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Choanoflagellates (Sarcomastigophora, Protozoa) from the Coastal Waters of Taiwan and Japan (II): Species Composition and Biogeography

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Seiko Hara, Jia-Chi Sheu, Yuh-ling Lee Chen and Eiji Takahashi (1997) Choanoflagellates (Sarcomastigophora, Protozoa) from the coastal waters of Taiwan and Japan II. Species composition and biogeography. *Zoological Studies* **36**(2): 98-110. Light and electron microscopical studies of sea microbes from the coastal waters of Taiwan have revealed an abundant choanoflagellate fauna from these Western Pacific subtropical waters. A total of 25 loricate (Acanthoecidae), 3 thecate (Salpingoecidae), and 1 naked (Codonosigidae) choanoflagellates were recorded for the 1st time from coastal waters of Taiwan. The Taiwanese loricate choanoflagellate fauna is more similar to that of Japan (20 species in common) than to that of the tropical Indian Ocean (11 species in common).

Key words: Acanthoecidae, Salpingoecidae, Codonosigidae, Morphology, Taxonomy.

The order Choanoflagellida (Sarcomastigophora, Protozoa) comprises heterotrophic protista with a single flagellum surrounded by a collar of tentacles (Levine et al. 1980). The Choanoflagellida includes 3 families: Codonosigidae, Salpingoecidae, and Acanthoecidae (Norris 1965).

Choanoflagellates, especially the Acanthoecidaeans, are believed to be major consumers of bacteria, and possibly dominant secondary producers in the saprotrophic food chain in a planktonic oceanic habitat (Fenchel 1982, Buck and Garrison 1988, Hara and Takahashi 1988). The choanoflagellates may thus play a key role in the initial stages of energy flow in a marine planktonic habitat (Azam et al. 1983, Tanoue and Hara 1986).

Morphological and taxonomical investigations based on modern techniques have dealt with choanoflagellates from circumpolar to tropical waters (Thomsen et al. 1991). In the northern Pacific region, the choanoflagellates have been studied in subarctic oceanic waters (Booth et al. 1982, Booth 1990), temperate coastal waters (Takahashi 1981, Hara and Takahashi 1984 1987a,b, Buck et al. 1991, Thomsen et al. 1991), and within the North Pacific central gyre (Hoepffner and Haas 1990).

The objective of this investigation was to examine for the 1st time the choanoflagellate species composition of Taiwanese waters, i.e., the subtropical Western Pacific region.

MATERIALS AND METHODS

Surface water samples were collected from September 1992 to July 1993 at 6 Taiwanese coastal localities. Details of sampling sites are described in Hara et al. (1996). The concentration and preparation of samples for electron microscopic observation are described elsewhere (Hara and Takahashi 1987a). Samples were concentrated in 2 different ways. Gravity sedimentation and

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concentration were applied to those sea water samples that contained little detrital material. Sea water samples with higher levels of detritus were centrifuged (3 000 rpm for 10 min) and afterwards rinsed with distilled water. This centrifugation and rinsing were repeated 5 times. Droplets of the concentrated sample were mounted on formvar-coated grids and dried at room temperature. After drying, the gravity-concentrated samples were desalted with distilled water twice. The grids were shadowed with chromium.

Seawater sub-samples (0.5 to 1.0 l) were enriched with Erdschreiber medium (Leadbeater and Davies 1984) and kept at room temperature for up to 2 wk. A small amount of the surface bacterial films and/or protozoan populations attached to the wall of the culture vessel were removed periodically with a Pasteur pipette. The material was mounted directly on glass slides for light microscopic observation of living cells. In addition, aliquots of cultured samples were fixed for electron microscopic observation.

A Zeiss Axioscope, fitted with a 100x plan-Neofluar objective (NA 1.30), was used for light microscopy. A JEOL 100B and 100S were used for transmission electron microscopy.

In this paper, the anterior projection (Thomsen and Buck 1991) is considered a structure independent from the longitudinal costa (Hara et al. 1996). The number of costal strips forming a longitudinal costa thus does not include the costal strips forming the anterior projection.

RESULTS AND DISCUSSION

Species composition

A total of 31 taxa (29 species and 2 subspecies) from 21 choanoflagellate genera was identified in the present study. Among these, 25 taxa were loricate (family Acanthoecidae), 3 thecate (family Salpingoecidae), and 1 naked (family Codonosigidae).

Family Codonosigidae

***Monosiga ovata* Kent, 1880**
(Fig. 1)

A naked and solitary sessile species was found in the Nanwan sample. Protoplasts are usually obovate after TEM preparation.

Family Salpingoecidae

***Salpingoeca inquillata* Kent, 1880**
(Fig. 2)

The theca is composed of a bell-shaped chamber and a slender stalk (Kent 1880). The chamber is widest in the middle part and slightly everts at the anterior. The chamber tapers posteriorly to form a stalk. In some specimens, the axis of the chamber is at a slight angle from the axis of the stalk. The theca illustrated in Fig. 2 has no protoplast. The protoplast with a flagellum surrounded by a collar, observed in light microscopy, was either severed from the theca or had burst during preparation for electron microscopy.

This specimen was found in cultured samples from Nanwan tidal pool water collected on 5 Jan. 1993.

***Salpingoeca tuba* Kent, 1880**
(Fig. 3)

S. tuba is solitary and embedded in a vase-shaped theca with a short stalk. The anterior part of the theca is almost tubular. The protoplast with a flagellum and a collar was either severed from the theca or had burst during preparation for electron microscopy.

