

A Systematic Study on Dendrochirotida (Echinodermata: Holothuroidea) in Korea

Rho, Boon Jo and Won, Jung Hye

(Department of Biology, College of Natural Sciences, Ewha Woman University,
Seoul 120-750, Republic of Korea)

한국산 수수류(극피동물 문, 해서 강)의 계통분류학적 연구

노 분 조 · 원 정 혜

(이화여자대학교 자연과학대학 생물학과)

적 요

한국의 해산 무척추동물상을 밝히는 연구의 일환으로서 극피동물 문의 한 분류군인 해서류 중 수수 아강(subclass Dendrochirotea)의 분류 및 분포를 밝히고자 1971년부터 1992년까지 우리나라 삼면연안에서 채집된 재료들을 동정, 분류하였다. 그 결과 수수 목(Order Dendrochirotea)의 4과, 13속에 속하는 16종을 얻었으며 이 중 다음의 11종이 한국미기록종으로 밝혀졌기에 보고한다: *Psolus squamatus*, *Lipotrachea japonicus*, *Phyllophorus* (*Phyllothuria*) *hypsipyrga*, *Phyllophorus* (*Phyllothuria*) *ordinatus*, *Neothyonidium minutum*, *Cucumella problematica*, *Neocucumis watasei*, *Amphicyclus japonicus*, *Cucumaria japonica*, *Cucumaria miniata* 및 *Pseudocnus capensis*.

Key words: Systematics, Dendrochirotida, Holothuroidea, Korea.

INTRODUCTION

The order Dendrochirotida is characterized by the dendritic tentacles with which introvert can be pulled down into the aquapharyngeal bulb by the contraction of five retractor muscles attached to the radial pieces of calcareous ring. The order contains the most various species in 6 orders of Echinodermata and occurs in all seas.

The study on the Korean holothurians was began by Mitsukuri (1912) who reported one species, *Stichopus japonicus* in the Sea of Japan. Since then 14 species, including *Stichopus japonicus*, have been recorded in Korea and six of them belong to order Dendrochirotida (Kamita and Sato, 1941; Rho and Shin, 1984, 1986; Yi, 1985).

The present study is carried out to clarify the taxonomy and distribution of the order in Korea. As a result, 16 species, 13 genera, 4 families were identified and 11 species of them were found for the first time in Korean fauna. In this paper, 11 unrecorded species were described and illustrated with plates.

MATERIALS AND METHODS

Materials were collected at 10 localities in the coastal lines and islands of Korea from April 1971 to September 1992 (Fig. 1). The specimens were living in the intertidal and subtidal zone, and found from various habitats such as sand, mud, between the roots of seaweeds and under the rock. They were anesthetized with menthol and after relaxation, fixed in 75% methyl alcohol. Their external and internal features were observed under the stereomicroscope. And then, some pieces of body wall of trunk, tentacles, tube feet and so on were taken out, and resolved with clorax to observe the calcareous deposits according to parts. They were observed under the light microscope but in detail under the scanning electron microscope (JSM 35FC).

The systematic scheme of Pawson (1965) and Heding and Panning (1954) were consulted in this study. The specimens are deposited in the Department of Biology, Ewha Womans University.

RESULTS

Phylum Echinodermata Klein, 1784 극피동물 문
Class Holothuroidea de Balinville, 1834 해서 강
Subclass Dendrochirotea Grube, 1840 수수 아강
Order Dendrochirotida Grube, 1840 수수 목
Family Psolidae Perrier, 1902 비늘해삼 과(신칭)
Genus *Psolus* Oken, 1815 비늘해삼 속(신칭)

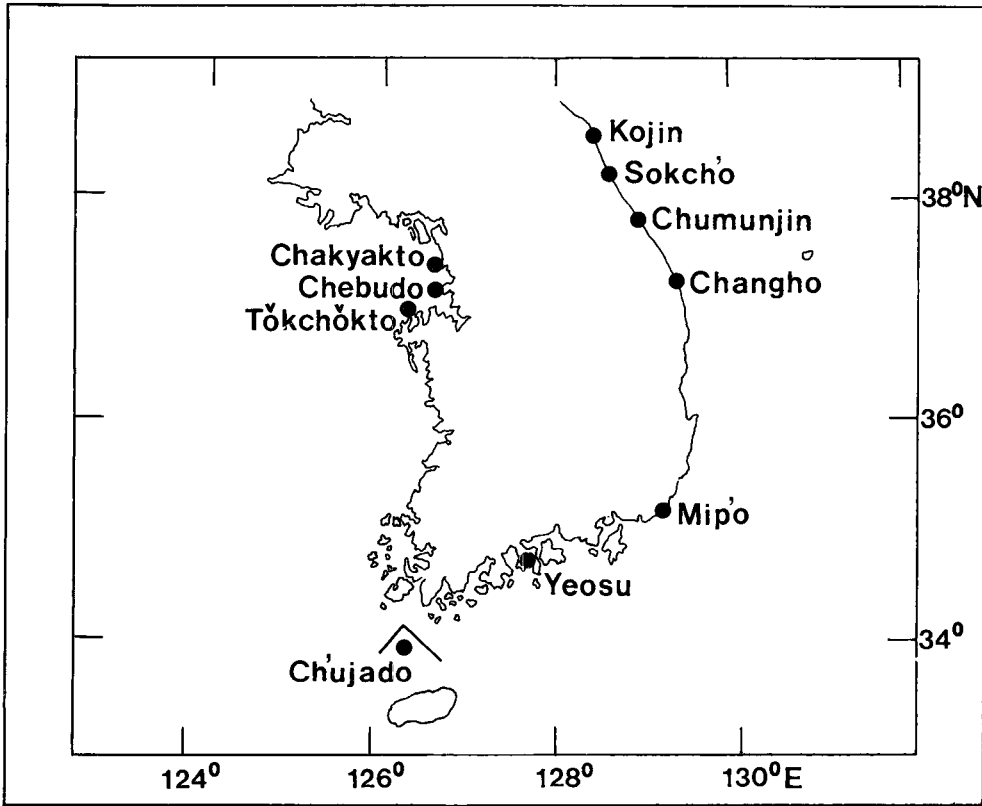


Fig. 1. Localities from which specimens of the present study were collected.

1. *Psolus squamatus* (Müller, 1788) 비늘해삼(신칭)(Pl. 1, Figs. 1-6)

Holothuria squamata Müller, 1788 (Taf. X., figs. 1-3).

Cuvieria squamata: Selenka, 1867 (p. 343).

Psolus (*Cuvieria*) *squamatus* var. ? : Théel, 1886 (pp. 89-90, 129, pl. VI, figs. 2, pl. XV, figs. 1-2).

Psolus squamatus: Clark, 1901a (p. 171); 1901b (p. 491); Mitsukuri, 1912 (p. 225); Ohshima, 1915 (p. 280); Ekman, 1923 (pp. 1-59); Mortensen, 1927 (pp. 417-419); Pawson, 1969 (p. 129); Imaoka, 1980 (pp. 361-372).

Psolus asper: Augustin, 1908 (pp. 30-31).

Psolus squamatus var. *segregatus*: Ekman, 1925 (p. 136); Deichmann, 1941 (pp. 147-148); 1947 (p. 340-341); Dormantay, 1953 (p. 138).

Material examined. Sokch'o, Jun. 29, 1988, 4 specimens (J.W. Lee and J.E. Lee).

Description. Size of body measured about $3.5\text{-}5.2 \times 1.2\text{-}2$ cm. Specimens almost flat with a circular sole folded in (Pl. 1, Fig. 1). In more contracted specimen, ventral having a narrow groove and sole not seen, so calcified scales of dorsal seem to cover whole body. But specimen with well exposed sole also found (Pl. 1, Fig. 4). Sole very thin, oval and white with two rows of tube feet in margin. No tube feet at midventral radius except a few at both ends. Dorsal surface covered with scales and no tube feet (Pl. 1, Fig. 3). Mouth and anus open to dorsal side and not projected. Scales with fine granules on surface oval, ivory or white, 4-7 mm long, and smaller at boundary part with ventral sole. Usually, 9-

11 scales between mouth and anus. And they relatively even in size. Five large triangular scales that enclosing mouth not form five distinct oral valves because of smaller scales at intervals. So no clear boundary with the other parts of dorsal. Very small scales enclosing anus and also not form 5 distinct valves but distinguished from the others by size. Tentacles 10 in number and white.

One large polian vesicle at left dorsal interradius, which wide and 1cm long. One stone canal with a very wrinkled spherical madreporite hanging on dorsal mesentery. Respiratory trees two, each running along lateral side of body, the right one long up to mouth and the left one smaller. Well developed retractor muscles of ventral divided with longitudinal muscles at 2/3 below of body. But, at the midventral radius, retractor muscles not found, and two dorsal ones divided at about anus. Gonad two, one in each side of dorsal mesentery and each genital tubules cylinder form without branches.

Calcareous deposits of sole a few perforated plate with some projections on surface. And they with 3-5 large holes and 0.15-0.2 mm in diameter (Pl. 1, Fig. 5). In tentacles, many perforated plates with smooth surface seen and its size 0.4-0.6 mm (Pl. 1, Fig. 6). Sometimes small and bended ones also found but almost over 0.2 mm.

Calcareous ring simple and radial and interrarial pieces separated each other. A notch seen on anterior margin of radial piece and, at bottom of it, with a shallow notch. Interrarial pieces look alike with radial except triangular anterior (Pl. 1, Fig. 2).

Distribution. North Atlantic (north Europe and Canada), Falkland, Barents Sea, Greenland, Pacific (America, Chile, Japan, and Korea).

Family Phyllophoridae Oestergren, 1907 앞사귀해삼 과

Subfamily Phyllophorinae Oestergren, 1907 앞사귀해삼 아과(신칭)

Genus *Lipotrapeza* Clark, 1938 화문해삼 속(신칭)

2. *Lipotrapeza japonicus* Heding and Panning, 1954 화문해삼(신칭)(Pl. 2, Figs. 1-10)

Lipotrapeza japonicus Heding and Panning, 1954 (pp. 176-178, Text-fig. 85).

Material examined. Mip'o, Jul. 14, 1974, 4 specimens (B.J. Rho); Dec. 28, 1974, 5 specimens (B.J. Rho and J.I. Song); Apr. 25, 1975, one specimen (J.I. Song and K.H. Lee); May 14, 1980, 2 specimens (B.J. Rho).

