

## **New Collections of Ascidians from the Western Pacific and Southeastern Asia**

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**Abstract**—Recent collections of ascidians from several western Pacific and southeast Asian islands have significantly increased the number of species known from the Indo-West Pacific region. We examined specimens from Palau, Chuuk, the Philippines, Indonesia, and Papua New Guinea. A large part of them were collected by the Coral Reef Research Foundation, based in Palau. Descriptions and figures are given for 99 species, 34 of which are new. Colonial forms predominate with a peculiar abundance of the Didemnidae family. The geographical distribution is indicated for each species, but the sampling is not sufficient to allow general statements, and presently it is not possible to delimit faunistic provinces in this large region.

### **Introduction**

The tropical western Pacific Ocean has a large area of shallow waters with numerous islands and reefs, and an extremely diverse coast-line. The diverse origins of the present day sea floor, the rather uniform temperature, and the high content of nutrients carried in sea water from nearby land masses, are all characters obviously favorable to the development of a varied fauna. For all invertebrates, the western Pacific is considered a major source of taxonomic diversity. Studies of scleractinian corals, for example, have shown a decreasing diversity from the western Pacific adjacent to the Indo-Malayan region which is considered to be the center of their evolution, to the central Pacific (Wells 1988). The same pattern is likely for ascidians, as they are most abundant on coral reefs in tropical regions.

Previously, ascidians had not been systematically collected in the western Pacific. Many of the described species were the result of sporadic collections from limited areas. The first descriptions of ascidians from this part of the world (Heller 1878, von Drasche 1884, Traustedt 1885) were made from specimens collected by Naval Officers interested in natural history and the specimens were deposited in large European Museums.

Most of our knowledge of ascidians of this region is due to the 1899–1900 *Siboga* Expedition and the works of Sluiter (1904, 1909). The only two kinds of habitats that were investigated were the reef flat accessible on foot, and bottoms

below 40 m depth explored with dredges from a ship. Ascidians, however, are common in virtually all shallow marine habitats which shows how limited sampling was in the early 20th century.

Other oceanographic expeditions to the western Pacific from which ascidians were collected were the *Challenger* Expedition (Herdman 1882, 1886), the *Albatross* Cruise (Van Name 1918), but they did not collect extensively. Later, samples from sporadic collections were deposited in several Museums. Those of the Smithsonian Institution were studied by Tokioka (1967). Millar (1975) described some from the Zoological Museum in Copenhagen. Smaller collections from the Arafura sea (Tokioka 1952), Palau Islands (Tokioka 1950, 1955), and Philippines (Tokioka 1970) have also increased our knowledge. Other short publications indicate that about 250 ascidian species have been recorded from Indonesia, and only about 100 species from the Philippines. These figures demonstrate how little is known about the western Pacific tunicate fauna.

The ascidian fauna is better known on each side of this wide tropical region. In Japan, over a period of 50 years, Tokioka, and later, Nishikawa have described more than 300 species. Around Australia, mostly on the Great Barrier Reef, ascidians were extensively collected and described by Kott in 1985, 1990 and 1992, and excluding the didemnids, which are not yet published, this fauna numbers more than 400 species. The ascidian fauna of Australia is estimated to be 500–600 species.

The recent popularity of SCUBA diving and the presence of specialists in the field have increased the number of ascidians collected and identified considerably. For example Kott (1981) described 60 species on the Fiji reef flat and Nishikawa (1984) recorded 62 species, excluding Didemnidae, in Micronesia (Chuuk, Pohnpei, and Majuro). We have recorded about 100 species from French Polynesia (Monniot & Monniot 1987) and 202 species from southern New Caledonia (C. Monniot 1987 to 1991, F. Monniot 1987 to 1994).

Nevertheless ascidians remain poorly known in the tropics. Besides the technical difficulties of collecting, especially colonial animals, a taxonomic study requires fully mature specimens, fixation in formalin, dissection and staining before any microscopic observation.

The present study includes collections made by the Coral Reef Research Foundation which is based in Palau, Caroline Islands, a few samples collected by colleagues at Scripps Institute of Oceanography, and specimens deposited in the Muséum National d'Histoire Naturelle (MNHN) collections. Many type specimens from several Museums were observed for comparisons; the species described here do not constitute a complete inventory. Very often only one specimen of each species was preserved and no intraspecific variation can be addressed. Often, a species previously collected from an area was not recollected elsewhere. No precise geographic distributions can be given among the different archipelagos and only very general conclusions can be drawn. The present work improves our knowledge of the shallow water fauna of the western Pacific by giving descriptions of many new species, and redescrptions of other poorly known species. This contribution clearly shows the great diversity of the western Pacific coastal fauna of ascidians and the need for future continued work on this group.

Order Aplousobranchia  
Family Polyclinidae  
*Aplidium controversum* new species  
Fig. 1, Pl. 1A

*Aplidium californicum*: F. Monniot 1987: 518, fig. 8 c-g, New Caledonia

*Aplidium multiplicatum*: Kott 1992a: 567, fig. 90, Australia

Holotype: MNHN: A1 Apl B 312—Palau, Koror State, marine lake, 7°17.81' N; 134°26.82' E, 1 m.