The theca illustrated in Fig. 3 also resembles the freshwater species *S. gracilis* and *S. vaginicola* (Boucaud-Camou 1967).

S. tuba was found in cultured samples from Nanwan tidal pool water collected on 5 Jan. 1993.

***Diploeca* aff. *elongata* (Fott) Bourrelly, 1957**
(Figs. 4, 5)

The species is sedentary and with a double theca. The outer theca (8 μm in diameter), which surrounds the posterior part of the protoplast, is thick, spherical and light brown in color. The hyaline inner theca, which surrounds the neck and the lower part of the collar, is much elongated (20-25 μm in length), and everted at the anterior end.

The cells illustrated here (Figs. 4, 5) are similar to *D. elongata* in general form, but differ in 2 aspects. The neck of the present specimen is 3 times longer than the cell chamber, as opposed to only twice as long in *D. elongata* (Starmach 1985; Fig. 973). In the Taiwanese cells, a narrow protoplast filament (ca. 0.4 μm in diameter) is situated at the center of the thecal neck (ca. 1.6 μm in diameter). In *D. elongata* the protoplast

completely fills the neck part of the internal theca (Starmach 1985). Finally, the marine habitat of this species also contradicts the freshwater habitat of *D. elongata*.

Found in cultured samples from Nanwan tidal pool water collected March 1993.

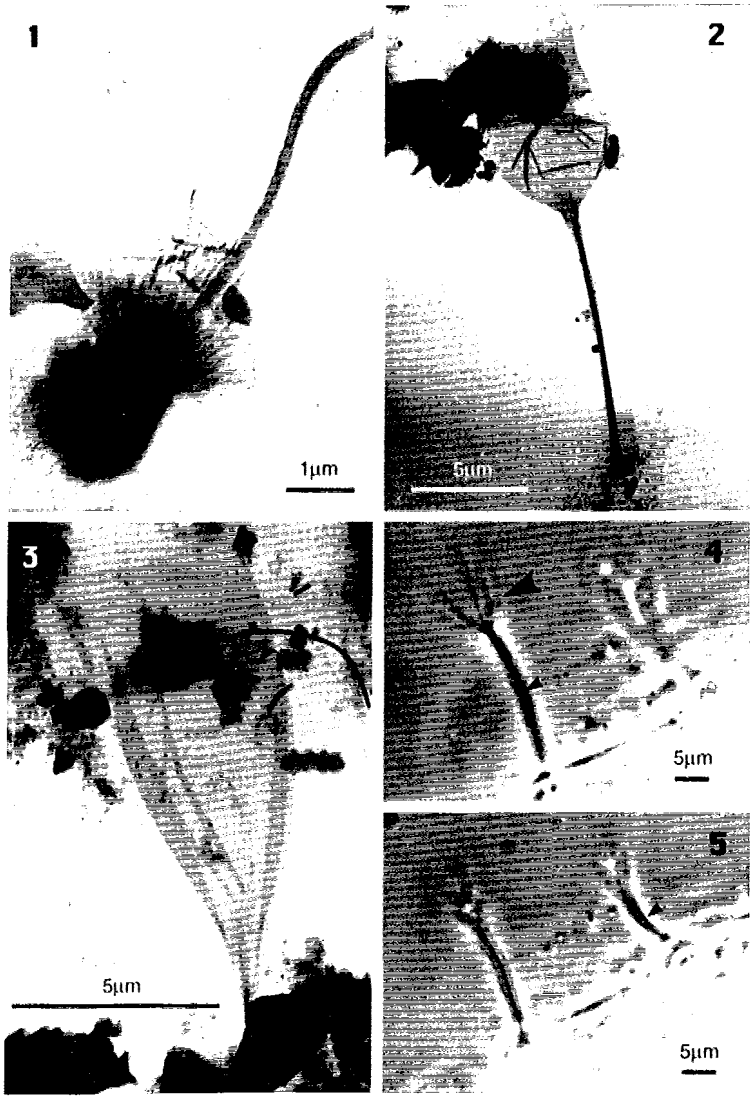
Acanthoecidae

Acanthocorbis camarensis Hara in Hara et al., 1996
(Fig. 6)

This species somewhat resembles *A. unguiculata* (Thomsen 1973), but is clearly distinguished from the latter by a prominent waist between the anterior and posterior chambers, the regularly arranged transverse and longitudinal costae at the anterior chamber, and the rounded apical tips of the anterior projections (Hara et al. 1996).

This species has been recorded from Taiwan, Hawaii, and Thailand (Hara et al. 1996).

Acanthoeca spectabilis Ellis, 1929
(Fig. 7)



Figs. 1-3. Transmission electron micrographs. 1. *Monosiga ovata* with a collar of tentacles and a flagellum. 2. Theca of *Salpingoeca inquillata* without protoplast. 3. Theca of *Salpingoeca tuba* without protoplast. **4 and 5.** Light micrographs of *Diploeca* aff. *elongata*. 4. The hyaline inner theca is elongate and everts at the anterior end (large arrowhead). The upper and lower parts of the protoplast are connected by a narrow thread-like string of cytoplasm (small arrowhead). 5. Notice a food particle (a small cyanobacter cell) in the middle of the neck (arrowhead).

This species is distributed worldwide (Thomsen 1982, Thomsen et al. 1990).

