

# 大阪湾における襟鞭毛虫類(Protozoa:Choanoflagellida)の 電子顕微鏡学的研究(2)

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# An Investigation with Electron Microscope of Marine Choanoflagellates (Protozoa: Choanoflagellida) from Osaka Bay, Japan

## II. Two New Genera and a New Species of Acanthoecidae<sup>1), 2)</sup>

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### Abstract

*Campyloacantha* n. gen. has characteristic "L" shaped costal strips, which form the anterior spines and the anterior transverse costa. Two species may be included in *Campyloacantha* n. gen.; *C. imbricata* n. sp. and *C. spinifera* n. comb. (= *Parvicorbicula spinifera* Leadbeater). The general form of the lorica of *Amoenoscopa caudata* n. gen. & n. sp. resembles that of *Polyoea* and *Acanthoea*. In *Amoenoscopa* n. gen., the anterior spines are long and consist of long heavy costal strips. By contrast, the anterior spines of *Polyoea* and *Acanthoea* comprise both long and short spines, which are made of delicate costal strips. The general form of the lorica of *Saroea paucicostata* n. sp. resembles that of *S. attenuata*. The specific characteristics are as follows: (1) the number of the longitudinal costae is 3-5, as compared to 6-8 in *S. attenuata*, (2) the number of longitudinal costal strips is 2, compared to 3-4 in *S. attenuata*, and (3) there are 2 transverse costae while there is 1 in *S. attenuata*.

Intensive studies have been carried out on the morphology and distribution of marine choanoflagellates, especially those of the family Acanthoecidae (e.g., THOMSEN & BOONRUANG 1984, MANTON et al. 1981, LEADBEATER 1980, HARA & TAKAHASHI 1984). Although it has become clear that the choanoflagellates have a world-wide distribution in surface seawater (e.g., THOMSEN 1978, MOESTRUP 1979, MANTON et al. 1980, BOOTH et al. 1982, BUCK & GARRISON 1983, HARA & TANOUÉ 1984), only little is so far known about choanoflagellate distribution in the western Pacific (HARA & TAKAHASHI 1984).

Morphological and taxonomical studies of Acanthoecidae species with an electron microscope have been carried out using the samples collected from Osaka Bay, southwestern Japan, from 1979 to 1980. In this part of the studies two new genera and a new species are established.

### Materials and Methods

Details of collection, concentration and preparation of samples for light and electron microscopical observations have been described in the previous part of this investigation (HARA & TAKA-

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HASHI 1987). The length of the lorica defined in this paper is the same as indicated in our previous paper (HARA & TAKAHASHI 1987).

## Results and Discussion

### *Campyloacantha* n. gen.

Cell is solitary. The lorica is composed of anterior spines, a lorica chamber and a posterior spine. Anterior spines are 3-5 in number, each of which is 6-8  $\mu\text{m}$  long and is composed of 1 costal strip. The conical lorica chamber is 10-11  $\mu\text{m}$  long and comprises 8 longitudinal and 1 transverse costae. The longitudinal costa is composed of two successive costal strips. The short anterior costal strips converge posteriorly in groups of 2-3 onto the front ends of the three long posterior costal strips, which converge at the posterior end of the lorica chamber. The transverse costa comprises 3-5 costal strips, and clockwise ends (viewed from anterior) of the transverse costal strips fuse with the posterior ends of the anterior spines each. Another ends of the transverse costal strips bent down obliquely to attach firmly to the bases of the anterior spines.

Type species: *Campyloacantha imbricata*.

Etymology: The generic name derived from the Greek campylo, "curved", and acantha, "spine".

### *Campyloacantha imbricata* n. sp.

(Plate I, 1-2)

*Diagnosis.* The species diagnosis is identical to the generic diagnosis.

*Iconotype:* Plate I, 1, collected from the surface water near the Shioya Coast, water temperature 15°C.

*Etymology:* The specific name derived from the Latin imbricata, "imbricated".