Description. Contracted body with many traverse wrinkles, measured about $1.5-7 \times 0.6-2.0$ cm. Body slightly curved, fusiform and posterior more slender than anterior. Tube feet distributed evenly all over body, therefore no difference between dorsal and ventral views (Pl. 2, Fig. 1). Color of body from light ocher to light brown. Tentacles 20 in number, which arranged basically two large ones at each interradius and middle and small ones at each radius in pair. But specimens with 18-22 tentacles also found. Surrounding anus, 10 anal papillae that twin at each radius seen and, inside of each twin of them, an anal tooth found.

Longitudinal and retractor muscle well developed. This divided from that at 1/2-1/3 below of body and connected with radial piece of calcareous ring. Dorsal retractor muscles divided at lower part than ventral. Polian vesicle 1-3, stone canal one and respiratory tree two. Gonad in bundle along both side of dorsal mesentery and each genital tubule cylindric form with no branches.

No calcareous deposits in body wall except posterior tip, in which a few tables found. And they with 4 pillared spire and some teeth on their tip of spire. Their size of disk 0.08-0.1 mm wide and

spire 0.05-0.06 mm high. Calcareous deposits of tube feet plates of 0.15×0.07 -0.08 mm and 0.25-0.35 mm end plate (Pl. 2, Fig. 4). In tentacles, rosettes of 0.05-0.18 mm with many projections on surface and rods of 0.05 - 0.15×0.005 - 0.01 mm with some holes at both ends observed. Sometimes, rods also with a few projections on surface (Pl. 2, Figs. 5-10). Rosettes found in introvert (Pl. 2, Fig. 3).

Shape of calcareous ring various depending on specimens. But, in all specimens, radial pieces having a median notch on anterior margin and two lesser notches, one to each side of median notch. And they also with middle or long posterior bifurcate mosaic processes. Interradial pieces also mosaic with triangular anterior but no posterior processes. A posterior notch of radial up to the middle of interradian (Pl. 2, Fig. 2).

Distribution. Japan, Korea.

Genus *Phyllophorus* Grube, 1840 앞사귀해삼 속(신칭)

3. *Phyllophorus (Phyllothuria) hypsiphyrga* (von Marenzeller, 1881)

높은탑해삼(신칭)(Pl. 3, Figs. 1-9)

Orcula hypsiphyrga von Marenzeller, 1881 (pp. 135-136, Taf. 5, fig. 10); Théel, 1886 (pp. 97, 149, pl. V, fig. 6a-b); Mitsukuri, 1896 (p. 410); Sluiter, 1901 (p. 109).

Phyllophorus hypsiphyrga: Ohshima, 1912 (pp. 87-91); 1919 (p. 147).

Phyllophorus (Phyllothuria) hypsiphyrga: Heding and Panning, 1954 (pp. 54, 151-152); Clark and Rowe, 1971 (pl. 29, fig. 19).

Material examined. Chakyakto, 2 specimens; Yeosu, Aug. 7, 1973, 1 specimen (B.J. Rho).

Description. Contracted body 5 - 10×1.3 - 2.2 cm in size, slightly curved, and fusiform with more slender posterior (Pl. 3, Fig. 1). Color of body brown or dark brown in alcohol. Tube feet can contract completely and distributed all over body. Body wall with many traverse wrinkles and a little rough for calcareous deposits. Tentacles 20 in number and unequal in size. Large ones disposed at interradian in five pairs and, inner of them, middle and small ones at each radius in pair.

Retractor muscles divided at $1/5$ below of body. Two respiratory tree extended long and one stone canal connected to dorsal mesentery. One large polian vesicle, about 2 cm long, at left dorsal interradian. Gonad developed along both sides of dorsal mesentery and each genital tubule cylindric form with some branches. One specimen with ova (0.05 mm) collected on August, 1973.

Calcareous deposits of body wall tables with 4 pillared spire. Disk of table, which about 0.07-0.1 mm in diameter, with 10-20 holes and its margin somewhat irregular but smooth (Pl. 3, Figs. 3-5). Length of table's spire, 0.1 mm and its end meet as a tip or with 4 teeth. In tube feet, 0.25 mm end plate and modified tables appear. This thick and mostly larger than those of body wall, thickened, with inclined spire or bended disk (pl. 3, fig. 6). In introvert, 0.02-0.03 mm rosettes, scarcely 0.07 mm, found (Pl. 3, Figs. 8-9). Very small and thin rods found in tentacles and its size 0.05 - 0.08×0.002 - 0.003 mm (Pl. 3, Fig. 7).

Five radial pieces of calcareous ring having a median notch on anterior margin and, both side of it, two lesser ones more. Radial also having a long posterior bifurcate processes that composed of 7-8 fragments. Interradial pieces perfect or composed of 2-3 fragments with triangular anterior part (Pl. 3, Fig. 2).

Distribution. China, Japan, Korea.

Remarks. The sizes of deposits in these specimens' tentacles (0.05-0.08 mm) are larger than those of Ohshima (1912) who described them as 0.04-0.16 mm. But the rest are in accord with this study. Heding and Pannig (1954) excluded *Orcula hypsipyrge* of Théel (1886) for the difference in the shape of calcareous ring and deposit. But the variability of this species is very high so we include the *Orcula hypsipyrge*. In spite of the variability, this species is characterized by having the high-spined tables, radial piece of calcareous ring with a long posterior bifurcate processe and perfect or 2-3 fragmented interradial.

4. *Phyllophorus (Phyllothuria) ordinatus* Chang, 1935 가시탐해삼(신칭)(Pl. 4, Figs. 1-9)

Phyllophorus ordinatus Chang, 1935 (p. 4-8, figs. 3-5).

Phyllophorus (Phyllothuria) ordinatus: Heding and Panning, 1954 (pp. 153-154).

Material examined. Chakyakto, Apr. 25, 1971, 5 specimens; Oct. 22, 1983, 1 specimen; May 4, 1985, 2 specimens; Oct. 4, 1986, 1 specimen; Feb., 1988, 7 specimens; Oct. 6, 1990, 7 specimens; Sep. 28, 1991, 8 specimens; Sep. 26, 1992, 3 specimens; Chebudo, Apr. 16, 1988, 5 specimens (B.J. Rho and J.W. Lee).

Description. Body U-shape, fusiform and $7-14 \times 2-2.5$ cm in size (Pl.4, Fig.1). But size of two young specimens, 3×0.8 and 4.5×1.5 cm respectively. Tube feet distribute all over body but more in ventral and, in relaxed body, rows running from anterior to posterior seen. Anal papillae 10 which twin at each radius and inside of them, five anal teeth found. Color of body various from light brown to dark brown and the end of podia, white. Tentacles 19-22 and their size nearly equal but according to specimens, somewhat different in size. So no rule in size and arrangement of tentacles.

One stone canal hanging on dorsal mesentery and one polian vesicle 2-2.5 cm long on left dorsal interradius. Retractor muscles divided with longitudinal muscles at $1/5$ below of body. Respiratory tree two and gonad developed along both side of dorsal mesentery. Gonad tubule cylindric form with no branches.

Calcareous deposits of body wall tables, disks of which 0.1 mm in diameter and irregular but smooth on margin. Spire composed of four pillars and they 0.07-0.08 mm high. One large holes at the center of disks and surrounding it more than eight small holes seen (Pl. 4, Fig. 4). And, in tube feet, tables also seen but sizes of their disk 0.2-0.25 mm in diameter and their spire 0.1 mm high (Pl. 4, Figs. 5-9). End plate 0.3 mm in diameter, composed of many plates. In introvert, 0.05-0.08 mm rosettes and often 0.1×0.005 mm rods found. In tentacles, no rosettes but rods of various size found. They ranged from $0.1-0.2 \times 0.005-0.01$ mm to $0.2-0.35 \times 0.015-0.03$ mm and both ends of them with some holes or branches (Pl. 4, Fig. 3).

Pieces of calcareous ring somewhat wide. Radial pieces having a symmetrical notch on anterior margin and two lesser ones, on both sides of median notch. They also having posterior bifurcate processes that composed of 5-7 fragments. Interradial pieces perfect with triangular anterior and a notch at bottom (Pl. 4, Fig. 2).

Distribution. China (Yin-Tao, Chiao-Chou Bay), Korea.

Remarks. This species have been collected for a long time in Chakyakto and the specimens which collected in April and October have the very developed gonad, therefore we suppose these to be the spawning season of this species. Chang (1935) described this species having the tentacles of two

different sizes. But in this study, completely relaxed specimens were observed and their tentacles were all equal.

Subfamily Semperiellinae Heding and Panning, 1954 샘패리엘 아과(신칭)

Genus *Neothyonidium* Deichmann, 1938 네오시오니드 속(신칭)

5. *Neothyonidium minutum* (Ohshima, 1915) 네오시오니드해삼(신칭)(Pl. 5, Figs. 1-4)

Phyllophorus minutus Ohshima, 1915 (p. 279, Tab. 11, fig. 31a-b).

Neothyonidium munitum: Heding and Panning, 1954 (pp. 194-196, Abb. 96).

Material examined. Ch'ujado, Feb. 6, 1986, 1 specimen (J.W. Lee and J.E. Lee), 100 m dept of water.

Description. Specimen with little internal organs and no posterior part of body. But calcareous ring and anterior part of body perfect, so autotomy supposed (Pl. 5, Fig. 1). Size of specimen 1.5×0.5 cm. Tube feet distributed all over body but, for contraction, exact distribution can not observed. Color of body dark brown in alcohol. Tentacles 20 in number, large ones disposed at each interradius in five pairs and small ones at each radius, also in five pairs. Retractor muscles divided at 0.4 cm below of specimen. Genital tubules cylinderic form with no branches.

Calcareous deposits of body wall tables with two pillared spire. Disk of table 0.06-0.09 mm wide and with 4 or 8 large holes (Pl. 5, Fig. 4). Spire having one or no cross beam and two teeth on its end. In tube feet, tables with long disk of $0.09-0.1 \times 0.04-0.05$ mm seen. Rods found in tentacles and their size $0.1-0.2 \times 0.003-0.01$ mm, with some holes in both ends (Pl. 5, Fig. 3).