Description: The colonies form cushions or balls, 2 to 3 cm across. The zooids are visible as pink spots through a translucent tunic and are arranged in double

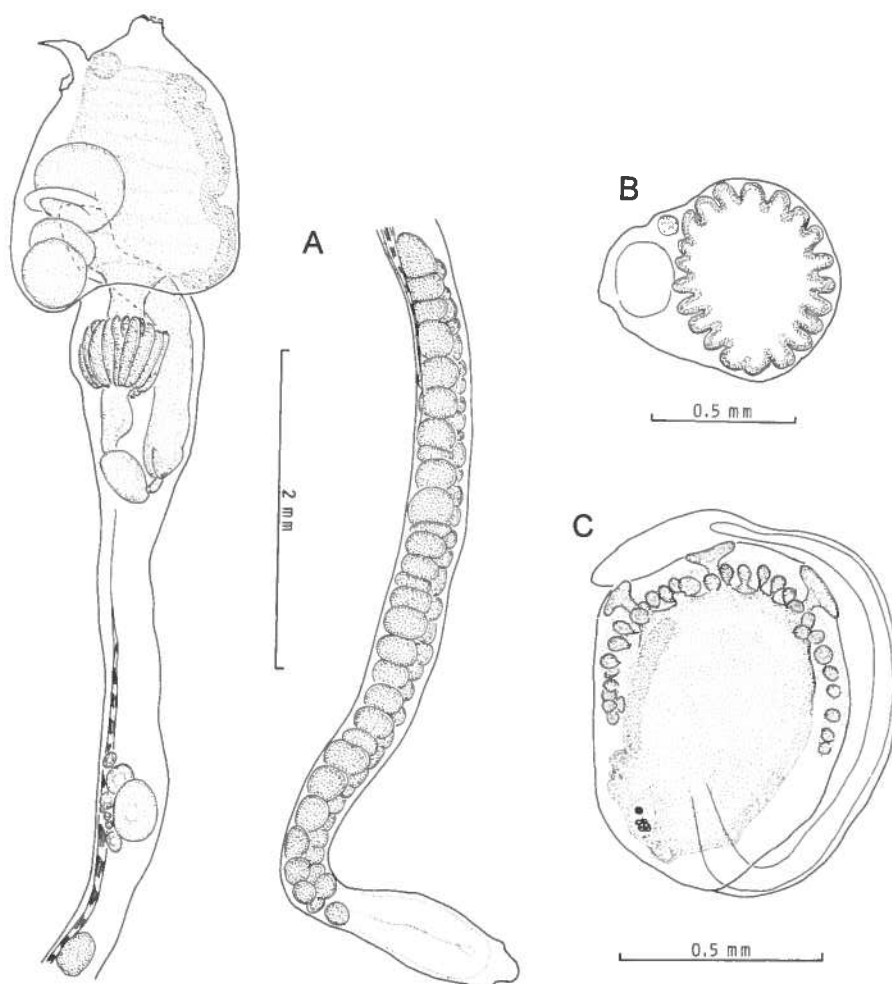


Figure 1. *Aplidium controversum* n. sp.: A, zooid; B, section of the stomach; C larva.

lines along cloacal channels that open at the top side of the colony. The general color is pale yellow (Pl. 1A). The consistency is soft, but there is no mucus.

The zooids reach 15 mm in total length. The thorax, 2 mm long when relaxed, is wide (Fig. 1A). The oral siphon has 6 lobes; its basal part encircled by white pigment cells. The cloacal aperture forms a short, narrow tube, dorsally prolonged in a stout, short, pointed languet (Fig. 1A). The latter sometimes has a pair of small lateral swellings. The thoracic muscles are mostly longitudinal. The branchial sac has 10 rows of 15 to 20 stigmata. The rapheal languets are only slightly displaced to the left side. The abdomen is shorter than the thorax. The stomach is plicated in 20 to 24 longitudinal folds (Fig. 1B), few of them incomplete. The post-stomach has an annular rod. The intestine begins with an olive-shaped segment, followed by a narrow tube joining the rectum between 2 well-marked caeca (Fig. 1A). The anus opens at two thirds of the way down the cloacal cavity. The post-abdomen is very long. The ovary lies some distance from the abdomen, followed by a double row of testis follicles extending down to the heart (Fig. 1A). Several larvae are incubated inside the cloacal cavity. They measure 0.9 mm and have 3 flat adhesive papillae. On each side there is a row of about 30 round epidermal vesicles along the anterior half of the perimeter of the trunk (Fig. 1C). The sensory organs are located posteriorly. In some larvae 2 rows of stigmata begin to differentiate.

Remarks: This species resembles the specimens identified as *Aplidium californicum* (Ritter, 1900) from New Caledonia by F. Monniot (1987) and *Aplidium multiplicatum* Sluiter, 1909 by Kott (1992a) except the synonyms she gave, which have to be verified by reexamining the specimens. However, we consider the Palau colonies are different and represent a new species, the species name reflecting the successive confusion of several authors about this species and its relatives.

The external appearance and numerous similar anatomical characters in *A. californicum* and *A. multiplicatum* have been noted by ascidian taxonomists for a long time. This caused Hartmeyer (1909–1911) and Kott (1963) to synonymize the two species, however insufficient descriptions have successively complicated the question. The type specimen of *A. multiplicatum* is registered at the Zoologisch Museum of Amsterdam, however the type of *A. californicum* has not been located. Only newly-collected specimens of the latter species from British Columbia have been studied. We provide a brief redescription of each species for comparison with *A. controversum*.

In *A. californicum* from British Columbia the colonies form rounded cushions, yellow or pale orange in color. The zooids are arranged in double rows converging to common cloacal openings at the upper part of the colony. The zooids have 6 oral lobes, 12 tentacles in 2 orders of size. The cloacal aperture forms a short tube and has a triangular short languet on its dorsal rim. The branchial sac has 8 to 11 rows of stigmata, usually 9 or 10. The dorsal rapheal languets are strongly displaced to the left side. The stomach has 14 to 15 deep folds, some of them interrupted or irregular. There is an annular post-stomach and 2 caeca at the beginning of the rectum. The post abdomen is elongated, with the ovary rather close to the gut loop, followed by a regular double row of testis



follicles occupying the whole length of the post-abdomen. The larvae, incubated in the cloacal cavity are small with 3 adhesive papillae, and an irregular half circle of small ectodermal vesicles. Two odd median vesicles lie between each adhesive papilla.