*Calliacantha* Leadbeater (LEADBEATER 1978) is closely related to *Campyloacantha* in having the conical lorica chamber, in the small number of the longitudinal costae and in the structures of the anterior and posterior spines each of which is formed by one bristle costal strip. In fact, the general form of *C. imbricata* n. gen. & n. sp. is very similar to that of *C. natans* (Grøntved) (MANTON & LEADBEATER 1978, Pl. I, 1 in the present study). These two genera, however, can be distinguished clearly by the following characteristics: costal strips forming anterior spine and transverse costa are connected but not fused in *Calliacantha*, while in *Campyloacantha* these costal strips are fused end to end and consequently form "L" shaped costal strips (Pl. I, 1-2). Another important difference is that the length of longitudinal costal strips are nearly equal in *Calliacantha*, but different in *Campyloacantha*. In the latter genus, the anterior one is about half in length of the posterior one (Pl. I, 1). These characteristics not only set *Campyloacantha* apart from *Calliacantha*, but also distinguishes this new genus from all the other genera of the family Acanthoecidae.

The seasonal distribution of *Campyloacantha imbricata* n. gen. & n. sp. is shown in Fig. 1. Three specimens were collected from Osaka Bay in warmer seasons when the water temperature was 15.0 to 23.7°C. Neither quantitative nor qualitative variation in lorica structure

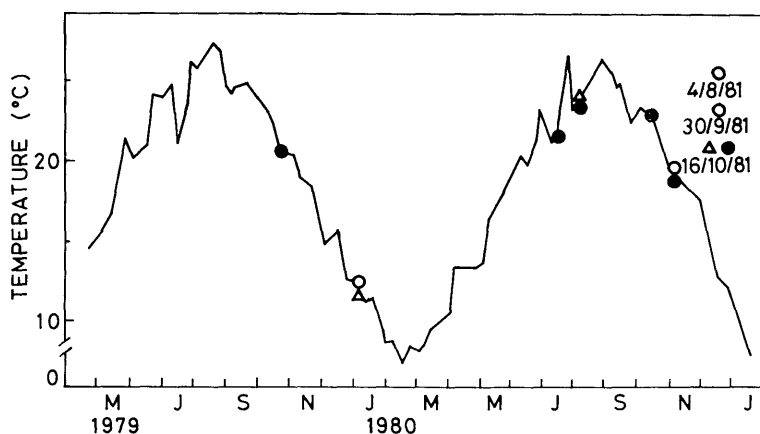


Fig. 1. Seasonal distribution of *Campyloacantha imbricata* n. gen. & n. sp. (open triangle), *Amoenoscopa caudata* n. gen. & n. sp. (open circle) and *Saroea paucicostata* n. sp. (solid circle) from April 1979 to December 1980. The occurrence of these species from January 1981 to August 1982 is indicated by the symbols to the corresponding water temperature in right. Their sampling dates are shown below the symbols.

was observed among these three specimens.

*Campyloacantha spinifera* (Leadbeater) n. comb.

*Parvicorbicula spinifera* Leadbeater, 1973, p. 245, fig. 2c.

The general lorica structure of *Parvicorbicula spinifera* described by LEADBEATER (1973, fig. 2c, pl. 15c, d) is quite similar to that of *Campyloacantha imbricata* n. gen. & n. sp. Particularly, the base of an anterior spine of *P. spinifera* apparently sticks firm on one end of a transverse costal strip and consequently they form a "L" shaped anterior costal strip. Judging from the photographs in LEADBEATER (1973, pl. 15c, d), the longitudinal costa consists of two costal strips and the anterior one is shorter than the posterior one. Additionally, both species have one conical lorica chamber that is composed of one transverse costa and some longitudinal costae which converge at the posterior ends of the lorica chambers. Based on the close similarity mentioned above in the structures of the loricae between *C. imbricata* n. gen. & n. sp. and *P. spinifera*, it is reasonable to include these two species in a same genus, *Campyloacantha*. These two species, however, differ as regards: (1) the number of anterior spines is 3-5 in *C. imbricata*, as compared to 6 in *P. spinifera*, (2) the general shape of the lorica chamber is long conical in *C. imbricata*, compared to short conical in *P. spinifera*, and (3) the height of the lorica is more than 16  $\mu\text{m}$  (without posterior spine) in *C. imbricata*, while it is only 8  $\mu\text{m}$  in *P. spinifera*. The existence of posterior spine is not clear in *P. spinifera*. It thus seems justified to transfer *P. spinifera* to a separate species in the new genus *Campyloacantha*.