Calcareous ring mosaic as a whole and 1.3 cm long at radial. Radial pieces having a deep median notch on anterior margin and 2 lesser notches, one to each side of median notch. And they also with 1 cm long posterior bifurcate processes. Interradial pieces 1.2 cm long and anterior sharp margin a little lower than radial. Between radial and interradial, border not clear (Pl. 5, Fig. 2).

Distribution. Japan, Korea.

Family Cucumariidae Ludwig, 1894 광삼 과

Subfamily Thyonidiinae Heding and Panning, 1954 시오니드 아과(신칭)

Genus *Cucumella* Ludwig and Heding, 1935 쿠쿠멜라광삼 속(신칭)

6. *Cucumella problematica* Heding and Panning, 1954 쿠쿠멜라광삼(신칭)

(Pl. 6, Figs. 1-10)

Cucumella problematica Heding and Panning, 1954 (pp. 68-69).

Material examined. Mip'o, Jun. 5, 1983, 6 specimens (S. Shin); Changho, Aug. 7, 1983, 1 specimen (J.H. Park and J.E. Seo).

Description. Contracted body $1-1.5 \times 0.3-0.6$ cm in size. Body fusiform with more slender posterior and color of it light brown or brown in alcohol (Pl. 6, Fig. 1). Tube feet large and arranged in two rows at each radius. And no tube feet found at interradii. 5 anal teeth surrounding anus. Tentacles 20, large ones disposed at each interradius in five pairs and, inner of them, small ones at each radius, also in five pairs. Body wall thin and somewhat rough for calcareous deposits.

Retractor muscles divided with longitudinal muscles about middle of body. Stone canal one, polian

vesicle one and respiratory tree two. Gonad very developed and each genital tubule two or three times branched. In contraction, aquapharyngeal bulb with 2 cm calcareous ring filling up $1/2-1/3$ of coelom.

Calcareous deposits of body wall tables with 3 pillared spire. Disks of them 0.07-0.08 mm in diameter and spire 0.04-0.05 mm high and with 3-6 teeth at its end (Pl. 6, Figs. 3, 7). Three large holes in the center of disk and they surrounded by 3-10 small holes. Disk alike triangle and its margin smooth. In introvert, tables which alike those of body wall found but their sizes smaller as 0.03-0.04 mm (Pl. 6, Fig. 5). In tube feet, tables, disks of which 0.07-0.11 mm wide, and 0.2-0.23 mm end plate found (Pl. 6, Figs. 8-10). In tentacles, rods which with many branches and sometimes developed as plate found. And their shapes irregular and their size various as 0.05-0.3 x 0.003-0.03 mm (Pl. 6, Figs. 4, 6).

Radial and interradial pieces of calcareous ring linked slenderly each other. Anterior of interradial pieces arrowhead form and posterior of them thinly divided in two, which linked to radial. Radial pieces which higher than interradial, having a deep median notch on anterior margin and, at both sides of it, two low notches showed. Posterior of radial with a wide notch and no process (Pl. 6, Fig. 2).

Distribution. Japan, Korea.

Genus *Neocucumis* Deichmann, 1944 신광삼 속(신칭)

7. *Neocucumis watasei* (Oshima, 1915) 와타세신광삼(신칭)(Pl. 7, Figs. 1-9)

Pseudocucumis watasei Ohshima, 1915 (pp. 273-274, pl. 10, fig. 25a-b); 1919 (p. 147).

Neocucumis watasei: Heding and Panning, 1954 (pp. 76-78).

Material examined. Mip'o, Jul. 15, 1974, 1 specimen (B.J. Rho); May 25, 1981, 1 specimen (J.E. Seo and J.I. Song); Jun. 5, 1983, 1 specimen (S. Shin).

Description. Relaxed body cylindric form and, including 0.4-0.8 cm inverted introvert, 1.8-3.5 × 0.45-0.5 cm in size (Pl. 7, Fig. 1). Tube feet arranged in two rows at each radius but, on introvert, they changed to oral papillae of zigzag row. Relaxed tube feet 1-1.3 mm long and no tube feet on interradial. Body wall thin but somewhat coarse for calcareous deposits. Color of body light ocher or white. Tentacles 20 in number, large ones disposed at interradial in five pairs and small and very small ones at each radius in pair but a little difference seen depending on specimens.

Stone canal one and madreporite alike overlapped two disks. One polian vesicle at left dorsal interradius and two respiratory tree with long, slender and simple branches. Gonad two tufts and genital tubules thin at base, but thickening toward the end and mostly dibranched.

Calcareous deposit of body wall tables with 0.08 mm disk and 0.05-0.06 mm spire. Spire composed of 4 pillars at base but unites by twos and with 2-4 teeth at its end. Disk having many holes and a cross structure protruded from underside of disk (Pl. 7, Figs. 6, 8). In tube feet, tables also seen but disks of them extending to both ends so 0.1 mm long and cross structure of disk not protruded (Pl. 7, Figs. 7, 9). In introvert, tables found, which somewhat slender and 0.05-0.06 mm in size (Pl. 7, Figs. 4-5). In tentacles, 0.06-0.5 × 0.01-0.05 mm rods appear, which a little bended with holes at both ends or on the whole, and scarcely with some branches (Pl. 7, Fig. 3).

Radial pieces of calcareous ring wide, with a deep anterior notch and, at both side of it, with two

lesser notches more. Interradial pieces which a little lower than radial triangular form with a deep and wide posterior notch (Pl. 7, Fig. 2).

Distribution. Japan, Korea.

Genus *Amphicyclus* Bell, 1884 이원축수해삼 속(신칭)

8. *Amphicyclus japonicus* Bell, 1884 이원축수해삼(신칭)(Pl. 5, Figs. 5-9)

Amphicyclus japonicus Bell, 1884 (p. 254); Théel, 1886 (p. 126); Ohshima, 1912 (pp. 71-76, pl. 1, figs. 5-6); 1915 (p. 276); Heding and Panning, 1954 (pp. 87-88).

Pseudocucumis japonicus: Mitsukuri, 1896 (p. 410); Bedford, 1898 (p. 844); Augustin, 1908 (p. 29).

Material examined. Ch'ujado, Feb. 6, 1986, 1 specimen (J.W. Lee & J.E. Seo), 100m dept of water, in the triton.

Description. Contracted body 4×1 cm in size, cylinderic form with a little more slender posterior (Pl. 5, Fig. 5). Tube feet arranged in two rows at each radius but toward the both ends of body, changed like a zigzag. Length of relaxed tube feet 1-2mm long. Color of body dark brown and the end of tube feet almost white. Tentacles 25 in three different sizes, large ones at each interradius in five pairs and, inner of them, two small ones and a middle one at each radius. Color of introvert and tentacles ivory.

Retractor muscles well developed and divided at $1/2-2/3$ below of body and dorsal ones divided at the lower site than ventral. Two Polian vesicles situated at left dorsal interradius and left ventral interradius respectively. And they slender and 1-1.2cm long. Stone canal one and madreporite like overlapped two disks. Gonad two tufts and each genital tubules dibranched. Respiratory tree two.

No calcareous deposits in body wall. In tube feet, both end plates which 0.27 mm wide and, surrounding them, 0.1-0.15 mm long plates observed. But in posterior end of body and introvert, tables with two pillared spire found. Spire of them low and almost reduced. Disks 0.07-0.08 mm in diameter with thin frame and 4-8 holes (Pl. 5, Fig. 7). In tentacles, rods which 0.1-0.14 mm with both ends branched or with some small holes seen (Pl. 5, Figs. 6,9).

Shape of calcareous ring peculiar with 4 notches on anterior margin of radial. Anterior part of radial broad, middle part of it narrow and posterior of it broad again. Radial pieces separated from interradius. Interradial pieces lower than radial. Their anterior like an arrowhead form and their posterior dibranched so look like inverted Y (Pl. 5, Fig. 8).

Distribution. Japan, Korea.

Remarks. This species had been recorded only in Japan but in this study, it also found in Chejudo. The present specimens has the great similarity with *Amphicyclus thomsoni* of New Zealand and *Amphicyclus mortensoni* of Australia (Heding and Panning, 1954). Heding and Panning (1954) divided these three species for the slight differences of their calcareous rings and deposits and geographical distribution. But we suppose these three species to be closely related each other or maybe one species.

Subfamily Cucumariinae Ludwig, 1894 광삼 아과(신칭)

Genus *Cucumaria* de Blainville, 1830 광삼 속

9. *Cucumaria japonica* Semper, 1868 타원광삼(신칭)(Pl. 8, Figs. 1-9)

Cucumaria japonica Semper, 1868 (p. 236); Théel, 1886 (p. 110); Mitsukuri, 1896 (p. 409); Clark, 1902 (p. 562); Augustin, 1908 (pp. 25-26, Text-fig. 18); Edwards, 1908 (pp. 61-62); Britten, 1906 (p. 133-135); Mitsukuri, 1912 (pp. 242-246, pl. VIII, figs. 67-68); Ohshima, 1915 (p. 255; 1919, p. 145); Bush, 1918 (p. 39, pl. 9, fig. 44); Oguro, 1961 (p. 2); Uchida et al., 1963 (p. 27).

Material examined. Kojin, Nov. 22, 1980, 1 specimen (B.J. Rho & S. Shin); Chumunjin, May 26, 1985, 2 specimens (H.S. Choe).

Description. Body oval form and $5.5-7.5 \times 3.5-4$ cm in size. Color of body light brown or brown in alcohol (Pl. 8, Figs. 1, 2). Tube feet arranged in 2 rows at each radius but in the middle part of contracted body, 3 rows also found. They can contract completely and their color lighter than body wall. In two ventral interradii, no tube feet seen but, in three dorsal interradii, a few small ones scattered. Below introvert, 3-4 oral papillae observed at each radius. They like as tube feet but having a little longer and slender tips. Surrounding anus, 5 pairs of anal papillae found and inside of them 5 anal teeth also located. Tentacles, all of equal size, 10 in number and they large and thickly developed.

Retractor muscles divided at $2/3$ below of body. Longitudinal muscles thick and each of them with a vertical groove at center, so look like two bands. One polian vesicle 3.5-4 cm long and situated at left dorsal interradius. Stone canal two each winds up and connects wrinkled sperical madreporite. Gonad two tufts and each genital tubules very slender and 3-3.5 cm long.