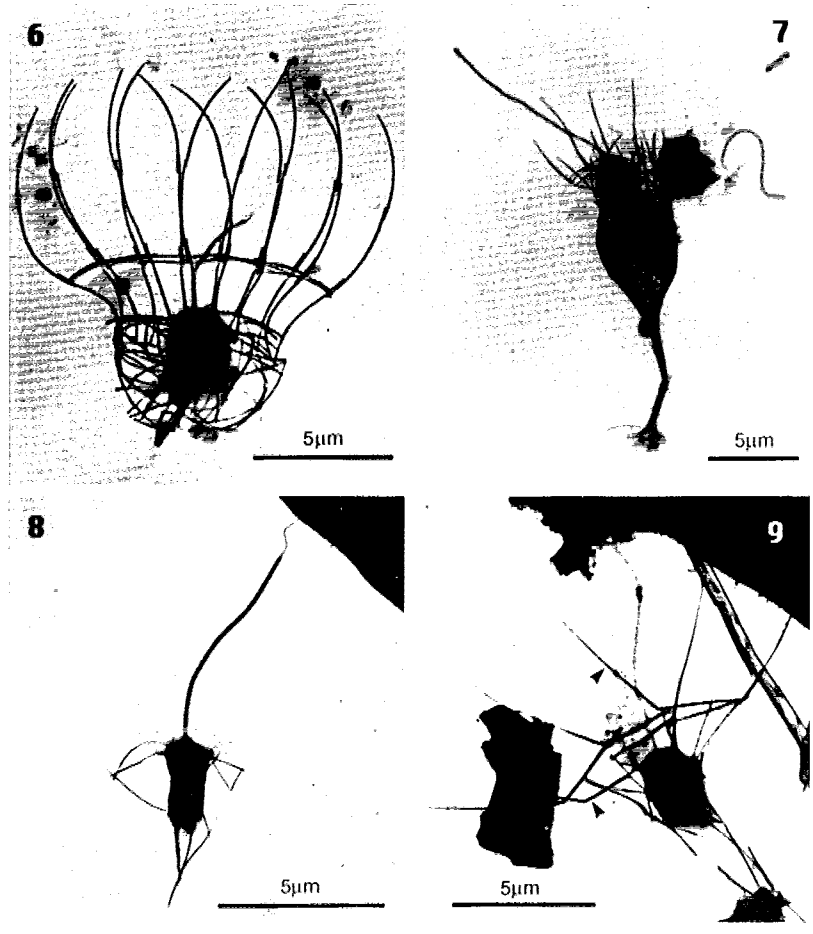
Apheloecion pentacanthum Thomsen in Thomsen and Boonruang, 1983b
(Fig. 8)

The protoplast is located in a simple lorica constructed from 5 longitudinal costae, 1 transverse costa, and a simple pedicel.

This species has been previously recorded from Thailand (Thomsen and Boonruang 1983b) and California (Thomsen et al. 1991).

Campyloacantha imbricata Hara and Takahashi, 1987b
(Fig. 9)

The characteristic "L"-shaped costal structures, formed by the fusion of an anterior projection and a transverse costal strip, are shown in Fig. 9 (see arrowheads). The Taiwanese specimens possess 5 or 6 anterior projections (each ca. 4.5 μm long) and are further characterized by a long, conical lorica chamber (> 9 μm) formed by more than 6 longitudinal costae each of which has 2 costal strips of unequal length. The genus *Campyloacantha* is comprised of 2 species (*C. imbricata* and *C. spinifera*). Hara and Takahashi (1987b) listed 3 morphological characteristics to distinguish these 2 species: 1) the number of anterior projections (3-5 in *C. imbricata* and 6 in *C. spinifera*); 2) the shape of the lorica chamber (long conical in *C. imbricata* and short conical in *C. spinifera*); and 3) the height of the lorica chamber (more than 16 μm in *C. imbricata* and up to 8 μm in *C. spinifera*). The Taiwanese specimens resemble the type material of *C. imbricata* in lorica chamber morphology. The fact that the longitudinal costa are each formed by 2 different-sized costal strips further



Figs. 6-9. Transmission electron micrographs. 6. *Acanthocorbis camarensis*. A complete lorica with protoplast. 7. *Acanthoeca spectabilis*. A lorica without protoplast. 8. A complete cell of *Apheloecion pentacanthum*. 9. Lorica of *Campyloacantha imbricata*; arrowheads indicate the characteristic "L" shaped costal strip, located at the anterior lorica end.

indicates that the material from Taiwan should be classified as *C. imbricata*.