The preserved specimens of *A. multiplicatum* that were examined, including the holotype and another colony collected near the type locality, were rather damaged. However, it could still be determined that they are similar in all characters, and both lack larvae. They are cushion like with zooids arranged in double rows. The oral siphon has 6 lobes. The cloacal siphon is narrow, not quite tubular, but rather opening in a vertical slit with a horse-shoe shaped rim opening dorsally. A triangular languet is inserted on the dorsal rim of the aperture. The branchial sac has 9 rows of stigmata. The abdomen is much smaller than the thorax. The esophagus is very short. The stomach has at least 20 longitudinal folds, few of them are incomplete. There is an annular post-stomach and caeca. The anus opens immediately posterior to the cloacal aperture, at the level of the second stigmata row. The post-abdomen is not continuous with the abdomen, but is separated by a constriction. The post-abdomen is short and contains many testis follicles in a bunch.

Many specimens identified as *A. multiplicatum* do not correspond to the species represented by the type, as they have an elongated post-abdomen with testes in 2 rows, a different stomach or a different cloacal siphon. In our opinion the following identifications of *A. multiplicatum* are erroneous: Van Name (1918), Tokioka (1953, 1954a, 1967), Millar (1963), Kott (1963, 1992a), Kott & Goodbody (1982), Nishikawa (1980, 1984, 1990), Rho (1975), Rho & Huh (1984), Rho & Lee (1989). The only descriptions that correspond well to the type specimen of *A. multiplicatum* are those of Millar (1975: 247), Nishikawa & Tokioka (1976: 379), and Renganathan & Monniot (1984: 259).

*Aplidium lineatum* new species

Fig. 2, Pl. 1B

Holotype: MNHN: A 1 Apl B 311—Indonesia, north Sulawesi, Manado area, 11°45.10'N; 124°58.87'E, 33 m.

Description: The colony was collected on the deepwater slope of a fringing reef. It was encrusting, about 1 cm thick and 6 × 4.5 cm across. The mammillated surface is bare. The oral apertures of zooids open at both sides of depressed lines which correspond to the internal cloacal channels. These furrows are easily seen in living colonies, yellow in color from the pigmented zooids visible through the transparent tunic; the species name refers to these lines (Pl. 1B). Between the zooid lines, the test forms white swellings. The general consistency is not gelatinous but rather firm.

The zooids are perpendicular to the colony surface, extending throughout its thickness. The oral siphon is wide and ends in 6 pointed lobes (Figs. 2A, B, C). The cloacal aperture is widely opened (Figs. 2A, B, C), uncovering a large part of the branchial sac. Its posterior margin has very small denticles. Dorsally, the

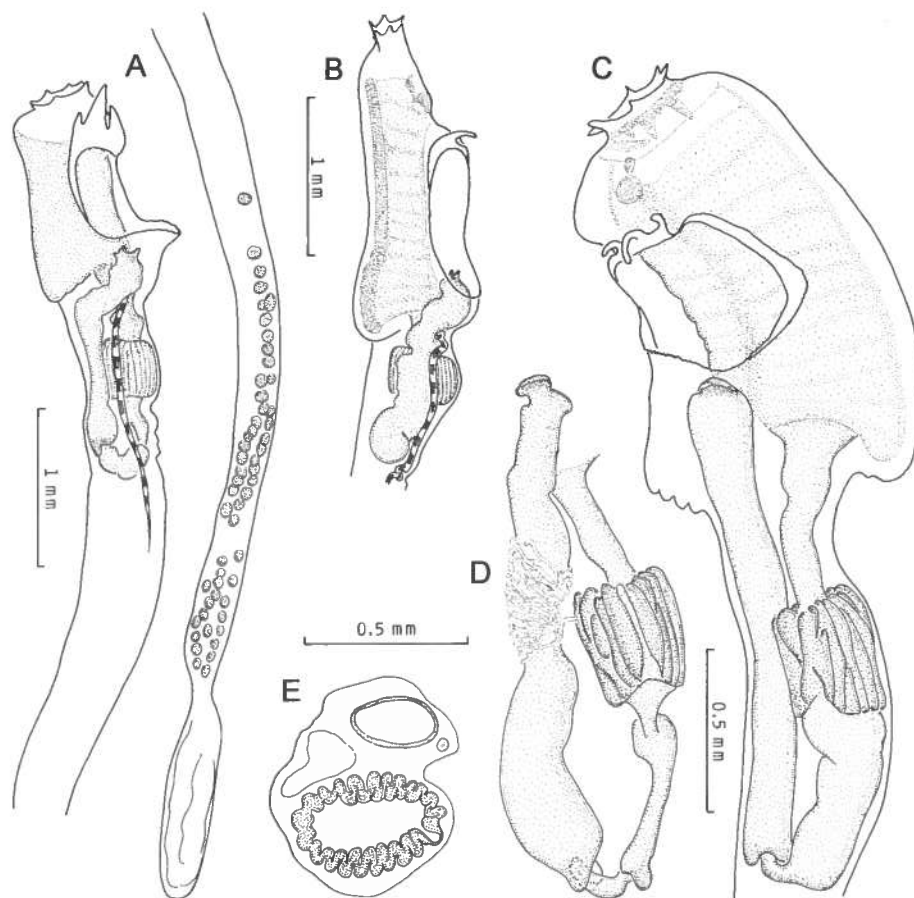


Figure 2. *Aplidium lineatum* n. sp.: A, zooid; B, C, thoraces; D, detail of the gut; E, section of the stomach.