Calcareous deposits of body wall perforated plates of 0.1-0.15 mm in size. They having some risings on surface and one spiny end which protruded out (Pl. 8, Fig. 3). In tube feet, perforated plate of 0.15-0.25 mm appear and they protruded toward two or three directions (Pl. 8, Figs. 5, 6). End plates of tube feet composed of several irregular plates. In oral papillae, plates such as tube feet found but they differ from those of tube feet in size, 0.2-0.3 mm. And they also with many risings and protruded toward all directions (Pl. 8, Fig. 7). In tentacles, rods with some holes and irregular perforated plates found. Plate of tentacles, 0.15-0.25 mm and smooth on surface (Pl. 8, Fig. 8). In introvert, small perforated plates which 0.1 mm in size with risings on surface and thin frame seen (Pl. 8, Fig. 9).

Calcareous ring weakly developed with narrow anterior part. Radial piece having a small notch on anterior margin and with a large posterior notch. Interradial pieces having sharp anterior and a posterior notch (Pl. 8, Fig. 4).

Distribution. Japan, Korea, Sakhalin.

10. *Cucumaria miniata* Brandt, 1835 소광삼(신칭)(Pl. 9, Figs. 1-5)

Cladodactyla miniata Brandt, 1835 (p. 44).

Cucumaria miniata: Selenka, 1867 (p. 350); Théel, 1886 (p. 102); Clark, 1901a (pp. 166, 171); 1901b (pp. 485, 493); Britten, 1906 (p. 141-143); Ohshima, 1915 (pp. 255-256).

Cucumaria albida: Selenka, 1867 (p. 350, Taf. XX, fig. 109).

Material examind. Kojin, Aug. 15, 1980, 1 specimen (B.J. Rho and S. Shin).

Desdription. Body cylinderic form and posterior part of it a little slender (Pl. 9, Fig. 1). Size of relaxed body 3.5×1 cm. Tube feet arranged in two rows which like a zigzag at each radius but entirely not found in interradii. Tentacles 10 in number and all of equal size. Color of body brown in alcohol and 5 anal teeth located around anus.

Retractor muscles somewhat slender and devided at $1/2$ below of body. One stone canal winding up and connected spherical wrinkled madreporite. Polian vesicle one at left dorsal interradius and 5 mm long. Respiratory tree two.

Body wall smooth on surface and calcareous deposits scarcely found. But in tube feet, irregular perforated plates of 0.1-0.25 mm observed. They having some small rising on surface and one spiny end which protruded out. And occasionally, they protruded toward 2-3 directions (Pl. 9, Figs. 3-4). In tentacles, irregular deposits which between plate and rod seen. And their size small of 0.1mm and smooth on surface (Pl. 9, Fig. 5).

Calcareous ring week and fragile. Anterior part of them like rod and, posterior of them with a notch which like semicircle (Pl. 9, Fig. 2).

Distribution. Alaska, Sitka, California, Japan, Korea.

Remarks. This species is similar to *Cucumaria japonica* in the shape of calcareous ring and deposits but the body of this species much slender and smaller than that of *Cucumaria japonica*. And this species also different in that tube feet are completely restricted on radial and arranged in zigzag.

Genus *Pseudocnus* Panning, 1949 수도크누스 속 (신칭)

11. *Pseudocnus capensis* (Théel, 1886) 수도크누스해삼 (신칭) (Pl. 10, Figs. 1-12)

Cucumaria capensis Théel, 1886 (pp. 62-64, pl. 5, fig. 2); Mitsukuri, 1912 (pp. 233-235, pl. VIII, fig. 74, text-fig. 45); Ohshima, 1915 (p. 258; 1919, p. 145).

Pseudocnus capensis: Panning, 1962 (p. 70).

Material examined. Mip'o, Jun. 5, 1983, many specimens (S. Shin); T'okch'okto, Oct. 16, 1985, one specimens (J.I. Song, J.W. Lee and H.S. Choe).

Description. Body cylinder or fusiform, and $1-2.5 \times 0.35-1$ cm in size (Pl. 10, Figs. 1-2). In most specimens, both ends of body bended up. Color of body ocher but small black spots scattered on dorsal side so tinged with black and introvert also somewhat black. In ventral, tube feet arranged in two rows at each radius but, in two lateral radii, like a zigzag. Dorsal of body hard for fir-cone shaped plates which covering as small scales. Tube feet of dorsal which scattered in both radii and interradii smaller than those of ventral. Scale structure observed more precisely about anus and mouth. Body wall thick and hard for many calcareous deposits. Tentacles 10 in number and two midventral ones smaller than the others. 5 small anal teeth appear.

Retractor muscles divide $1/2-1/3$ below of body. Polian vesicle one at left dorsal interradius and stone canal one. Gonad two tufts and each genital tubule slende, with no branch. Respiratory tree two.

Calcareous deposits of body wall knobbed button with 4 or more holes which 0.06-0.15 mm in size and baskets which small and flat observed (Pl. 10, Figs. 5, 8, 11). In ventral, knobbed button developed to large and thick ones and 0.2-0.3 mm in size (Pl. 10, Fig. 12). In tube feet, 0.3-0.4 mm

rods (Pl. 10, Fig. 6) and 0.2 mm endplate found (Pl. 10, Fig. 4). In dorsal, large and thick fir-cone shaped plate which 0.4-0.5 mm in size found and for which scale-like structure of dorsal appears (Pl. 10, Figs. 7, 10). In tentacles, irregular rods, which bended or branched at both ends of them and widened at middle part (Pl. 10, Fig. 9). And they various in size as $0.05-0.4 \times 0.005-0.05$ mm. Rosettes and, occasionally, small rods which similar those of tentacles appear in introvert.

Calcareous ring simple so radial and interradial pieces alike each other. But anterior of radial plate have a small notch and anterior of interradial triangular. Notchs in posterior of radial deeper than interradial (Pl. 10, Fig. 3).

Distribution. Timore Island, Sulu Islands, Cape Town, Japan, Korea.

Remarks. The fir-cone shaped plate of dorsal of this species have a spiny protrusion which more developed in the small specimens. But, on the contrary, the plate have the more smooth margin in large or old specimens. So we can supposed the fir-cone shaped plate to change smooth gradually as time passes.

ABSTRACT

The present study is to examine the taxonomy and distribution of holothurians (especially Subclass Dendrochirotacea) as a part of study on marine invertebrate of Korea. The materials were collected at 10 localities in the coastal seas and islands of Korea from April, 1971 to September, 1992. As a result, 16 dendrochirotida species belonging to 13 genera, 4 families were identified, of which 11 species have not been recorded in Korean fauna before.

REFERENCES

- Augustin, E., 1908. Beiträge zur Naturgeschichte Ostasiens. Über Japanische Seewalzen. Abh. Bayer. Akad. Wiss. Suppl., **1**(1): 1-44.
- Bedford, F.P., 1898. Report on the holothurians collected by Mr. J. Stanley Gardiner at Fauafuti and Rotuma. Proc. Zool. Soc. Lond., **15**: 834-849, pls. 52-53.
- Bell, F.J., 1884. Studies in the Holothuroidea-III. On *Amphycylus*, a new genus of dendrochirotous holothurians, and its bearing on the classification of the family. Proc. Zool. Soc. London, pp. 253-258 (cited from Ohshima, 1912).
- Brandt, J.F., 1835. Prodrom. descript. Anim. ab H. Mertensio in orbis terrarum circumnavigatione observatorum. Fasc I., pp. 42-61 (cited from Théel, 1886).
- Britten, M., 1906. Holothurien aus dem Japanischen and Ochotskischen Meere. Bull. Acad. Imp. Sci. St.-Petersbourg. Ve. Ser. T., **25**: 123-157.
- Bush, M., 1918. Key to the echinoderms of Friday harbor, Washington. Pub. Puget Sound Biol. Sta., **2**(33): 36-42.
- Chang, F.Y., 1935. Additions to the holothurians of the Chinese coast. Cont. Inst. Zool. Nat. Acad. Peiping, **2**(3): 1-15.

- Clark, A.M. and F.W. E. Rowe, 1971. Monograph of shallow-water Indo-West Pacific echinoderms. Trustee Br. Mus. (Nat. His.), London, U. K.: 1-238, 30 pls.
- Clark, H.L., 1901a. The holothurians of the Pacific Coast of North America. Zool. Anz., **24**: 162-171, 14 text-figs.
- Clark, H.L., 1901b. Synopsis of North-American invertebrates. XV. The Holothurioidea. Amer. Nat., **35**: 479-493.
- Clark, H.L., 1902. Notes on some North Pacific Holothurians. Zool. Anz. XXV Band pp. 562-564.
- Deichmann, E., 1941. The Holothurioidea collected by the Velero III during the years 1932 to 1938. Part I, Dendrochirota. Allan Hancock Pacific Expeditions, **8**(3): 61-195, pls. 10-30.
- Deichmann, E., 1947. Shallow water holothurians from Cabo de Hornos and adjacent waters. Anales del Museo Argentino de Ciencias Naturales, Tomo XLII, pp. 325-352.
- Domantay, J.S., 1953. A brief summary of the Pacific and Atlantic Holothuroidea of the Allan Hancock Foundation Collections. Philip. Jour. Sci., **82**: 133-140.
- Edwards, C.L., 1908. The holothurians of the North Pacific Coast of North America collected by the Albatross in 1903. Proc. U.S. Nat. Mus., **33**(1558): 49-68.
- Ekman, S., 1923. Über *Psolus squamatus* und verwante Arten. Ark. Zool., **15**(5): 1-59, 37 text-figs.
- Ekman, S., 1925. Holothurien. Futher Zool. Results Swed. Antarct. Exped., **1**(6): 1-194.
- Heding, S.G. and A. Panning, 1954. Phyllophoridae. Eine Bearbeitung der Polytentaculaten Dendrochiroten Holothurien des Zoologischen Museums in Kopenhagen. Spolia Zool. Mus. Haun., **13**: 7-209, 102 figs.
- Imaoka, T., 1980. Observation on *Psolus squamatus* (Koren) from Okhotsk Sea (Dendrochirota: Psolidae). Publ. Seto Mar. Biol. Lab., **25**(5/6): 361-372.
- Kamita, T. and T.N. Sato, 1941. Marine Fauna at Jinsen Bay, Korea. Jour. Chosen nat. Hist. Sci., **30**: 1-3.
- Marenzeller, E. von., 1881. Neue Holothurien von Japan und China. Verh. Zool.-Botan. Ges. Wien, **31**: 121-140, pls. 4-5.
- Mitsukuri, K., 1896. A list of holothurians known to occur in Japan. Zool. Mag. Tokyo, **8**: 405-413.
- Mitsukuri, K., 1912. Studies on actinopodous holothurioidea. Jour. Coll. Sci., Tokyo Imp. Univ., **29**(2): 1-284.
- Mortensen, Th., 1927. Handbook of the Echinoderms of the British Isles, PP. 350-438.
- Müller, O. F., 1788. Zoologica Danica (cited from Slenka, 1867)
- Oguro, C., 1961. The Fauna of Akkeshi Bay XXVI. Holothuroidea. Publ. Akkeshi. Mar. Biol. Stat., **11**: 1-4.
- Ohshima, H., 1912. On the systems of Phyllophorinae with descriptions of the species found in Japan. Annot. Zool. Japon. Bd. **81**: 53-96.
- Ohshima, H., 1915. Report on the holothurians collected by the United States Fisheries Steamer "Albatross" in the Northwestern Pacific during the summer of 1906. Proc. U.S. Nat. Mus., **48**: 213-291, pls. 8-11.
- Ohshima, H., 1919. Holothurians collected by Albatross in the North-Western Pacific. Zool. Magaz. Tokyo, **31**: 139-149 (in Japanese).
- Panning, A., 1962. Bemerkungen über die Holothurien- Familie Cucumariidae (Ordnung Dendrochirota) S. Teil. Die Gattung *Pseudocnus* Panning 1949, Mitt. Hamburg. Zool. Mus. Inst. Band **60**: S. 57-80.
- Pawson, D.L., 1965. A revised classification of the Dendrochirote Holothurians. Breviora Mus. Comp. Zool., **214**: 1-7.
- Pawson, D.L., 1969. Holothuroidea from Chile report No. 46 of the Lund University Chile Expedition 1948-1949, Sarsia, **38**: 121-146.
- Rho, B.J. and S. Shin, 1984. A systematic study on the Holothuroidea in Korea 1. Dendrochirotida. Bull. Inst.

