these closely related species published by Bradford (1976), Brodskii (1950), Chen and Zhang (1965), Kim (1985), Ueda (1986 a, b) and Yoo *et al.* (1991) (Table 1, 2). There are many previous key characters unacceptable to classify them . Finally, we attentioned on the rostral filament which can be the most important key character or, was not clearly defined on these species.

The subgenus was characterized by its rostrum, although this subgenus is closely related with subgenus *Acartiura* (Arostratae group), (Steuer, 1915; Bradford, 1976). *Acartia tonsa* which belongs to subgenus *Acanthacartia* has no rostral filament (Bowman, Smithsonian Institution, in litt. 1974: cited from Bradford, 1976). *A. bifilosa* has been classified into the subgenus *Acanthacartia* which has a rostrum(Steuer, 1915; Brodskii, 1967; Kim, 1985; Yoo *et al.*, 1991). However, there were no figures about the rostrum of *A. bifilosa*. Recently, Chen and Zhang (1965) described that the rostral filament of *A. bifilosa* female is uncertain. Fleminger noticed that the rostral filaments of *A. tonsa* are weak and often difficult to find in the specimens from coastal waters of the Gulf of Mexico where salinities are near the lower limits of tolerance (Bowman, 1965).

We searched for the existence of a rostrum to identify *Acartia* specimens exactly with SEM.

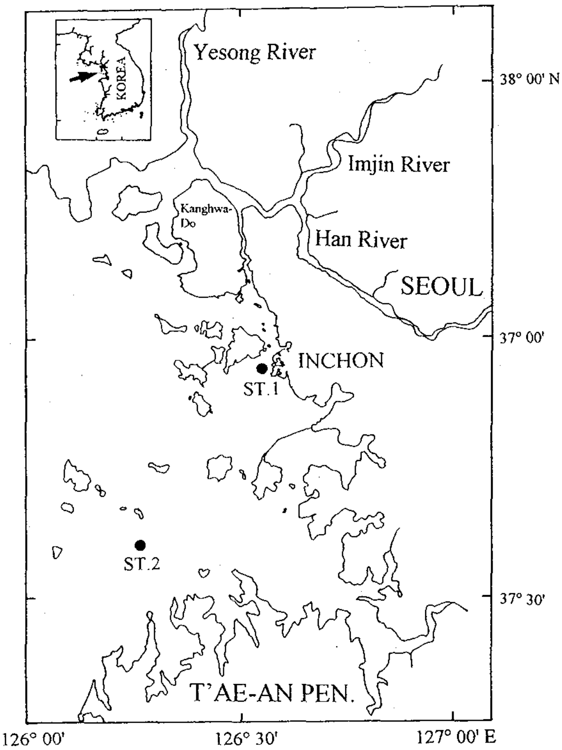

Fig. 1. Map of sampling area in Kyeonggi Bay, Yellow Sea in 1993. ST. 1: May 10; ST. 2: May 14.

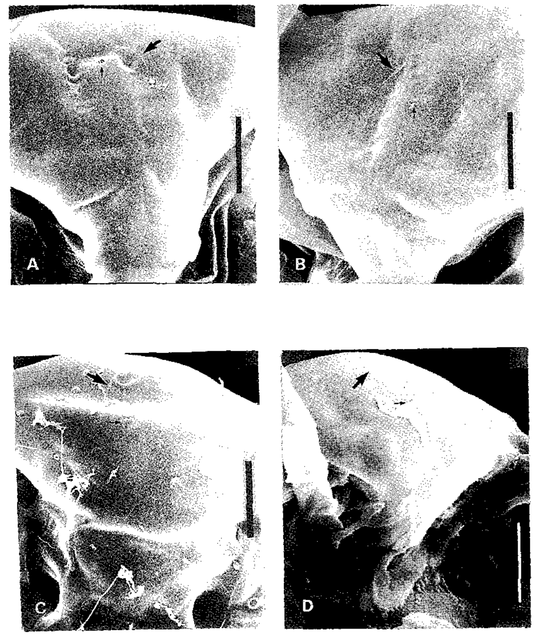

Fig. 2. Anterio-ventral view of the top of the head. A: *Acartia bifilosa*, male; B: *Acartia bifilosa*, female; C: *Acartia clausi*, male; D: *Acartia clausi*, female. ➞ indicates the frontal filament. → indicates the frontal aperture. Scale bar(black or white): A, B: 15.0μm; C: 20.0μm; D: 30.0μm

Plankton samples were collected at inner and outer part of Kyeonggi Bay in May 1993 (Fig. 1). A conical type net (50 cm mouth diameter and 0.10 mm mesh openings) was hauled vertically from the water depth of 10 m to the surface by hand. Zooplankton samples were fixed and preserved with 4% buffered formaldehyde-sea-water solution (UNESCO, 1976). The species of *Acartia* were sorted and dissected in the lactic acid or distilled water under the dissective stereo-microscope.