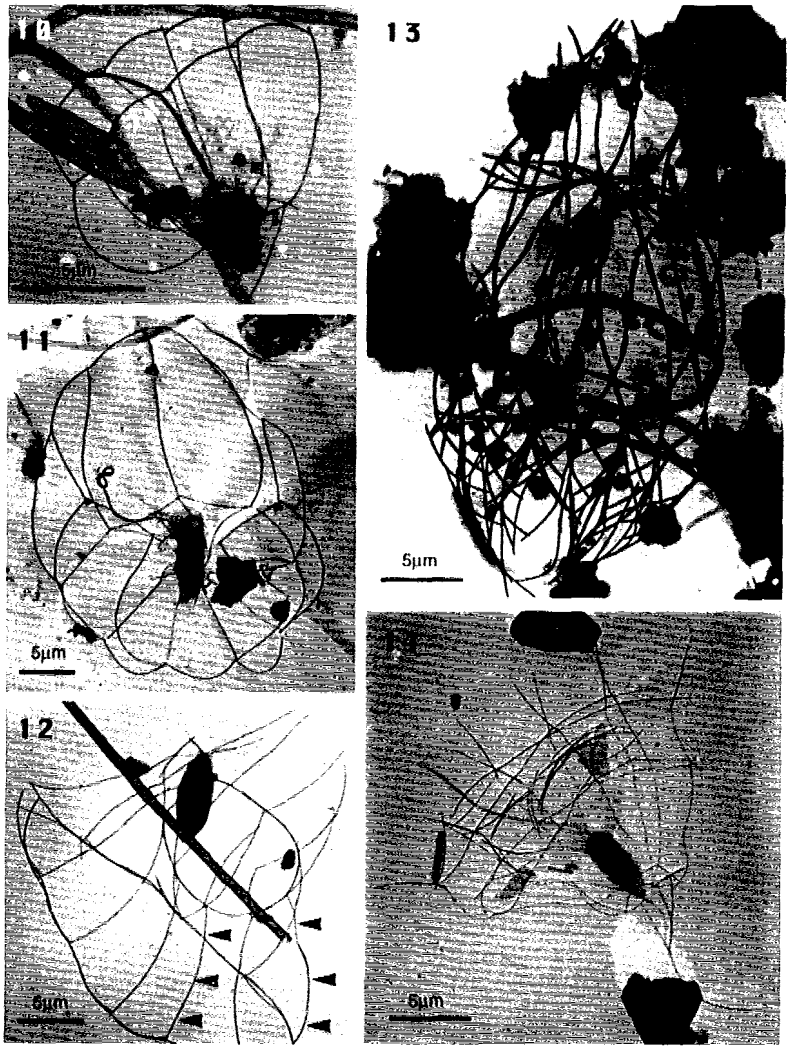
There are, however, some differences between the present specimens and the Japanese type specimen of *C. imbricata*. The cells from Taiwan have shorter anterior projections than the type specimen (6-8 μm). However, this difference should be regarded as intraspecific variation within *C. imbricata*. The number of anterior projections in Taiwanese specimens bridges the gap between *C. imbricata* and *C. spinifera*. This emphasizes that the number of anterior projections can no longer be considered as a species-specific characteristic. The form and size of the lorica chamber thus constitute the best criteria to distinguish these 2 species, although the size ranges are also closer to each other following this study.

This species was previously recorded only from Osaka Bay, Japan (Hara and Takahashi 1987b).

Cosmoeca phuketensis Thomsen in Thomsen and Boonruang, 1984

(Fig. 10)

This species was previously recorded from the Mediterranean Sea, Sargasso Sea, East Australian



Figs. 10-14. Transmission electron micrographs. 10. A complete cell of *Cosmoeca phuketensis*. A reduced diameter at the level of the 2nd transverse costa results in a conical-shaped lorica. 11. A complete cell of *Cosmoeca ventricosa*. The barrel-shaped lorica results from equal diameter of the 2 anterior transverse costae. 12. A lorica of *Crinolina isefiordensis* without protoplast. Arrowheads indicate 3 costal strips of the longitudinal costa. 13. *Diaphanoeca spiralifurca*. An empty lorica with spiral and bifurcating arrangements of longitudinal costae at the posterior part of the lorica. 14. A cell of *Diaphanoeca undulata* which has accumulated additional costal strips at the level of the collar. Some premature costal strips appear in the protoplast.

Current, and coastal waters of Egypt and Thailand (Thomsen and Boonruang 1984).

Cosmoeca ventricosa Thomsen in Thomsen and Boonruang, 1984
(Fig. 11)

In addition to the main morphological type, the *Cos. ventricosa* complex includes a number of tentative forms with minor variability in either lorica dimensions or in morphological details (Thomsen and Boonruang 1984, Thomsen et al. 1990).

The present specimens are identical to the original type.

This taxon has a worldwide distribution (Thomsen et al. 1991).

Crinolina isefiordensis Thomsen, 1976
(Fig. 12)

The skirt-shaped lorica, which is open at both ends, is constructed of 11 anterior projections and a lorica chamber. Each of the anterior projections is comprised of 2 costal strips and arise from a longitudinal costa. The lorica chamber is comprised of 11 longitudinal (15-16 (12) in the type material) and 2 transverse costae. Each longitudinal costa is composed of 3 costal strips (arrowheads in Fig. 12; 4-5 in the type material). Total height of the lorica is 19 μm (25-30 μm in the type material) and the diameters of the 1st and the 2nd transverse costae are 10 μm and 20 μm, respectively (10-13 μm and 20-31 μm, respectively, in the type material). From the above, it is obvious that the Taiwanese specimens significantly expand the morphological variability of this taxon.

Cri. isefiordensis was previously reported from northern Europe to the Southern Ocean (Thomsen et al. 1991).

Diaphanoeca spiralifurca Hara in Hara et al., 1996
(Fig. 13)

This species closely resembles *Dia. grandis* and *Dia. sphaerica* (Thomsen 1982). Morphological details distinguishing these 3 species have been described by Hara et al. (1996).

This species is recorded from Taiwan, Japan (Hara et al. 1996), and Western Australia (Dr. S. Tong, pers. comm.).

Diaphanoeca undulata Thomsen, 1982
(Fig. 14)

This species has been recorded from the Arctic, temperate North Pacific, and the temperate North Atlantic (Thomsen et al. 1991).

Diplotheca costata Valkanov, 1970
(Fig. 15)

This species has been previously recorded from subarctic to temperate Atlantic and Mediterranean areas (Leadbeater 1974, Thomsen 1979). This is the first non-European record of *Diplotheca costata*.

Nannoeca minuta (Leadbeater) Thomsen, 1988
(Fig. 16)

This species has been recorded from Europe, the western coast of the U.S.A., southern Chile, New Zealand, the Red Sea, Thailand (Thomsen 1988), and Japan.