- Litt. Biota, Mokpo Nation. Coll., **1**(1): 43-55.
- Rho, B.J. and S. Shin, 1986. A systematic study on the Holothuroidea in Chejudo. Kor. J. Zool., **29**(4): 245-256.
- Selenka, E., 1867. Beiträge zur Anatomie und Systematik der Holothurien. Zeits. f. w. zool., pp. 291-373, Taf. 17-20.
- Semper, C., 1868. Reisen im Archipel der Philippinen. Teil. II. Bd. i, Holothurien, pp. 1-288, pls. 1-11 (cited from Théel, 1886).
- Sluiter, C., 1901. Die Holothurien der Siboga-Expedition. Siboga Expeditie, **44**: 1-142.
- Théel, H., 1886. Report on the Holothuroidea dredged by H.M.S. Challenger during the years 1873-1876. Part II. Zool. Chall. Exp., **39**: 1-290.
- Uchida, T., M. Yamada, F. Iwata, C. Oguro and Z. Nagao, 1963. The Zoological Environs of the Akkeshi Marine Biological Station. Publ. Akkeshi Mar. Biol. Stat., **13**: 1-36, 6 pls.
- Yi, S.K., 1985. Studies on the Holothuroidea in the coastal waters of Korea 1. Synaptidae. Ocean Research, **7**: 1-9.

RECEIVED: 14 September 1993

ACCEPTED: 11 October 1993

EXPLANATION OF PLATES 1-10

PLATE 1

Psolus squamatus (Müller, 1788) 비늘해삼 (scale size: 1, 3, 4-1 cm; 2-1 mm; 5, 6-0.1 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Fig. 3. Dorsal view of body.

Fig. 4. Ventral view of body.

Fig. 5. Plates from sole.

Fig. 6. Plates from tentacle.

PLATE 2

Lipotrapeza japonicus Heding & Panning, 1954 화문해삼 (scale size: 1-1 cm; 2-1 mm; 4, 5, 6, 9-0.1 mm; 3, 7, 8, 10-0.01 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Fig. 3. Rosette from introvert.

Fig. 4. Plate from body wall.

Figs. 5~10. Rosettes and rods from tentacle.

PLATE 3

Phyllophorus (Phyllothuria) hypsipyrge (von Marenzeller, 1881) 높은탑해삼 (scale size: 1-1 cm; 2-2 mm; 3, 4, 6-0.05 mm; 5-0.1 mm; 7, 8, 9-0.02 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Figs. 3~5. Tables from body wall.

Fig. 6. Lateral view of table from podia.

Fig. 7. Rods from tentacle.

Figs. 8~9. Rosettes from introvert.

PLATE 4

Phyllophorus (Phyllothuria) ordinatus Chang, 1935 가시탑해삼 (scale size: 1-1 cm; 2-2 mm; 3, 4, 6, 7, 8-0.1 mm; 5, 9-0.05 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Fig. 3. Rods from tentacle.

Fig. 4. Tables from body wall.

Figs. 5~9. Tables from podia.

PLATE 5

Neothyonidium minutum (Ohshima, 1915) 네오시오니드해삼 (scale size: 1, 2-2 mm; 3-0.1 mm; 4-0.05 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Fig. 3. Rods from tentacle.

Fig. 4. Tables from body wall.

Amphicyclus japonicus Bell, 1884 이원촉수해삼 (scale size: 5-1 cm; 6, 7-0.1 mm; 8-1 mm)

Fig. 5. Right lateral view of body.

Figs. 6, 9. Rods from tentacle.

Fig. 7. Tables from introvert.

Fig. 8. A part of calcareous ring.

PLATE 6

Cucumella problematica Heding & Panning, 1954 쿠쿠멜라광삼 (scale size: 1-2 mm; 2-1 mm; 3, 5, 8-0.1 mm; 4, 6, 7, 9, 10-0.05 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Fig. 3. Tables from body wall.

Fig. 4, 6. Rods from tentacle.

Fig. 5. Disk of table from introvert.

Fig. 7. Lateral view of table from body wall.

Fig. 8. Tables from podia.

Fig. 9. Disks of tables from podia

Fig. 10. Lateral view of table from podia.

PLATE 7

Neocucumis watasei (Ohshima, 1915) 와타세신광삼 (scale size: 1–5 mm; 2–1 mm; 3, 5, 6, 7, 8, 9–0.05 mm; 4–0.1 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Fig. 3. Rods from tentacle.

Figs. 4, 5. Tables from introvert.

Figs. 6, 8. Tables from body wall.

Fig. 7. End plate and tables from podia.

Fig. 9. Table from podia.

PLATE 8

Cucumaria japonica Semper, 1867 타원광삼 (scale size: 1, 2–1 cm; 3, 5, 6, 7, 8, 9–0.1 mm; 4–5 mm)

Fig. 1. Right lateral view of relaxed body.

Fig. 2. Right lateral view of contracted body.

Fig. 3. Plates from body wall.

Fig. 4. A part of calcareous ring.

Figs. 5, 6. Plates from podia.

Fig. 7. Plates from papillae of introvert.

Fig. 8. Rods or plates from tentacle.

Fig. 9. Plates from introvert.

PLATE 9

Cucumaria miniata Brandt, 1835 소광삼 (scale size: 1–1 cm; 2–1 mm; 3, 4, 5–0.1 mm)

Fig. 1. Right lateral view of body.

Fig. 2. A part of calcareous ring.

Figs. 3, 4. Plates from podia.

Fig. 5. Rods or plates of tentacle.

PLATE 10

Pseudocnus capensis (Théel, 1886) 수도크누스해삼 (scale size: 1–5 mm; 2–2 mm; 3–1 mm; 4, 6, 7, 9, 10, 12–0.1 mm; 5, 8, 11–0.05 mm)

Fig. 1. Right lateral view of body.

Fig. 2. Right lateral view of young individual.

Fig. 3. A part of calcareous ring.

Fig. 4. End plate from podia.

Fig. 5. Minute flat cup from body wall.

Fig. 6. rods from podia.

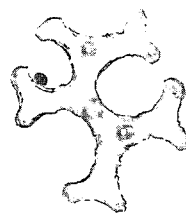
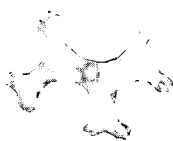
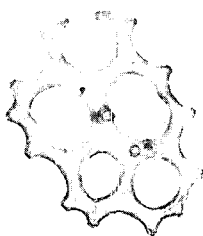
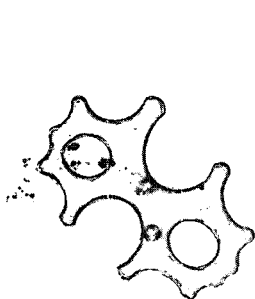
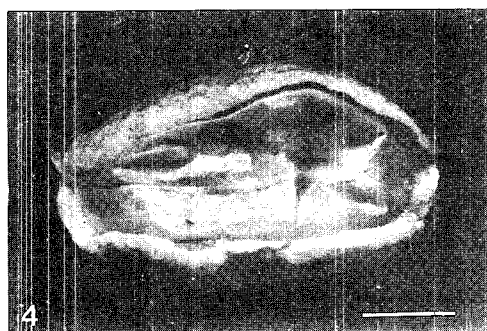
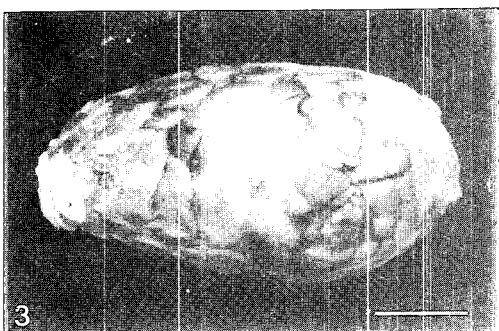
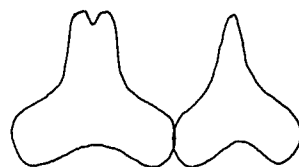
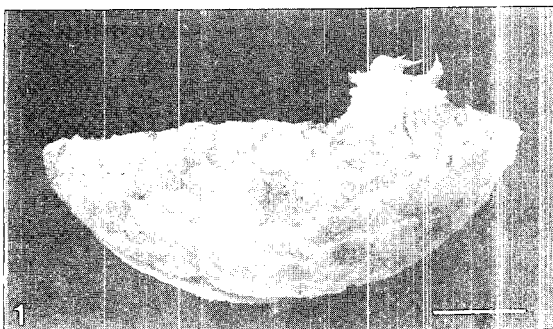
Figs. 7, 10. Fir-cone plate from dorsal body wall.