margin of the aperture is prolonged by a short languet, either simple (Fig. 2B) or divided in 3 deeply cut lobes (Figs. 2A, C). The thoracic muscles are mostly longitudinal. The branchial sac has 12 or 13 rows of stigmata, 18 per row in the anterior part; it is not perforated along the dorsal line. The gut is about the same length as the thorax. The esophagus is slightly swollen in a ring in its middle part (Figs. 2C, D). The stomach is cylindrical with an average of 20 longitudinal folds, rarely interrupted (Figs. 2D, E). The post-stomach makes a ring. The posterior intestine begins with marked caeca at the bottom of the gut loop (Fig. 2C). The elongated post-abdomen (Fig. 2A) contains poorly-developed gonads in the studied colony. The ovary is located at the beginning of the posterior half of the post-abdomen, followed by numerous testis follicles in two irregular lines. Larvae were not present.

Remarks: *Aplidium lineatum* n. sp. differs from other *Aplidium* species due to its zooids lining depressed cloacal channels, the numerous stomacal folds and the particularly large cloacal apertures.

*Aplidium longithorax* F. Monniot, 1987

Pl. 1C

*Aplidium longithorax* F. Monniot, 1987: 525, fig. C-G, pl. II F, New Caledonia.

*Aplidium protectans*: Kott, 1963: 102, New South Wales, and 1992: 579, Queensland., Australia

Material Examined: MNHN: A1 Apl B 317 and 331—Palau, Rock Islands, Island "29", 7°19.52'N; 134°29.62'E, 12 m; and Mutremdiu, 7°16.51'N; 134°31.55'E, Barrier Reef.

The colonies are not very well preserved. They have the shape of a flattened cushion attached to the substrate by a narrow part. The largest diameter is 6.5 cm with a thickness of 3.5 cm for the middle of the colony. The surface is flat with round hollows in which the oral apertures of the zooids are arranged in circular systems around common cloacal apertures. The test was yellow in life (Pl. 1C) and retained its color when preserved. The zooids had red thoraces and yellow abdomens.

Even though strongly contracted, the zooids are large, some exceeding 1.5 cm in length. The oral aperture generally has 8 lobes, but occasionally 7 or 9. The cloacal aperture is far anterior; its dorsal rim is elongated in a short languet generally ending in 3 lobes. The branchial sac has 20 to 22 rows of stigmata that do not reach the endostyle. There is no constriction between thorax and abdomen. The stomach is cylindrical with 5 folds. The post-abdomen is very long with numerous testis follicles along its entire length. The ovary was not developed in the colonies studied here. Only one embryo was found in the posterior part of the cloacal cavity of one zooid, it was not yet differentiated into a tadpole.

All characters are quite similar to those observed in New Caledonian colonies.

These characters are similar to those of specimens identified as *Aplidium protectans* (Herdman, 1899) by Kott (1992a). However, we examined the type colony of *Amaroucium protectans* Herdman, 1899, collected in Port Jackson, New South Wales, loaned by the Australian Museum in Sydney, and this specimen obviously belongs to the genus *Polycitor*. We also examined the colony identified by Kott (1963) as *A. protectans*, lent by the Australian Museum, and while not very well preserved, this specimen is almost certainly *Aplidium longithorax*.

Geographic Distribution: The species was previously known from the south western Pacific (New Caledonia—Eastern Australia) and is now extended to the Palau Islands.

*Aplidium tabascum* Kott, 1992

Pl. 1D

*Aplidium tabascum* Kott, 1992a: 589, fig. 103, Queensland, Australia.

Material Examined: MNHN: A1 Apl B 314—Papua New Guinea, Madang, main shipping channel, 5°12.40'S; 145°48.85'E, 30 m.

The colonies are encrusting, several centimeters in length and 1 cm in thickness. The colony surface is uneven because divided into compartments of swollen areas with the tunic densely impregnated with sand, separated by depressed, sand-free channels along which the oral apertures open in double rows (Pl. 1D). Sometimes, at the junction of several canals, are large common cloacal apertures. The colony surface is uneven because patches without sand have zooids of various heights. The internal tunic is red with no sand around the zooids. The red pigment is particularly abundant around the oral siphon and above the endostyle.

The zooids are perpendicular to the colony surface. The oral aperture has 6 dentate lobes above a strong sphincter. The cloacal aperture is low, variable in size, either in a short tube or uncovering part of the branchial sac between the 4th and 6th rows of stigmata. The cloacal languet is on the dorsal rim of the siphon and can be simple, bilobed or deeply cut into 3 lobes. The oral tentacles are located on the anterior portion of the siphon. The branchial sac has 14 rows of long stigmata. The thorax is narrow and the number of stigmata could not be counted. The esophagus is short, conical and thinner where it connects to the stomach. The stomach is in the anterior half of the abdomen. It has 5 folds, which are shorter on each side of the typhlosolis. No annular post-stomach was seen; the rectum starts with well-developed caeca. The post-abdomen is variable in length. It is always longer than the rest of the zooid and particularly long when the ovary is not developed. The testis follicles are far posterior next to the heart. When the ovary is visible, it is far behind the gut. The larvae are incubated in the cloacal cavity. Only one larva matures at a time and protrudes in a body wall dilatation which is not pedunculated. The tadpole has 3 adhesive papillae on thin stalks. On each side is an anterior crescent of numerous button-like vesicles, sometimes interrupted in its middle either on one side or both sides of the larva. The sensory vesicle contains an ocellus and an otolith.