*Amoenoscopa* n. gen.

Cell is solitary. The lorica is 19-23  $\mu\text{m}$  long (without stalk) and comprises anterior spines, a lorica chamber and a massive stalk. Anterior spines are 15-18 in number and are composed

of 2 costal strips. The apical end of the anterior costal strip of the spine is trifurcated. The lorica chamber is composed of 20–26 longitudinal and 2–3 transverse costae. Each of the longitudinal costae is composed of one costal strip and they converge posteriorly onto the long massive stalk which is a bundle of 3–4 costal strips. Transverse costal strips connect on the inside of the lorica chamber and the base of the anterior spines. All the costal strips are thickened and elongated.

Type species: *Amoenoscopa caudata* n. gen. & n. sp.

Etymology: The generic name derived from the Latin *amoeno*, “beautiful” and *scopa*, “broom”.

*Amoenoscopa caudata* n. sp.

(Plate I, 3–5)

*Diagnosis.* The species diagnosis is identical to the generic diagnosis.

Iconotype: Plate I, 3, collected from the surface water of the Shioya Coast on 4 August 1981, water temperature 25.2°C.

Etymology: The specific name derived from the Latin *caudata*, “with a stalk.”

In general, the form, dimensions and the structure of the lorica of *Amoenoscopa* n. gen. are similar to that of *Polyoea* and/or *Acanthoea* (cf. LEADBEATER 1978, HARA & TAKAHASHI 1984, Pl. I, 3 in the present study). In these three genera, the champagne glass-like lorica are formed by anterior spines, a lorica chamber and a massive stalk, and the apical tips of the anterior spines are trifurcated (Pl. I, 3, 5) and the transverse costal strips are arranged on the inside of the anterior spines and the lorica chamber (Pl. I, 4). The anterior spine structure, however, distinguishes *Amoenoscopa* clearly from *Polyoea* and *Acanthoea*. In *Amoenoscopa* n. gen., long and heavy costal strips constitute the anterior spines, that are connected by transverse costal strips only at its base (Pl. I, 3). By contrast, anterior spines of *Polyoea* and *Acanthoea* are composed of both long and short spines, each of them is made up of delicate costal strips. Moreover, the spines of the latter two genera are backed by a band of regularly arranged transverse costal strips at the middle of the spines as well as the connection at the base (LEADBEATER 1979, HARA & TAKAHASHI 1984). Based on the heterogeneity of anterior spine structures between ‘*Amoenoscopa*’ and ‘*Polyoea* and *Acanthoea*’, it is justified to place *Amoenoscopa* in a separate genus in Acanthoecidae. On the other hand, *Polyoea* and *Acanthoea* are obviously closely related genera in the family because of the similarity of the anterior spine morphology (LEADBEATER 1979, HARA & TAKAHASHI 1984).

In addition to *Amoenoscopa caudata* n. gen. & n. sp., four species, i.e. *Acanthoea spectabilis*, *Polyoea dichotoma*, *Stephanoeca cauliculata*, and *Parvicorbicula pedunculata*, have been shown to possess massive stalks (LEADBEATER 1980, HARA & TAKAHASHI 1984, Pl. I, 3 in the present study). Although the morphological details of the massive stalks are different in these five species (LEADBEATER 1980), a dense arrangement of longitudinal costal strips at the posterior half of the lorica (Pl. I, 3, 4), from where the massive stalk is projected, is a feature shared among these five species.

The seasonal distribution of *Amoenoscopa caudata* n. gen. & n. sp. is shown in Fig. 1.