Parvicorbicula aff. *superpositus* Booth, 1990
(Fig. 17)

Taiwanese specimens of *P. superpositus* differ from the subarctic Pacific type-material in having an equal number of anterior projections and longitudinal costae.

It should be noted that the present species, e.g., regarding the existence of anterior projections, does not confirm with the generic type, *P. socialis* (see e.g., Thomsen and Buck 1991).

Platypleura cercophora Thomsen in Thomsen and Boonruang, 1983a
(Fig. 18)

This species has been previously recorded from Thailand only (Thomsen and Boonruang 1983a).

Platypleura infundibuliformis (Leadbeater) Thomsen in Thomsen and Boonruang, 1983a
(Fig. 19)

This species has been recorded from Denmark, Norway, the Mediterranean, the Red Sea, New Zealand, Thailand (Thomsen and Boonruang 1984, Espeland and Throndsen 1986), and Japan.

Pleurasiga echinocostata Espeland in Espeland and Throndsen, 1986
(Figs. 20, 21)

This species was initially reported by Lead-

beater (1973) as *Ple. reynoldsii* aff. and later separated from *Ple. reynoldsii* because of the absence of a 2nd transverse costa. *Ple. echinocostata* has only 1 transverse costa located at the anterior end of the lorica. Part of the Taiwanese material agrees well with the type material in lorica morphology and numerical features (Fig. 20). However, in some cells the lorica lacks the anteriorly pointing spines located at 1 end of each anterior transverse costal strip (Fig. 21). The 2 forms were found in the same water samples. More materials will be needed to further analyze this morphological variability before any decision is made about possible taxonomic consequences.

This taxon was previously reported from the Mediterranean (Leadbeater 1973, as *Parvicorbicula reynoldsii* aff.), Norway (Espeland and Throndsen 1986), the North Pacific Central Gyre (Hoepffner and Haas 1990), and California (Thomsen et al. 1991).

Polyoeca dichotoma Kent, 1881

(Fig. 22)

(*P. dumosa* Dunkerly, 1910)

This species has been recorded from coastal Europe (Kent 1880-82, Dunkerly 1910, Boucaud-Camou 1996, Leadbeater 1979), the west coast of the U.S.A. (Norris 1965), and Japan (Hara and Takahashi 1984).

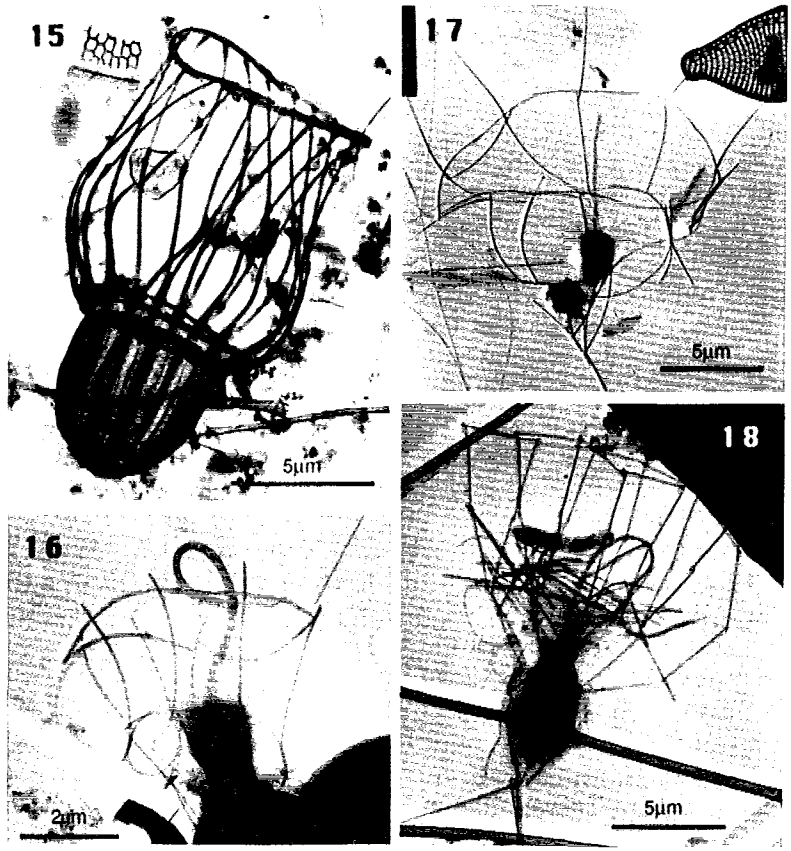
Saroeca paucicostata Hara and Takahashi, 1987b

(Fig. 23)

This species has been reported from West Greenland (Thomsen 1982 as *Sar. attenuata*) and Japan (Hara and Takahashi 1987b).

Savillea parva (Ellis) Loeblich III, 1967

(Fig. 24)



Figs. 15-18. Transmission electron micrographs. 15. A complete lorica of *Diplotheca costata*. A pair of transverse costae form part of the waist separating the 2 chambers. 16. A somewhat damaged cell of *Nannoeca minuta*. 17. A complete cell of *Parvicorbicula* aff. *superpositus* with anterior projections extending from the end of each longitudinal costa. 18. *Platypleura cercophora*. Notice bundles of costal strips in the collar region indicating that cell division is in progress.

This species has been recorded from coastal Europe (Ellis 1929 as *Diaphanoeca parva*, Leadbeater 1972), the North Atlantic (Throndsen 1974), the west coast of the U.S.A. (Norris 1965 as *Ellipsiella parva*), Antarctica (Thomsen et al. 1990), and Japan.