Remarks: These colonies correspond closely to *A. tabascum* in the color, and arrangement of the zooids. But the size of the zooids, varying here between 5 and 10 mm, is larger than the 2–3 mm indicated by Kott (1992a). The number of rows of stigmata, the cloacal languet and the stomach are similar. The tadpole is the same except that the interruption in the middle of the crescent of vesicles was not always present in our specimens.

This species differs from *A. cellis* F. Monniot, 1987 from New Caledonia, which has a colorless tunic, a small simple cloacal languet, no strong oral sphincter, a short post-abdomen and male follicles just posterior to the ovary. The larvae are slightly different.

Geographic Distribution: The species was previously only recorded from Queensland.

*Aplidium* sp. A  
Fig. 3A, B, Pl. 1E

Material Examined: MNHN: A1 Apl B 313—Papua New Guinea, New Ireland, Kavieng, 2°45.06'S; 150°42.84'E, 20 m.

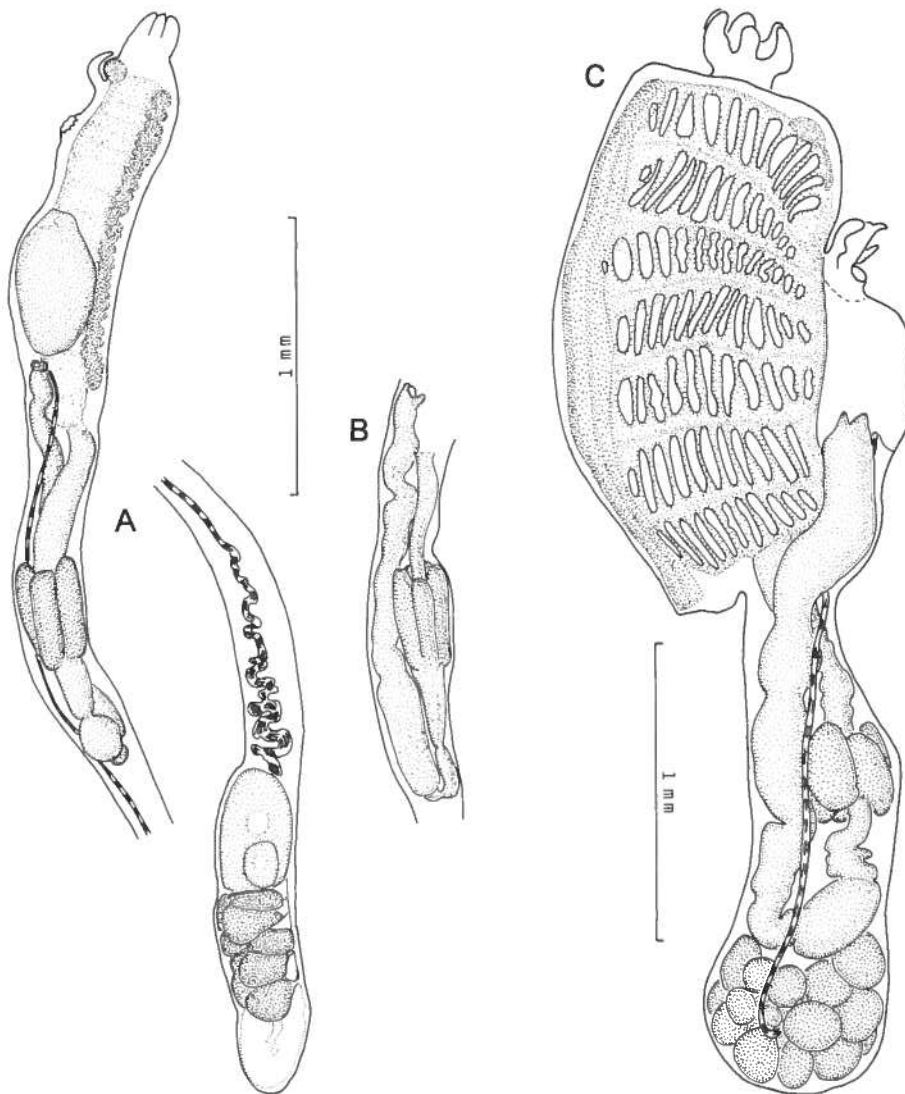


Figure 3. *Aplidium* sp. (A), A: zooid; B, detail of the gut. *Aplidium* sp. (B): C, zooid.

The colonies (Pl. 1E) are fleshy, cone-like with tapering but rounded ends, 3 to 6 cm long and 1 cm in diameter. The color is translucent brown, the zooid apertures are lined along deep long furrows which converge into circular common cloacal openings. Brown pigment cells are irregularly distributed in the thickness of the test and are absent in the zooids.

The zooids are thin and elongated (Fig. 3A). The oral siphon has 6 digitiform lobes. The cloacal siphon is narrow, with a muscular ring at its rim. A cloacal

languet is located at some distance from the aperture (Fig. 3A). It is tapered at the free extremity or cleft in 2 or 3 teeth. The branchial sac has 13 to 15 rows of stigmata. The abdomen comprises a long esophagus, a long cylindrical stomach with 5 deep folds (Fig. 3B), an oval posterior stomach, a mid-intestine slightly dilated and a posterior intestine beginning with caeca. The post-abdomen is particularly long. The gonads are located at the very posterior extremity (Fig. 3A) with a short testis, with few follicles in two rows and an ovary immediately anterior to it. Some embryos were incubated in the cloacal cavity, but at an early stage of development.