Fig. 8, 11. Knobbed plates from body wall.

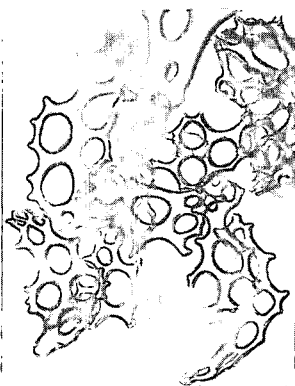
Fig. 9. Rods from tentacles.

Fig. 12. Fir-cone plate from ventral body wall.

PLATE 1



5



6

PLATE 2

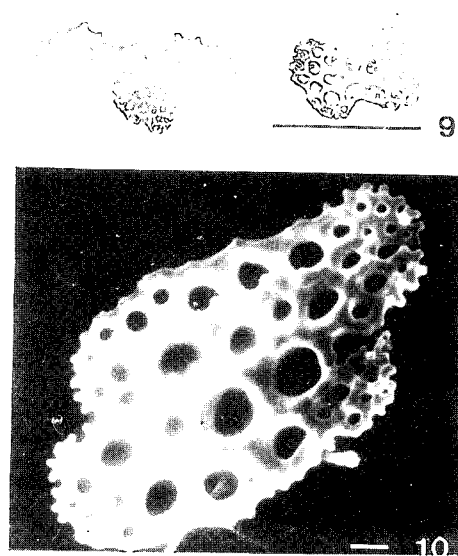
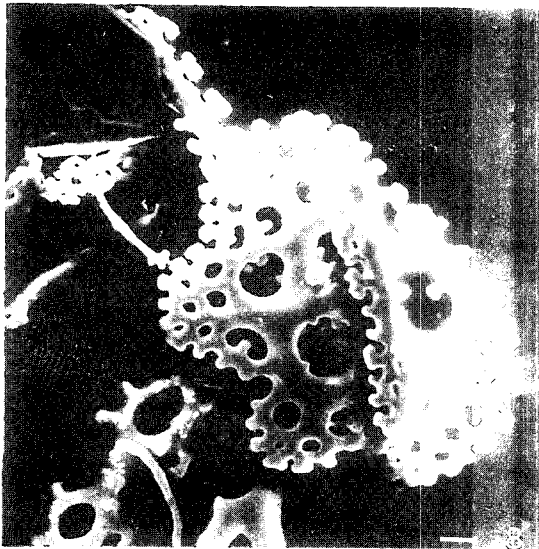
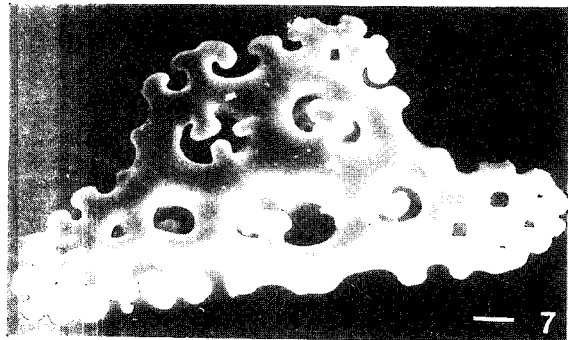
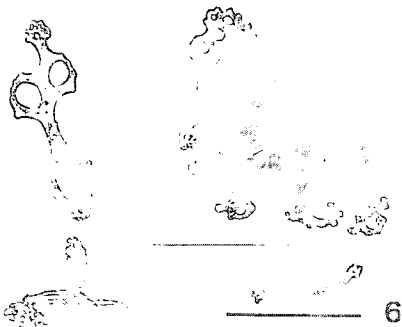
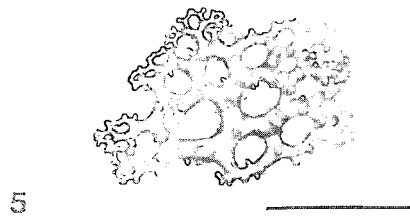
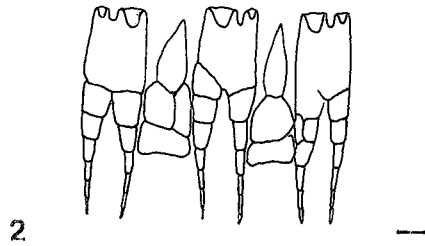
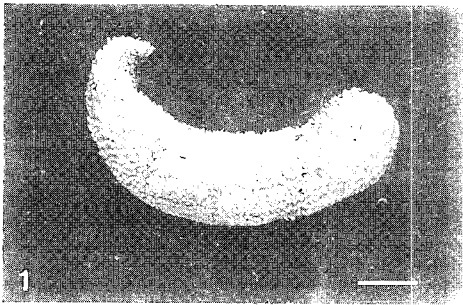


PLATE 3

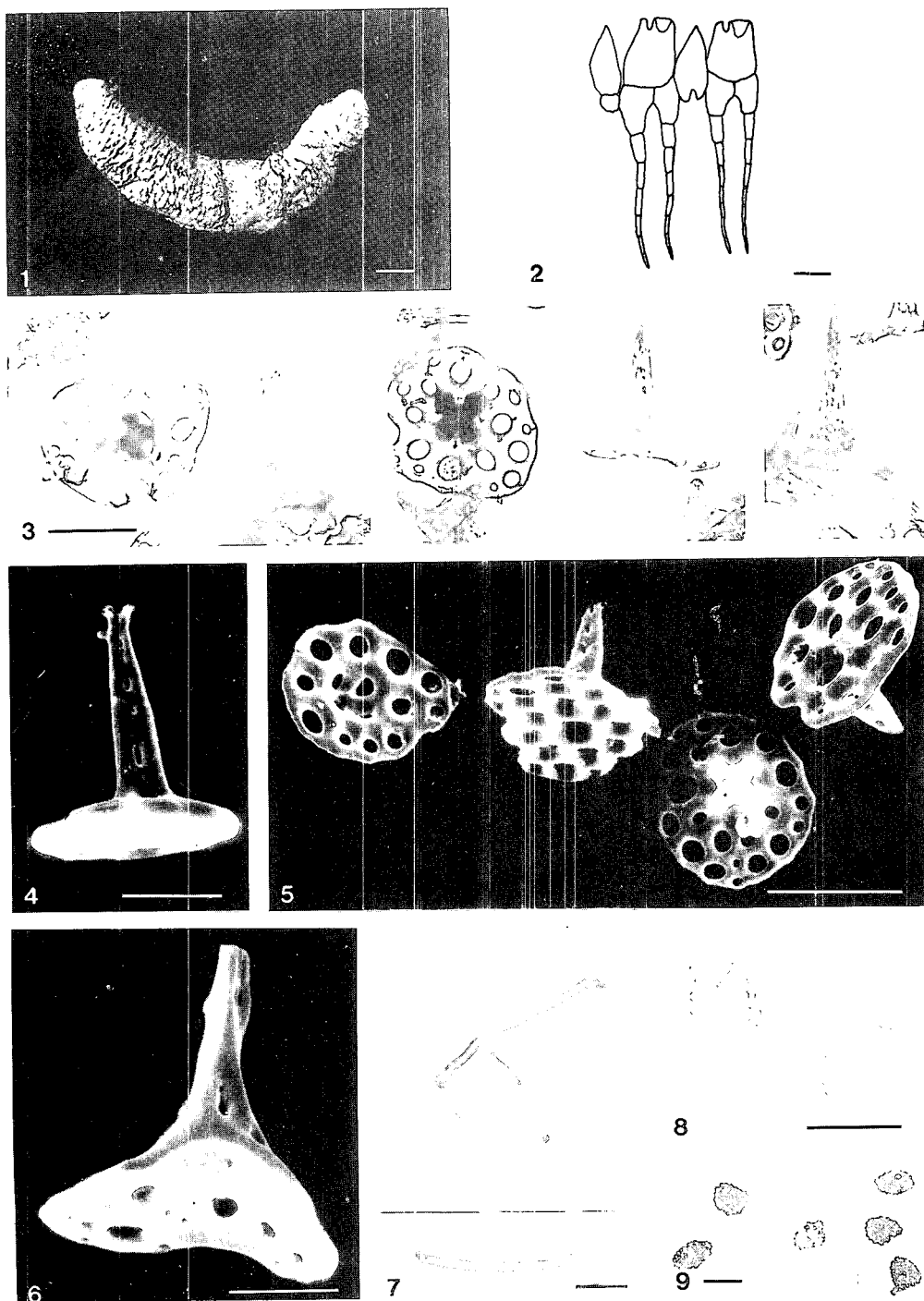
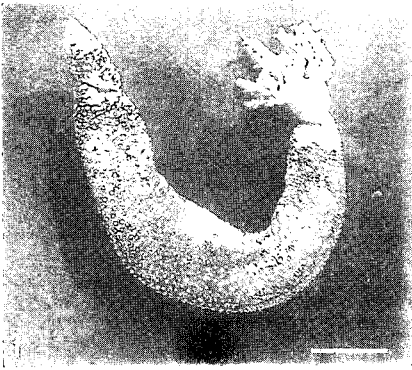
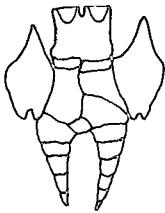


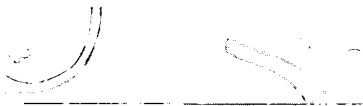
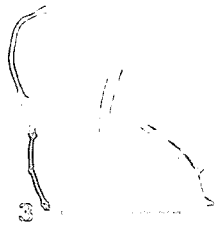
PLATE 4