Since photomicroscopic observations with transparent light made erroneous visions on the surface structure of the anterior part of *A. bifilosa* from ventral view, we examined the rostal filaments of *A. bifilosa* with SEM. For the examination with SEM, *Acartia* specimens were washed in the distilled water (pH 7). The 5th legs of the specimens were dissected in the distilled water on the plastic slide which is specially designed with several concave holes. At first, the specimens were identified under the photomicroscope (Nikon: ×600), then freeze-dried and observed with SEM (Hitachi X-650).

Through SEM observation, we did not find out any rostral filament in both species. However, there were two thin, very short filaments (frontal filaments) which could be misinterpreted as a rostrum and minute apertures (frontal apertures) on the anterio-ventral top of the head (Fig. 2~3) in the two species.

Two thin, very short filaments on the top of the heads of calanoids were reported in large size (Brodskii, 1967; Park, 1980). Park (1980) and Vaupel Klein(1982) also described these filaments and pores on the large sized calanoids. The structure of these integumental organs of *Euchirella messinensis* have been described and the possible functions are discussed in detail (Vaupel Klein 1982). However, the minute pores on the anterio-ventral top of the head were observed in *A. clausi* and *A. bifilosa* for the first time in this study.

We have found three grooves in the anterio-ventral head of *A. bifilosa* (Fig. 2 A, B). Two of the grooves were short while the other central one was long. The filaments could be mistaken for these grooves from side view under the photomicroscope.

There were confusions in identification on A. *bifilosa* and A. *clausi* (*omorii*) because *A. bifilosa* was classified into the subgenus *Acanthacartia* even though it has no rostrum. It should be classified into subgenus *Acartiura* or *genus Acartia*.

The difference between *Acanthacartia* and *Acartiura* is especially confusing when we consider with *Acartia tonsa* as Arostrae (*Acanthacartia*) (Bradford, 1976). Bradford (1976) cited that *Acanthacartia* differs from *Acartiura* in the fact that the spermathecal canal appears to be looped only in ventral part (Steuer, 1923). She also described that the anterior heavy spine on the terminal exopod segment of left leg 5 of male *Acartiura* is a simple spine but *A. bifilosa* and *A. tonsa (Acanthacartia)* have one or more accessory spines arising from the base of the heavy spine (Sminov, 1936; Esterly, 1911; Steuer, 1934; Abraham, 1970; Tanaka, 1965: cited from Bradford, 1976). Based on these characteristics of *Acanthacartia,* in the partial revision of the subgenus *Acartiura* she classified *A. bifilosa* and *A. tonsa* into the subgenus *Acanthacartia* and excluded these species in her study.

However, the spermathecal canal of *A. bifilosa* looped in lateral part as well as ventral part (Fig. 3 C). Two spermathecal canals are opened downward at the lateral side of the genital cavity which has only one genital pore. Until now, it has been believed that there are more than one genital pores on the genital segment in this species (Brodskii, 1967; Tanaka, 1965; Bradford, 1976; Kang and Lee, 1990). The spermathecal canals show the 1st semispiral and the 2nd 1(1/4)spiral form. The anterior heavy spine on the terminal exopod segment of the 5th left leg of the *A. bifilosa* male was a simple spine(Fig. 4 C, D, E).