Remarks: This species differs from *A. caelestis* F. Monniot, 1987, which is encrusted with sand and has gonads occupying the entire abdomen. *A. cellis* F. Monniot, 1987 has a short post-abdomen and an atrial languet on the rim of the cloacal aperture. *A. clivosum* Kott, 1992a has a different colony shape, a tubular cloacal siphon. *A. crateriferum* (Sluiter, 1909) has more rows of stigmata and gonads that do not reach the heart. *A. lenticulum* Kott, 1992a is encrusted with sand, has more rows of stigmata and a different abdomen. *Aplidium longithorax* F. Monniot, 1987 has zooids in rosettes, an atrial languet at the rim of the cloacal aperture and more rows of stigmata. *A. nadaense* Nishikawa, 1980 is densely embedded with sand.

*Aplidium* sp. B

Fig. 3C, Pl. 1F

Material Examined: MNHN: A1 Apl B 330—Palau, Koror State, Risong Lake, 7°18.74'N; 134°28.04'E, 1 m.

The colonies are spherical, somewhat translucent. The oral siphons are seen as small red spots, lined in double rows converging into a single cloacal opening, also of a deep red, at the top of each colony (Pl. 1F). The colonies are grouped in clusters. They are soft and measure no more than 2 cm in diameter. The red color of the zooids completely fades in formalin. Fine sand particles are scattered throughout the soft tunic. The zooids are very short. The oral siphons have 6 round lobes. The cloacal aperture is narrow with a sphincter and a tridentate languet at its upper rim (Fig. 3C). There are 10 longitudinal muscles on each side of the thorax. The branchial sac has 7 rows of stigmata with 10 to 15 stigmata in the first row (Fig. 3C). The abdomen and post-abdomen are very short and not clearly separated (Fig. 3C). The gut loop is narrow. The stomach has 5 deep folds. A cluster of testis follicles (10 to 12) is located just posterior to the gut loop, some are located inside the loop. The ovary was not observed and no larvae were present.

*Aplidiopsis ocellatus* new species

Fig. 4, Pl. 1G

Holotype: MNHN: A1 Apl A 15—Indonesia, north Sulawesi, west of Manado, 1°23.50'N; 124°44.60'E, 7 m.

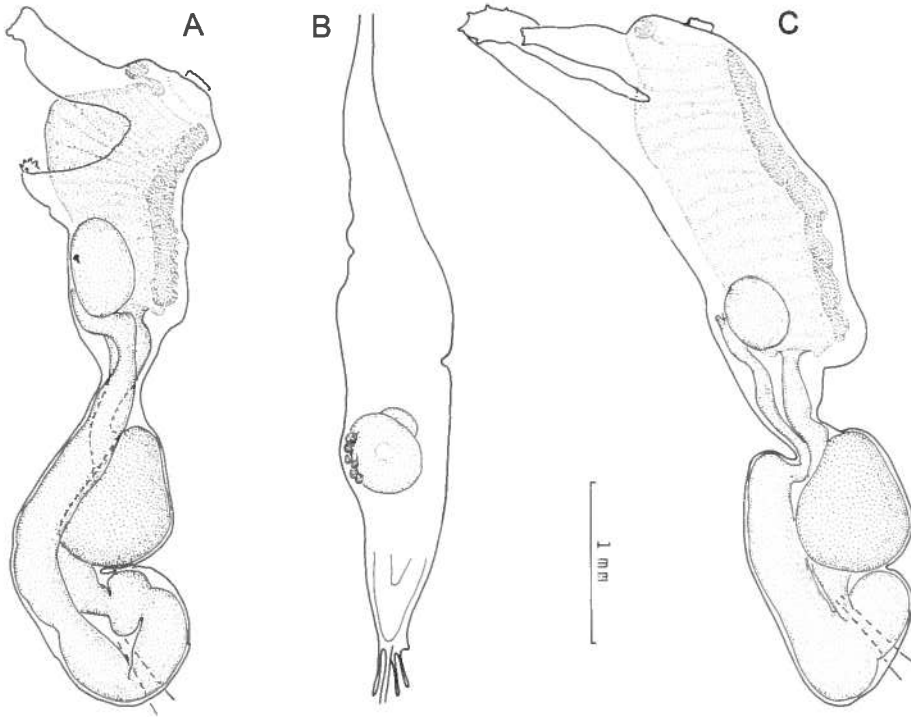


Figure 4. *Aplidiopsis ocellatus* n. sp.: A, B, zooid; C, thorax and abdomen of another zooid.

**Description:** The colonies have several clavate lobes, 1 to 2 cm high, raised above a common base. The test surface is olive green, smooth, without encrustations (Pl. 1G). The oral apertures and common cloacal openings appear in dark brown, which is the internal color of the colony. The common cloacal openings and some of the oral siphons are circled in yellow, hence the species name. There are 1 to 3 circular or stellate systems of zooids in each lobe of the colony. The yellow and olive pigment totally disappeared in formalin and the colonies turned brown. The superficial test is tougher than the internal tunic which is soft and gelatinous.

The zooids are perpendicular to the colony surface with their post-abdomens parallel. The edge of the oral siphon is undulated by contraction, but is lobed. The cloacal aperture is deeply cut between two lips (Figs. 4A, C); the dorsal lip is produced into a languet with an undulating tip; the posterior lip has a round margin with 5 distinct teeth (Fig. 4A). A small button-like protrusion sometimes exists below the posterior lip. The branchial sac has 17 rows of about 30 stigmata separated by high transverse membranes that lack papillae. The rapheal languets displaced to the left side are wide at their base but with sharp extremities. The abdomen is shorter than the thorax, with the typical *Aplidiopsis* shape. The stomach is voluminous. The fusiform post-abdomen emerges from the middle of the

gut loop; it is long, with abundant reserve material. Only the ovary was present (Fig. 4B). There were no fully developed larvae in the colony studied, but in some zooids, a single young embryo was being incubated in the posterior part of the cloacal cavity.