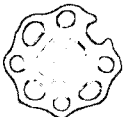
2



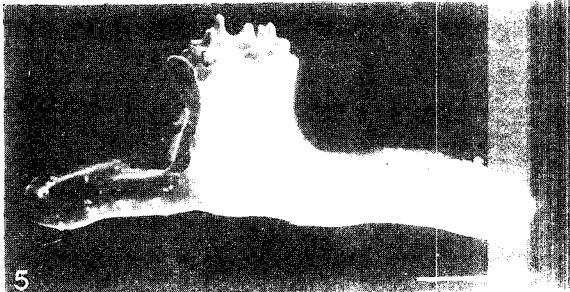
3



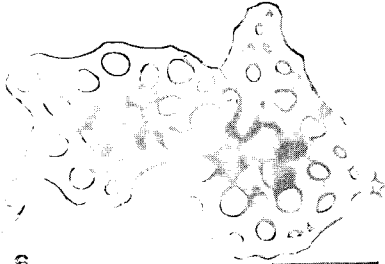
4



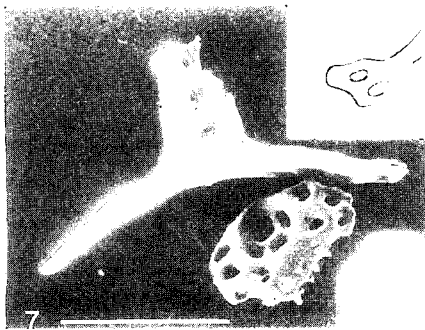
5



6



7



8



9

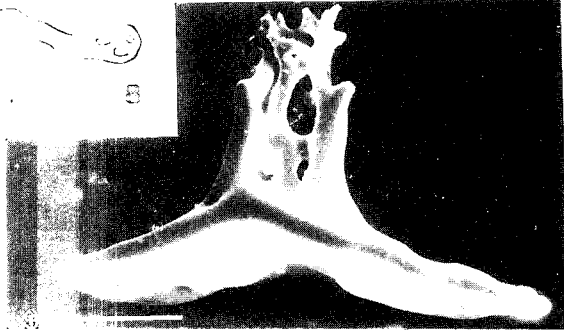


PLATE 5

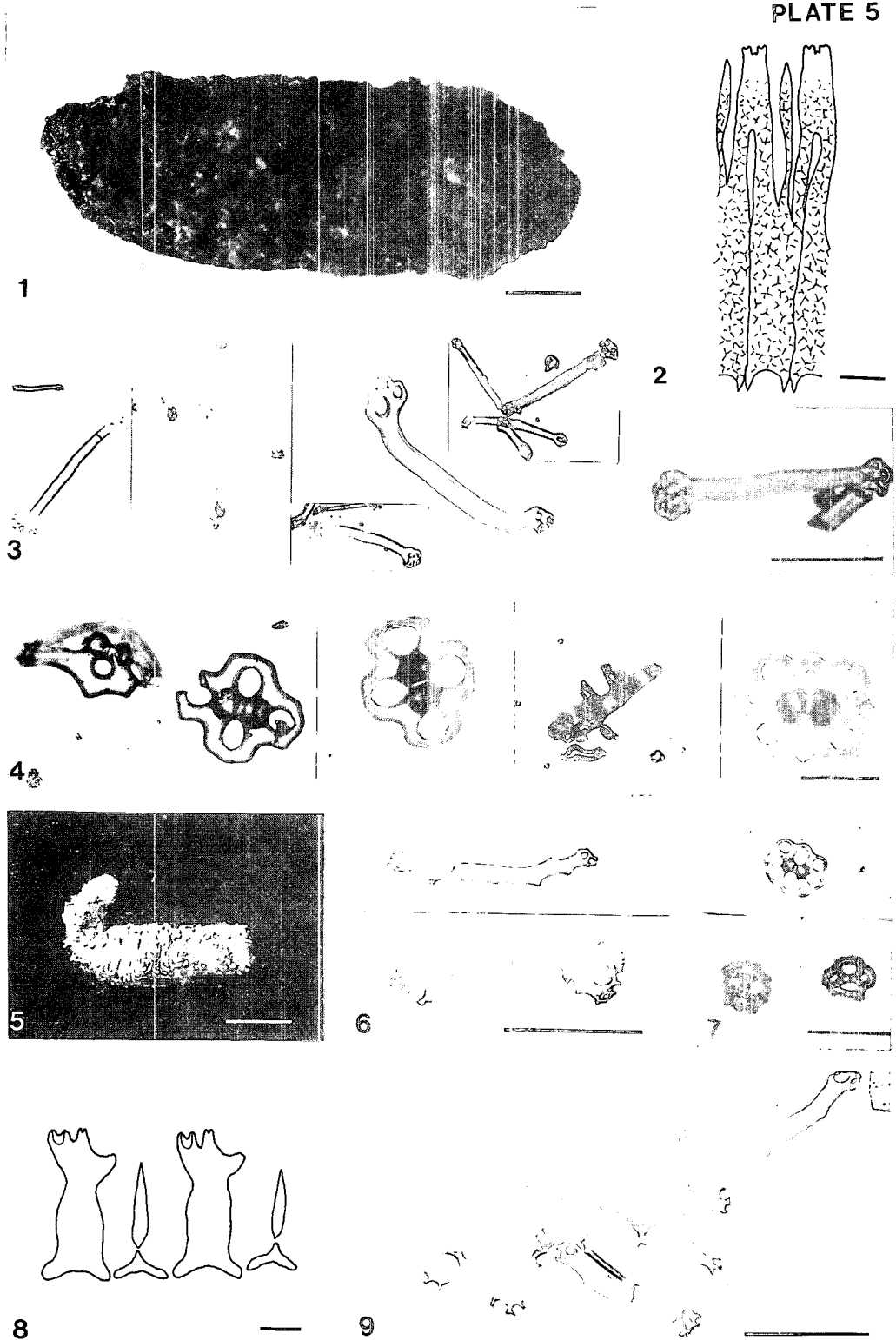
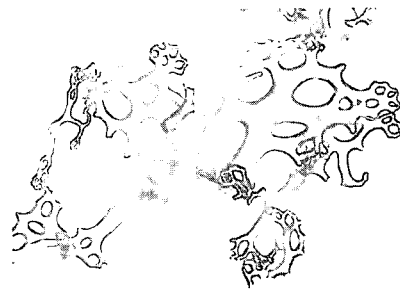
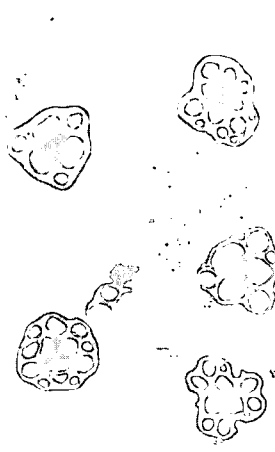
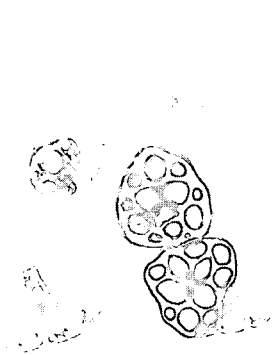
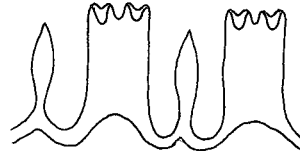
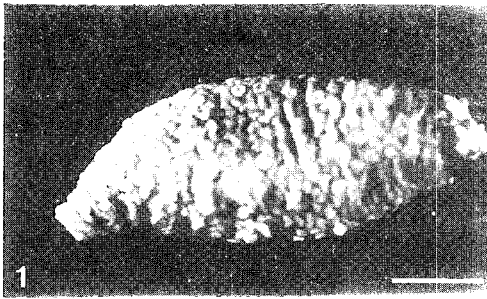


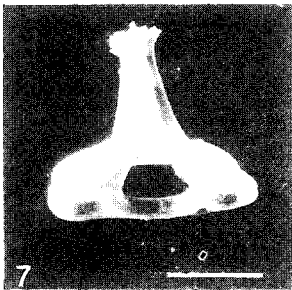
PLATE 6



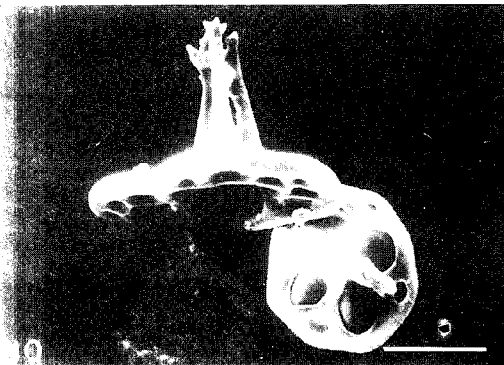
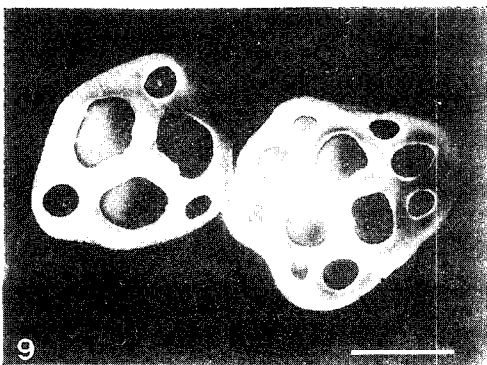
3