Stephanacantha formosa Thomsen in Thomsen and Boonruang, 1983a

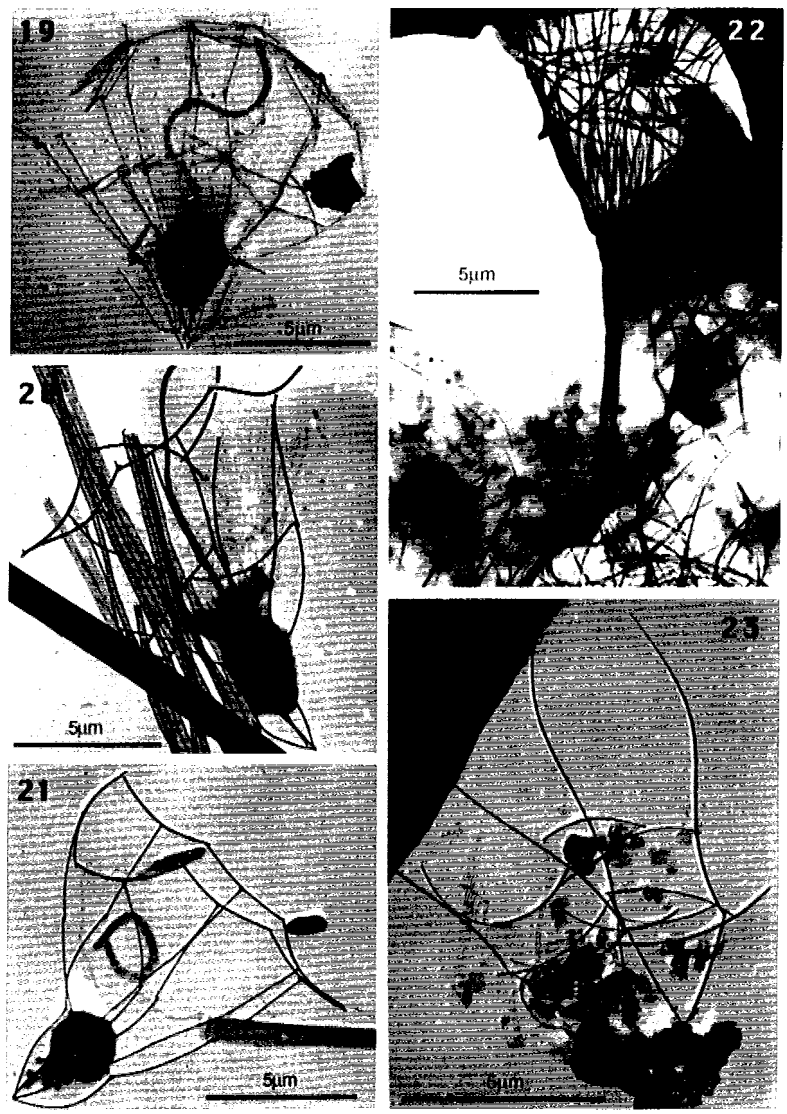
(Fig. 25)

Previously recorded from Thailand and the Sargasso Sea (see Thomsen and Boonruang 1983a). This is the 1st record from the Pacific area.

Stephanoeca apheles Thomsen in Thomsen et al., 1991

(Fig. 26)

The lorica, ca. 16 μm in length, consists of 14-18 (14-16) longitudinal and 3 transverse costae. The diameters of the lorica are 4.5 μm (3.8-4.8 μm) and 7.5 μm (5-7 μm) at the anterior and middle



Figs. 19-23. Transmission electron micrographs. 19. *Platypleura infundibuliformis*. The costal strips are flattened and with a conspicuous midrib. 20, 21. *Pleurasiga echinocostata*. 20. Cell with a spicule extending forward from 1 end of each transverse costal strip. 21. Lorica without a spicule at 1 end of each transverse costal strip. 22. *Polyoeca dichotoma*. The lorica is partially distorted, but closely arranged costal strips and the aggregated pedicel are obvious. 23. Empty lorica of *Saroeca paucicostata*, the simple pedicel is not visible.

transverse costae, respectively. Numbers in brackets refer to the type material (Thomsen et al. 1991).

Ste. apheles has been previously reported from the Baltic Sea and California (see Thomsen et al. 1991).

Stephanoeca aff. *cupula* in Thomsen, 1988
(Fig. 27)