This species is particularly characterized by the shape and color of the colonies, numerous rows of stigmata and the very peculiar shape of the lips of the cloacal aperture.

*Polyclinum pute* Monniot & Monniot, 1987

Fig. 5

*Polyclinum pute* Monniot & Monniot, 1987a: 84 fig. 30 BC, Polynesia; F. Monniot, 1987: 514, New Caledonia.

*Polyclinum tsutsui*: Kott, 1992:463, western Australia and Queensland.

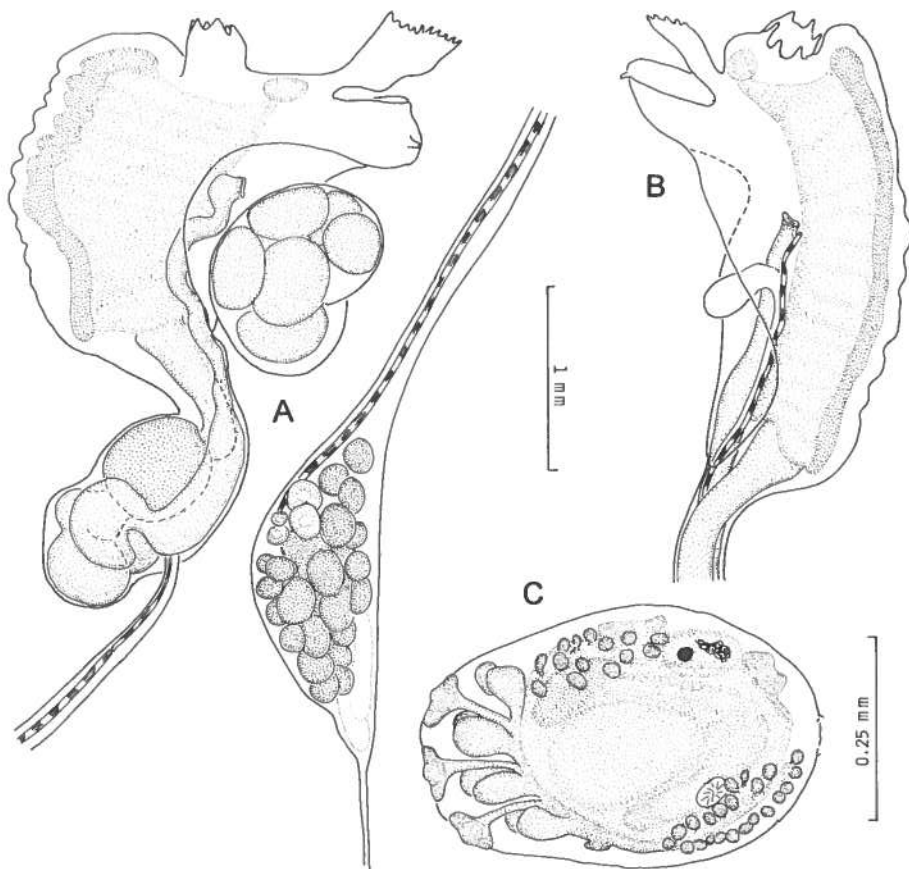


Figure 5. *Polyclinum pute* Monniot & Monniot, 1987: A, zooid in two parts; B, thorax of a zooid with an empty brood pouch; C, larva.



Material Examined: MNHN: A1 Pol 50—Palau, Airai State, S.W. Airai Channel, Ngermutidech, 7°18.64'N; 134°31.12'E, 0–1 m, seagrass bed.

The colonies are black, somewhat greenish internally. Some sand is encrusted at their base and in small patches on the surface. The colonies are several centimeters across and encrust algae. The zooids form circular systems around common cloacal openings. The tunic is rubbery, internally devoid of sand and soft. Black pigment cells are present everywhere. The zooids have a large thorax with 6 sharp oral lobes (Figs. 5A, B). The cloacal siphon opens horizontally at the top of the branchial sac, almost at the same level as the oral siphon (Figs. 5A, B). The dorsal part is produced in a languet, generally long and narrow, ending in a point or numerous small teeth. A button-like protrusion is located dorsally under the cloacal siphon (Figs. 5A, B). There are 12 to 14 rows of 20 to 25 stigmata. They are separated by transverse sinuses bordered by 12 to 14 elongated papillae on each side. The body wall has strong muscular longitudinal bundles. Dorsally, in the middle part of the thorax, a stalked brood pouch contains up to 6 embryos (Fig. 5A). The abdomen has the typical shape of the genus and is folded under the thorax. The post-abdomen is inserted in the middle part of the abdomen; it has a long peduncle, that may reach 3 times the length of its enlarged posterior part that contains the gonads. There are between 10 to 20 testis follicles and the ovary is central. The larvae are small and rounded (Fig. 5C). They possess 3 wide anterior adhesive papillae on a thin and short stalk. There are 4 pairs of ectodermal ampullae anteriorly. A patch of small vesicles lies dorsally, on each side. Inside the visceral mass 1 to 3 characteristic crystals of calcium oxalate can be seen in polarized light.