5

6



8



9

10

PLATE 7

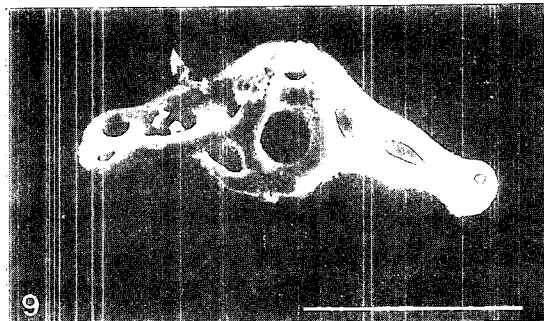
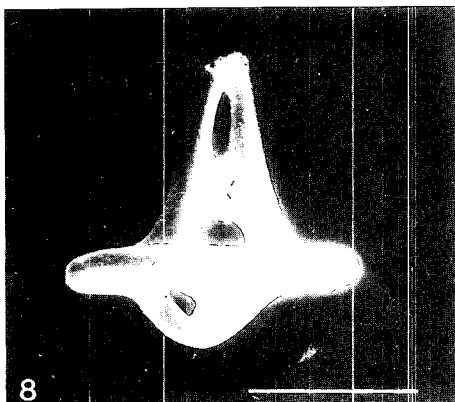
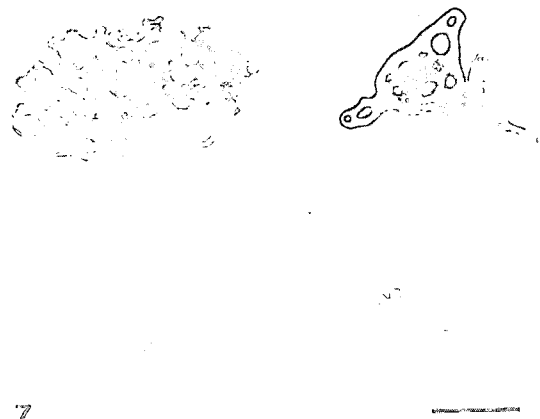
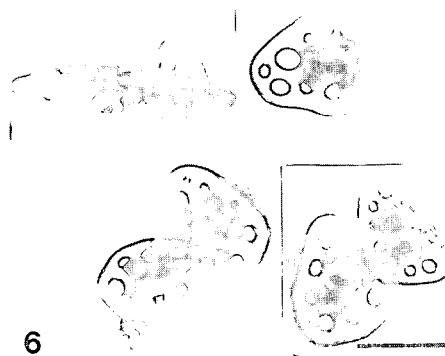
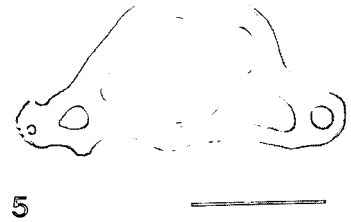
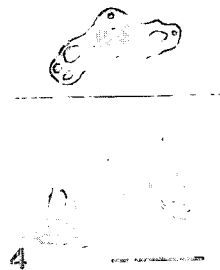
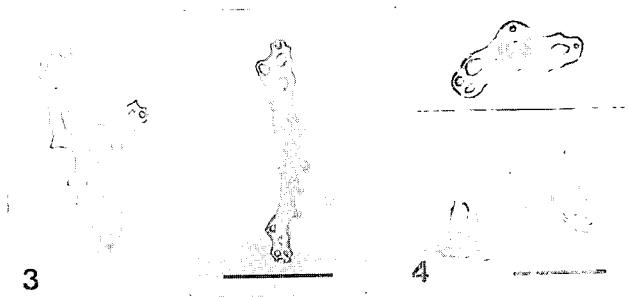
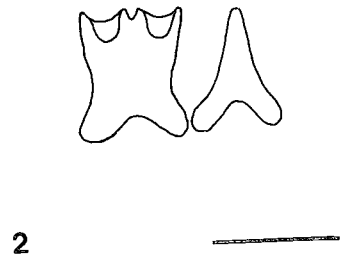
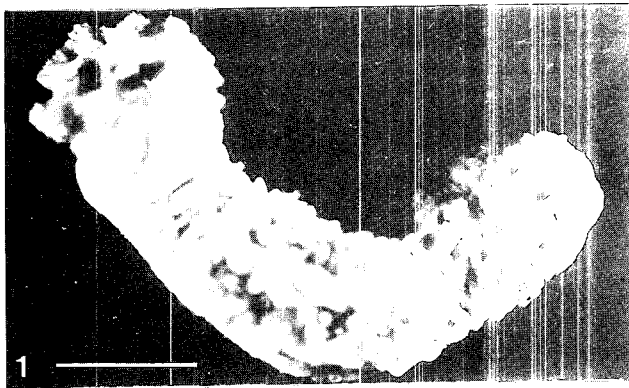


PLATE 8

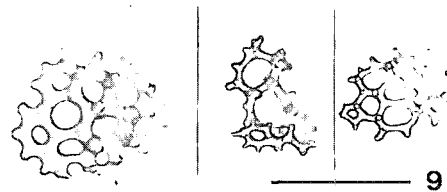
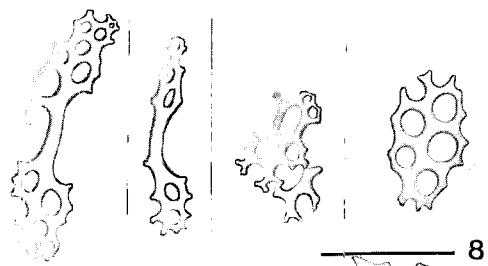
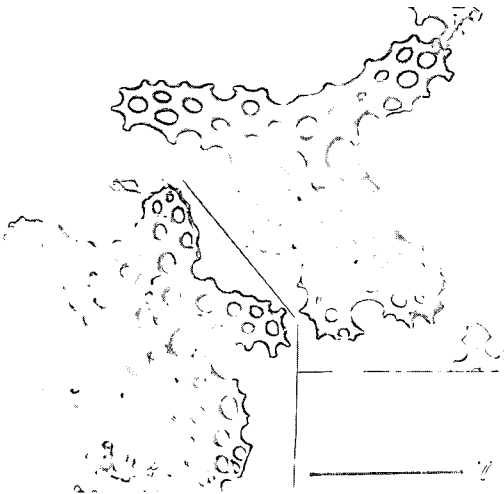
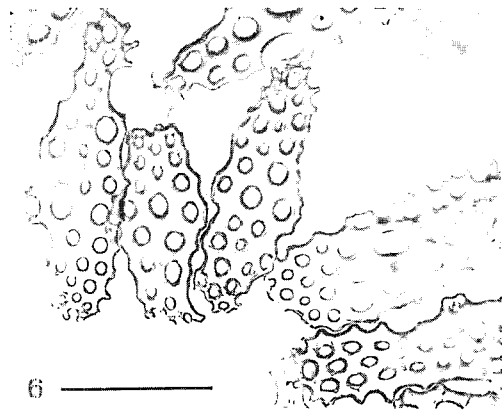
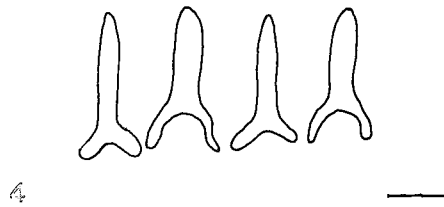
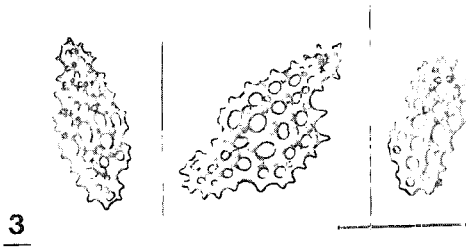
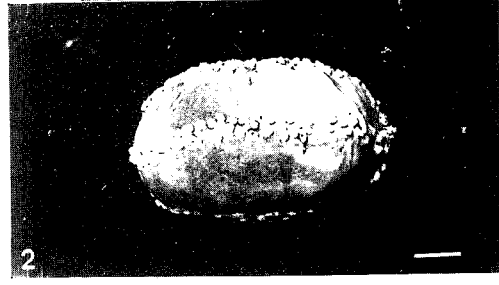


PLATE 9

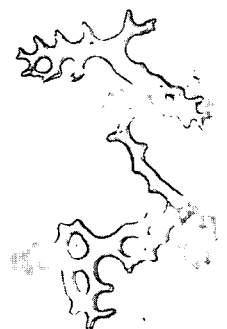
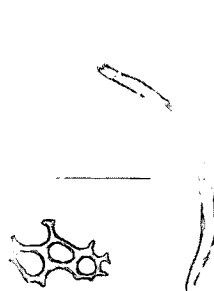
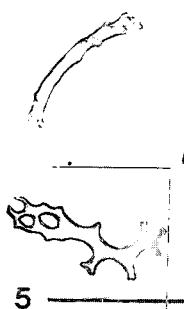
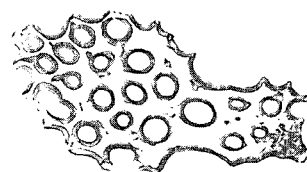
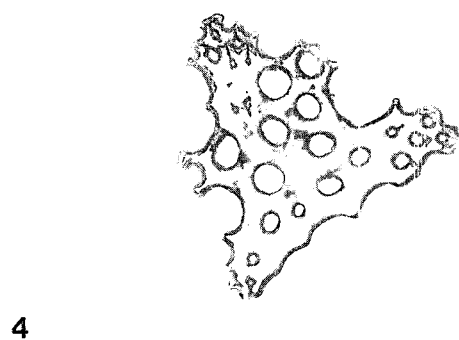
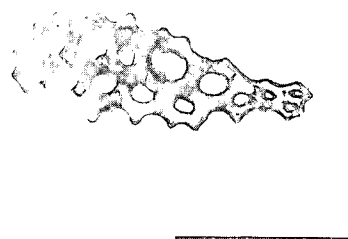
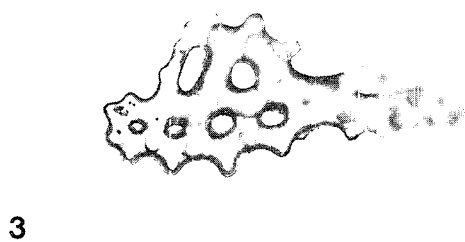
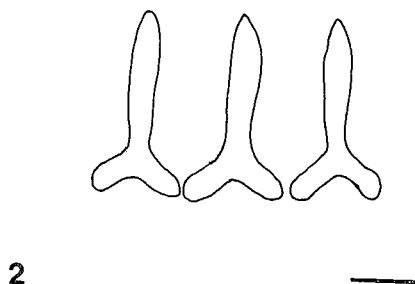
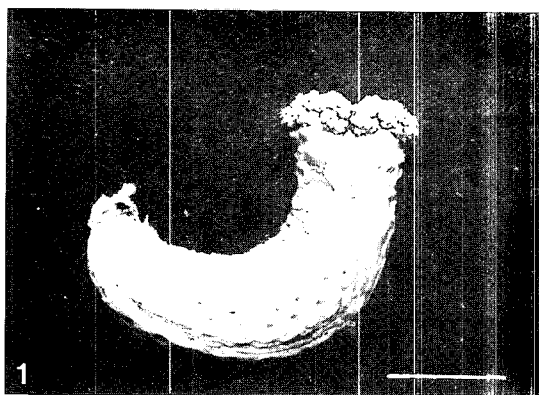


PLATE 10