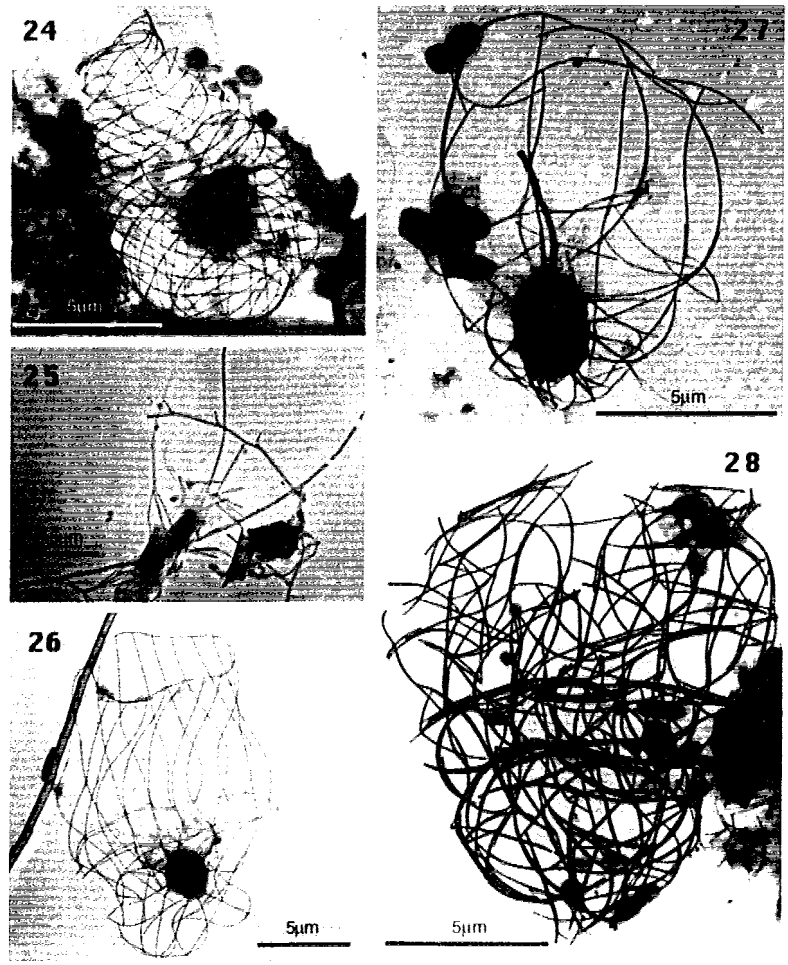
The lorica, ca. 11 μm in length and 4.5-5 μm in diameter, consists of anterior and posterior chambers. The anterior chamber is formed by 8 longitudinal and 2 transverse costae. The 2 anterior transverse costae are located at the anterior lorica end and at the connections between the 1st and 2nd longitudinal costal strips. The connections are distinct 3-point joints (Fig. 27). The posterior lorica chamber consists of more or less irregularly arranged costal strips.

The species is known from Denmark (Thomsen 1988) and Antarctica (Hara et al. 1986).

Stephanoeca diplocostata Ellis, 1929
(Fig. 28)
(*Ste. pedicellata* Leadbeater, 1972)

This species has previously been reported from the subarctic and temperate Atlantic, the Mediterranean, the temperate Pacific, the Southern Ocean (Thomsen et al. 1991), and Japan.

Stephanoeca diplocostata paucicostata Throndsen, 1969
(Fig. 29)



Figs. 24-28. Transmission electron micrographs. 24. *Savillea parva*. The costae form 2 layers of spirals. 25. *Stephanacantha formosa* with lorica consisting of flattened costal strips. 26. A complete specimen of *Stephanoeca apheles*. 27. *Stephanoeca* aff. *cupula*. Notice the 3-point joints at the 1st and 2nd transverse costae. 28. Empty lorica of *Stephanoeca diplocostata* with thick costal strips at the waist.

The single specimen observed carries a simple pedicel (Fig. 29), a feature which has not previously been seen in *Ste. diplocostata paucicostata*. In *Ste. diplocostata*, it was shown (Leadbeater 1979) that clonal material either developed a stalk or was stalkless dependent on settling behavior.

Ste. diplocostata paucicostata was previously reported from subarctic Atlantic, temperate North and South Pacific, tropical Indian, and Antarctic waters (Thomsen et al. 1991).

Stephanoeca supracostata Hara in Hara et al. 1996

(Fig. 30)

The existence of an additional transverse costa near the middle of the anterior lorica chamber distinguishes this species from *Ste. elegans*. Based on observations of Japanese specimens, *Ste. supracostata* is furthermore characterized by a smaller number (12-18) of longitudinal costae (20-25 in *Ste. elegans*).

Ste. elegans sensu stricto is distributed in temperate Atlantic, temperate Pacific, and Mediterranean waters, whereas *Ste. supracostata* is so far only known from Taiwan and Japan (Hara et al. 1996).

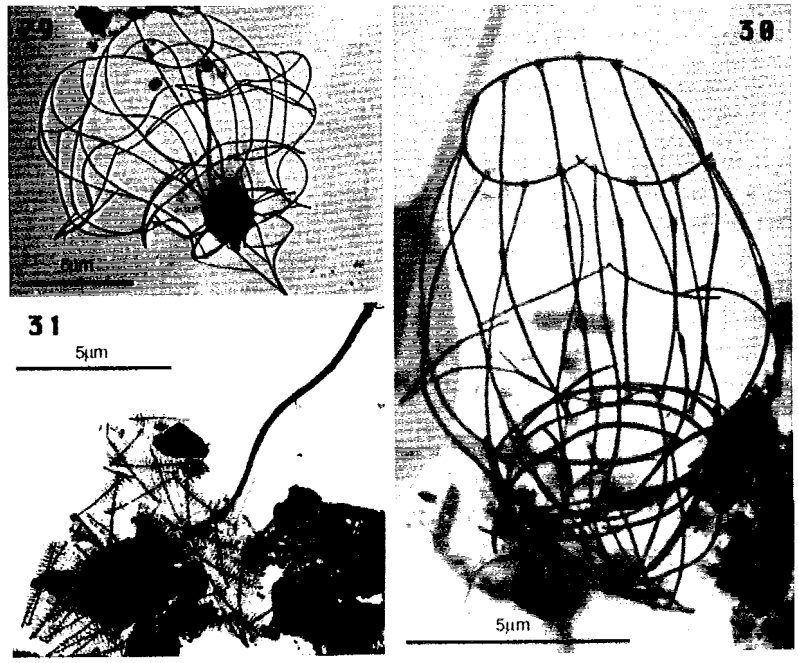
Syndetophyllum pulchellum (Leadbeater) Thomsen and Moestrup, 1983

(Fig. 31)

This species has previously been recorded from the Mediterranean (Leadbeater 1974), the Red Sea (Thomsen 1978), New Zealand (Moestrup 1979), Thailand (Thomsen and Moestrup 1983), and Japan.