Table 1. Summerized key characters of males of *Acartia species* closely related each other. O: present or yes, X: absent or no in this study; (O): present or yes, (X): absent or no in the previous studies; P: prosome length

Characters	*A. clausi*	*A.* sp.	*A. omorii*	*A. hudsonica*	*A. biflosa*	as a key
Rostral Filament	X(X)	(X)	(X)	(X)	X(O)	X
Rostrum	O(X)	(-)	(-)	(-)	O(O)	X
Posterior metasome with spines or hairs	O(O)	(O)	(O)	(O)	O(O)	X
End of thorax round	O(O)	(O)	(O)	(O)	(O)	X
Urosome segments with spines, spinules or hairs	O(O)	O(O)	(O)	(O)	O(O)	X
Large body length	1.1 P : 0.8~0.9 (1.0~1.1/ 0.7~1.0/ 1.0~1.2)	(0.8~1.1)	0.8~1.1 (0.8~0.9/ 0.9~1.1)	0.8~1.1 (0.8~1.0/ 0.9~1.1)	0.9 P : 0.6~0.8 (1.0~1.1/ 0.7~0.8/ 0.7~0.9)	X
Length:width of right caudal ramus >1.4	1.1~1.4 (1.0~1.2)	(1.2~1.4)	(1.1~1.3)	(1.2~1.3)	1.2~2.0	X
Right leg 5 joint 1 with large inner distal lobe	O(O)	O(O)	O(O)	O(O)	O(O)	X
Right leg 5 joint 2 iner lobe with 2 processes	O(O/X)	(O/X)	(O/O/O/X)	(O/X/X/O)	X(X)	X
Left leg 5 joint 1 with small spinules	O(O)	(O)	(O)	(O)	X(X)	O
Left leg 5 joint 2 with rows of large spines	X(X)	(X)	(X)	(X)	O(O)	O
Left leg 5 teminal expod joint shorter than expod joint 1	O(O/O/O)	(O)	(X/O/O))	(O/O/O)	X(X/X)	(O)
Left leg 5 joint 2 inner lobe with spinules pr hairs	O(O/O)	(O)	(O)	(O/O)	X(-)	O
Left leg 5 terminal exopod joint with short spine	O(O/O/X)	(O/X)	(X)	(X)	O(O/O)	X

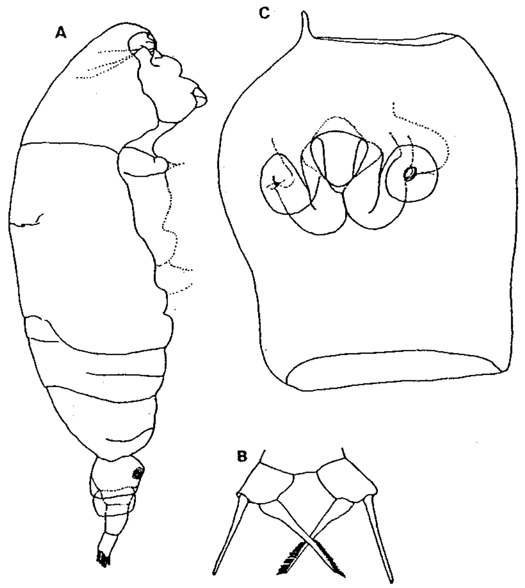

Fig. 3. *Acartia bifilosa*, female. A: Lateral view of the body; B: Anterior surface of the 5th leg; C: Spermathecal canal of genital segment in dorsal view. Scale bar: A: 0.5 mm; B-C: 0.05 mm.

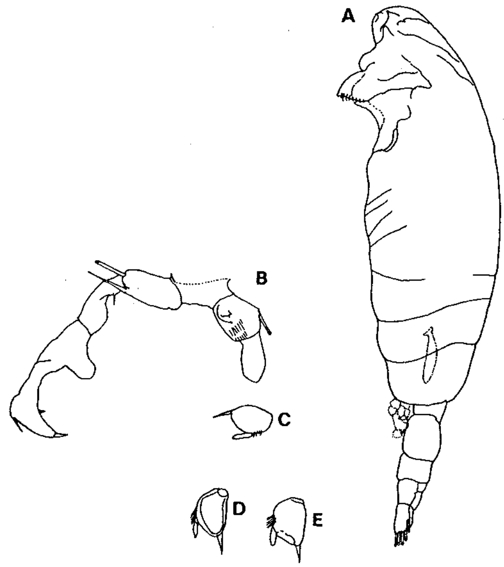

Fig. 4. *Acartia bifilosa*, male. A: Lateral view of the body; B: Posterior surface of the 5th leg; C-E: Terminal exopod segment of the left 5th leg with simple spine. Scale bar: A: 0.5 mm; B-E: 0. 05 mm.