The four specimens examined were found in surface seawater samples from various seasons, i.e. from summer to winter (the water temperature varied from 12.0 to 25.2°C). This species may be eurythermal. Neither quantitative nor qualitative variation in lorica structure was observed among the four specimens.

*Saroeca paucicostata* n. sp.

(Plate I, 6-8)

*Saroeca attenuata* Thomsen, 1982, p. 26, fig. 95 (not Thomsen, 1979).

Cell is solitary and planktonic. The protoplast is 3-6  $\mu\text{m}$  long and 1.5-3  $\mu\text{m}$  wide after desiccation. The flagellum is 5-14  $\mu\text{m}$  long and is surrounded by a ring of tentacles. The lorica is 17.5-29.5  $\mu\text{m}$  long and comprises anterior spines (5-10  $\mu\text{m}$  in length), a lorica chamber (5-8  $\mu\text{m}$  in length) and a posterior spine (7-12  $\mu\text{m}$  in length). There are commonly four, occasionally three or five, longitudinal costae, each formed by two successive costal strips that converge at the posterior end of the lorica chamber. The anterior sigmoidal costal strips are exceptionally long and slender and 7.5-12.5  $\mu\text{m}$  long. The anterior three fourths of the costal strips project beyond the lorica chamber to form the anterior spines. The posterior longitudinal costal strips are simply curved and 4-6  $\mu\text{m}$  in length. There are two transverse costae. The anterior one, 2.5-4.0  $\mu\text{m}$  in length, is composed of 6-10 costal strips and crosses the anterior longitudinal costal strips at the proximal one fourth of the strips, where they are widest. The junctions are mostly "T"-shaped. The posterior transverse costa, 1.5-2.5  $\mu\text{m}$  in diameter, is composed of 4-6 costal strips and crosses at the junctions of the anterior and the posterior longitudinal costal strips. The posterior spine is sigmoidal, 7-12  $\mu\text{m}$  in length, and projects from the posterior end of the lorica chamber.

Iconotype: Pl. I, 6 depicts a cell collected on 14 October 1980 from water at 22.7°C.

Etymology: The specific name derives from the Latin *paucicostata*, "having a small number of costae".

The present species is obviously closely related to *Saroeca attenuata* described by THOMSEN (1979) as can be seen from the general form of the lorica, the small number of the longitudinal costae and, especially, the very long anterior longitudinal costal strips and the level at which the anterior transverse costa crosses the longitudinal costae, i.e. they connect with the anterior longitudinal costal strips at their widest point (THOMSEN 1979, Pl. I, 6-8 in the present study). These characteristics separate these two species from the other species of Acanthoecidae and make it reasonable to include these two species in a same genus.

There are, however, some significant differences between the present species and *S. attenuata*. First, in this species there are two transverse costae, one connects the first longitudinal costal strips at the widest point and the other is located at the connection between the first and the second longitudinal costal strips (Pl. I, 6-8). By contrast, in *S. attenuata*, there is only one transverse costa that connects the longitudinal costae at the widest point of the first longitudinal costal strips. Second, in the present species, each of the longitudinal costae are formed by two successive costal strips that do not join (Pl. I, 7) or join (Pl. I, 6-8) each other before terminating posteriorly. By contrast, three or four costal strips form the longitudinal costae

of *S. attenuata* and the longitudinal costae always join each other before they terminate posteriorly (THOMSEN 1979).

The characteristics mentioned above seem to exclude the present species from the previous generic category of *Saroeca*, as well as differentiate the present species from *S. attenuata*. The genus *Saroeca* has been initially defined as the genus in which the longitudinal costae join each other before terminating and only one transverse costa exists (THOMSEN 1979). However, the essential similarity between *S. paucicostata* and *S. attenuata* does not allow us to classify these two species in separate genera. Instead, we intend to emend the generic diagnosis of *Saroeca* (see below). The small number, 3 to 5, of longitudinal costae in the present species (Pl. I, 6-8), from which the specific name has been derived, also distinguishes it from *S. attenuata* with 6 to 8 longitudinal costae.