Biogeography

The diversity of loricate choanoflagellates in Taiwan and 2 other Asian regions (tropical Indian Ocean and Japan) is shown in Table 1. The recordings clearly reflect the gross biogeographical characteristics of the regions, i.e. a temperate region (Japan), a subtropical region (Taiwan), and a tropical region (Indian Ocean). Several taxa (*Cosmoeca ventricosa*, *Cos. phuketensis*, *Crinolina isefiordensis*, *Platypleura infundibuliformis*, *Pleurasiga echinocostata*, *Stephanoeca diplocostata paucicostata*, and *Syndetophyllum pulchellum*) are present in all these regions. The majority of these taxa (*Cosmoeca ventricosa*, *Cos. phuketensis*, *Crinolina isefiordensis*, *Pleurasiga echinocostata*, and *Stephanoeca diplocostata paucicostata*) are



Figs. 29-31. Transmission electron micrographs. 29. Complete cell of *Stephanoeca diplocostata paucicostata* with a simple pedicel. 30. Complete lorica of *Stephanoeca supracostata* with a transverse costa at the middle of the anterior chamber. One end of longitudinal costal strip is spatulate. 31. Complete cell of *Syndetophyllum pulchellum* showing the flattened costal strips with midribs and striped elaborations.

Table 1. Distribution in the Asian area of Acanthoecidaean choanoflagellates observed in Taiwan samples

	Japan[a]	Taiwan	Tropical[b] Indian Ocean
Acanthocorbis camarensis		+	+
Acanthoeca spectabilis	+	+	
Apheloecion pentacanthum		+	+
Campyloacantha imbricata	+	+	
Cosmoeca phuketensis		+	+
Cos. ventricosa	+	+	+
Crinolina isefiordensis	+	+	+
Diaphanoeca spiralifurca	+	+	
Dia. undulata	+	+	
Diplotheca costata	+	+	
Nannoeca minuta	+	+	
Parvicorbicula aff. *superpositus*	+	+	
Platypleura cercophora		+	+
Pla. infundibuliformis	+	+	+
Pleurasiga echinocostata	+	+	+
Polyoeca dichotoma	+	+	
Saroeca paucicostata	+	+	
Savillea parva	+	+	
Stephanacantha formosa		+	+
Stephanoeca apheles	+	+	
Ste. aff. *cupula*	+	+	
Ste. diplocostata	+	+	
Ste. diplocostata paucicostata	+	+	+
Ste. supracostata	+	+	
Syndetophyllum pulchellum	+	+	+

[a]Takahashi 1981, Throndsen 1983, Hara and Takahashi 1984 1987a,b, and this study.
[b]Thomsen 1973, Thomsen and Moestrup 1983, Thomsen et al. 1991, and this study.

cosmopolitan (Thomsen et al. 1991). Despite the apparent ubiquitousness of some taxa it is hardly possible to assume that only 1 genetic type could thrive in all habitats. However, our knowledge about the loricate choanoflagellate ecotypes is quite limited, and it is obvious that further studies are necessary to elucidate the physiological and morphological adaptation processes of such cosmopolitan choanoflagellate species.

All the 4 local choanoflagellates species which bear loricae consisting of flattened costal strips (*Platypleura cercophora*, *Pla. infundibuliformis*, *Stephanacantha formosa*, and *Syndetophyllum pulchellum*) have also been reported in the tropical Indian Ocean. Two of these (*Pla. infundibuliformis* and *Syndetophyllum pulchellum*) have been observed in Japan. By contrast, none have been reported from Californian waters which have the other 3 species with flattened costal strips commonly found in the tropical Indian Ocean (Thomsen et al. 1991). These distributional patterns imply that these loricate choanoflagellates bearing flattened costal strips are warm water species (Thomsen and Moestrup 1983) and their evolutionary center is located in the tropical Indian Ocean.

The fact that 20 out of the 25 species of loricate choanoflagellates observed in Taiwan are also found in Japan indicates the close relationship between the choanoflagellate faunas of these regions. Comparatively speaking, the choanoflagellate fauna of Taiwan is more similar to that of temperate Japan than to the tropical Indian Ocean fauna (only 11 species are shared between Taiwan and the tropical Indian Ocean). The similarity between Japan and Taiwan may partly be explained by overlapping sea water temperatures between the 2 regions and also by the fact that both are impacted by the Kuroshio current system.

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臺灣沿岸海域之襟鞭毛蟲 (肉質鞭毛蟲亞門，原生動物門) (II)：種類組成及其生物地理學

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本研究探討臺灣沿岸海域之微生物，利用光學顯微鏡及電子顯微鏡之觀察，記錄了西太平洋亞熱帶海域豐富的襟鞭毛蟲種類相。包括25種具矽質骨架之襟鞭毛蟲，3種具鞘膜者及一種裸露細胞者，均是臺灣沿海海域襟鞭毛蟲之新記錄種。臺灣海域具矽質骨架之襟鞭毛蟲種類相，與日本者較相似 (20種相同)，與熱帶印度洋海域者相似性較低 (11種相同)。

關鍵詞：襟鞭毛蟲，形態，分類。

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