Table 2. Summerized key characters of females of *Acartia* species closely related each other. O: present or yes, X: absent or no in this study; (O): present or yes, (X): absent or no in the previous studies; P: prosome length.

Characters	*A. clausi*	*A.* sp	*A. omorii*	*A.hudsonica*	*A. bifilosa*	as a key
Rostral Filament	X(X)	(X)	(X)	(X)	X(O)	X
Rostrum	O(X)	(-)	(-)	(-)	O(O)	X
Posterior metasome with spines or hairs	O(O/X)	(O)	(O)	(O)	O(-)	X
End of thorax round	O(O)	(O)	(O)	(O)	(O)	X
Genital swelling placed approximately centrally on segment	X(O)	(O)	(O)	(X)	O/X(-)	X
Length:width of genital segment > 1.1	1.2~1.7 (1.1~1.2)	(1.0~1.2)	0.8~1.1 (1.0~1.1/ 0.9~1.1/ 0.8~1.1)	1.0~1.4 (1.2~1.4/ 1.1~1.4/ 1.0~1.3)	0.6~1.6	X
Urosme segments with spines, spinules or hairs	O(O/X/O)	(O)	(O)		O(X/O)	X
Large body length	1.2 P:0.9~1.0 (0.9~1.2/ 0.7~1.2/ 1.0~1.4)	(0.9~1.2)	0.8~1.5 (0.9~1.1/ > 0.75/ 0.9~1.2)	0.6~1.2 (0.9~1.1/ <0.75/ 0.9~1.2)	1.1 P:0.7~0.9 (1.1/ 0.8~0.9/ 0.8~1.0)	X
Leg 5 joint 2 with small spinules on inner and outer margin	O(O)	(O)	(O)	(O)	X(X)	O

In the early or latter studies (Steuer, 1915; Brodskii, 1967; Bradford, 1976; Kim, 1985; Yoo *et al.*, 1991), *A. bifilosa* has been discribed to have rostral filaments (rostrum). Chen and Zhang (1965) pointed out that the rostral filaments of *A. bifilosa* female were uncertain, however there was no comment on the rostral filaments of the male.

A. bifilosa female has slender spinules only on the distal inner margin of the terminal joint of the 5th leg. While *A. clausi* (*omorii*) female has thick spines on the distal inner and outer margins of the 5th leg (Brodskii, 1967; Chen and Zhang, 1965; Kim, 1985; Sim *et al.*, 1988). *A. bifilosa* female also appeared to have shorter body segments than *A. clausi* (*omorii*). However, *A. hudsonica* also has this character (Bradford, 1976; Ueda, 1986a). *A. bifilosa* male has swollen inner lobe at the 4th segment of right 5th leg. While *A. clausi* (*omorii*) male has a separated inner lobe at the segment (Chen and Zhang, 1965; Kim, 1985; Sim *et al.*, 1988). This characteristic of *A. bifilosa* male is similar to *A. hudsonica* (Pinhey, 1926; Ueda, 1986a; Kang and Lee, 1990). But Bradford (1976) and Yoo *et al.* (1991) described *A. hudsonica* to have a slightly seperated inner lobe.

A. bifilosa male also could be identified by the length of 4th segment (terminal segment) of left 5th leg which is almost equal to the length of 3rd segment of left 5th leg. But the 4th segment (terminal segment) of left 5th leg of *A. clausi* (*omorii*) male is shorter than the 3rd segment of left 5th leg.

Bradford (1976) described the length ratio of the 4th segment to the 3rd segment of left 5th leg in subgenus *Acartiura* as the important key characteristics of *A. omorii*. Recently, Kimmerer (1993) recommended that *A. hudsonica* and *A. omorii* needs more taxonomic work to facilitate ecological research in Tomales Bay, California.

In conclusion, *A. bifilosa* in the area studied, does not have a rostral filament but have three grooves with longer central one. It is no longer reasonable to classify *A. bifilosa* into a subgenus Acanthacartia of the Rostratae group. *A. bifilosa* should be included in the subgenus *Acartiua* of the Arostratae group or only in the genus *Acartia*. And there were two thin, very short filaments and minute apertures on the anterio-ventral top of the head in both the species of *A. bifilosa* and *A. clausi*. Further studies on the role of the filaments and apertures are necessary.

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