Variation of the absolute lorica size among the present specimens rule out simple interpretation of a direct influence on size by temperature (Fig. 2a). The ratios in length, however, of the anterior longitudinal costal strip and posterior spine to the posterior longitudinal costal strip are constant, regardless different lorica sizes, at different temperatures and different sampling periods (Fig. 2b).

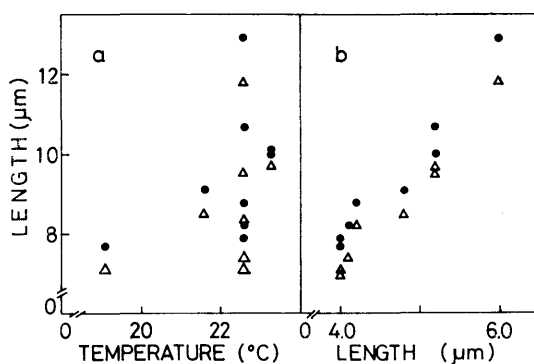


Fig. 2. Changes in length of anterior (circle) and posterior (triangle) spines of *Saroeca paucicostata* n. sp. (ordinate) (a) with water temperature (abscissa), and (b) with the length of the second longitudinal costal strips (abscissa). Mean water temperature over five days before each sampling was taken.

The *Saroeca attenuata* specimen reported from West Greenland (fig. 95 in THOMSEN 1982) has only five longitudinal costae, each of which is formed by two costal strips and two transverse costae. These characteristics indicate that his specimen should be identified as *S. paucicostata* rather than *S. attenuata*. The lorica dimensions of the specimen from West Greenland, calculated from fig. 95 in THOMSEN (1982), are slightly larger than those of the samples we have described here. However, each ratio of the costal strip lengths at the different levels is included within the range of variation found in our samples.

*Saroeca paucicostata* in Osaka Bay occurred when water temperature ranged from 20.1 to 23.3°C (Fig. 1). This species can be found off west Greenland (*Saroeca attenuata* in THOMSEN,

1982, also see above) where water temperatures are lower than 13°C. The range from 13°C to 23.3°C is assigned to this species (THOMSEN 1982, this study).

### Revised Taxonomic Description

*Saroeca* Thomsen, emend. (THOMSEN, H. A., 1979, *Acta Bot. Fenn.*, **110**, p. 25)

*Diagnosis.* Cell is solitary, with a flagellum surrounded by a collar of tentacles. Lorica is conical, with a small number of long, attenuating costal strips diverging anteriorly, and stipitate posteriorly. One or two transverse costae, the anterior one connects with the anterior longitudinal costal strips at the point where they are widest.

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### Explanation of Plate I

*Campyloacantha imbricata* n. gen. & n. sp.

1. A whole lorica. Anterior spines are fused with transverse costal strips to form "L" shaped costal strips. Anterior short and posterior long costal strips form a longitudinal costa. Scale: 2  $\mu$ m.
2. A partly destroyed lorica of *Campyloacantha imbricata* n. gen. & n. sp. "L" shaped anterior spines are conspicuous. Scale: 2  $\mu$ m.

*Amoenoscopa caudata* n. gen. & n. sp.

3. A whole lorica. Arrowheads indicate a massive stalk. Scale: 2  $\mu$ m.
4. SEM image of a lorica chamber. Transverse costae arranged inside of anterior spines or longitudinal costae. Scale: 1  $\mu$ m.
5. Trifurcated anterior tips of anterior spine costal strips. Scale: 1  $\mu$ m.

*Saroeca paucicostata* n. sp.

6. A complete cell with protoplast, flagellum and collar. The number of longitudinal costae is reduced from five at the anterior spines to four at the posterior part of the lorica chamber. Scale: 5  $\mu$ m.
7. A cell with four anterior spines. The number of longitudinal costae is not reduced posteriorly. Scale: 5  $\mu$ m.
8. A lorica with four anterior spines. The longitudinal costae reduce in number to three at the posterior end of the lorica chamber. Two transverse costae are clearly indicated. Scale: 5  $\mu$ m.

PLATE I