All characters correspond closely to the type specimen from Polynesia and to New Caledonian colonies. The only difference with the original description is the two patches of vesicles in the larva, which were not described but were also present in the oldest tadpoles of the New Caledonian specimens.

Remarks: The synonymy of *P. pute* with *Polyclinum tsutsui* Tokioka, 1954b proposed by Kott (1992a) cannot be justified. The type specimen of *P. tsutsui* has been examined, but the zooids are not fully mature, the post-abdomens are poorly developed and there are no embryos. However, in pl. XVIII fig. 2, Tokioka (1954) illustrates a zooid with an embryo located in the cloacal cavity with no trace of a pedunculate pouch. We also examined colonies Tokioka (1967) ascribed to his Japanese species. The colonies from Philippines and Palau had no larvae, but in the largest of the 2 colonies from Gilbert islands zooids remained with young embryos incubated in the cloacal cavity, and inside the oviduct. There was no trace of a protruding or pedunculate diverticulum, so Tokioka's species *P. tsutsui* apparently lacks a pedunculate incubatory pouch. Therefore, the specimens identified by Kott from Australia should be considered to be *P. pute*.

Geographic Distribution: Palau, Queensland, New Caledonia, and Polynesia.

***Pseudodistoma coronatum* new species**

Figs. 6A–E, Pl. 5H

Holotype: MNHN: A1 Pse 31—Papua New Guinea, Duke of York Islands, Makada Island, east side, 4°06.28'S; 152°25.45'E, 15 m.

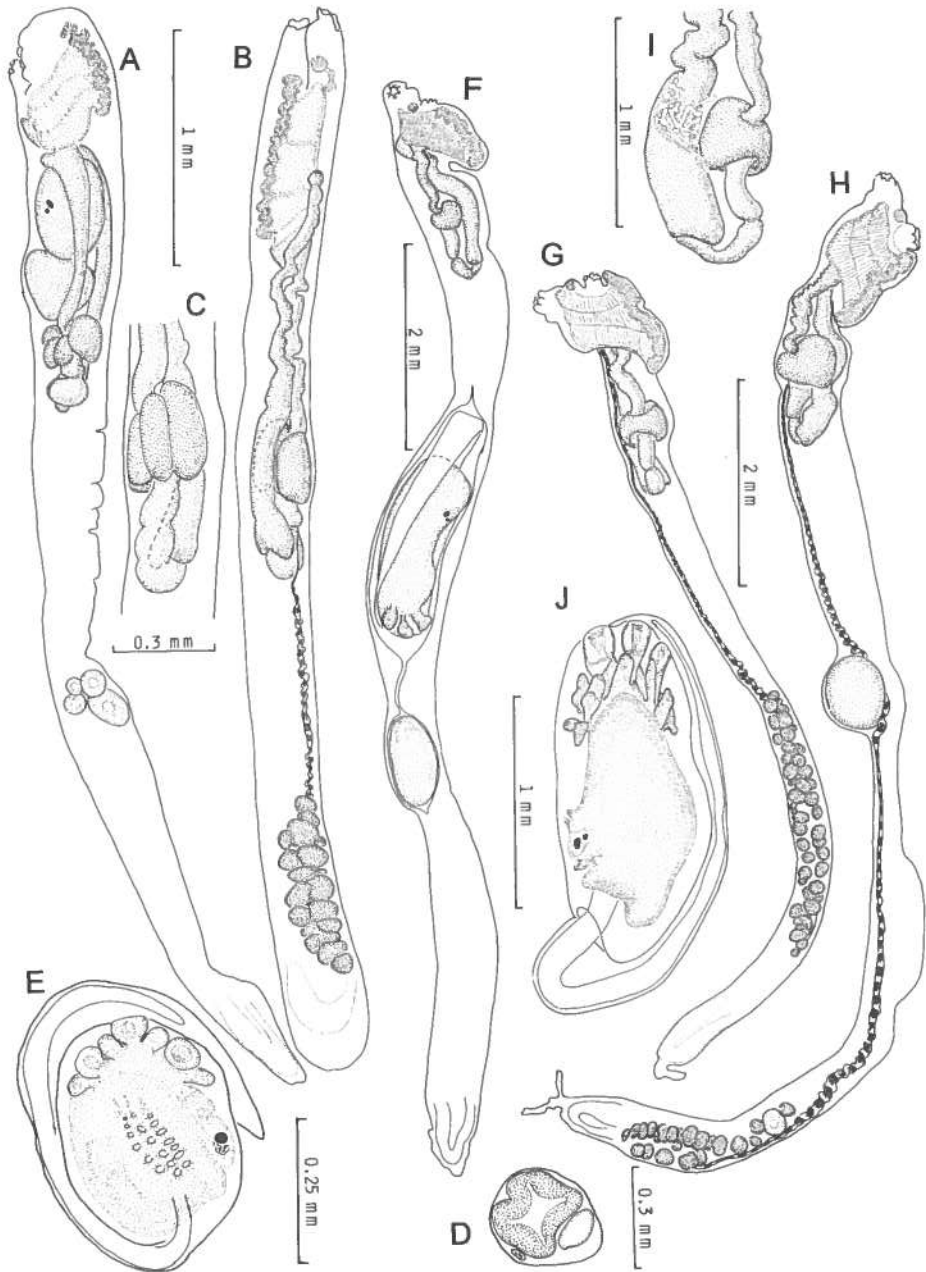


Figure 6. *Pseudodistoma coronatum* n. sp.: A, B, zooids; C, detail of the gut; D, section of the stomach; E, larva. *Pseudodistoma megalarva* n. sp.: F, G, H, different zooids; I, detail of the gut; J, larva.

**Description:** The colonies are encrusting sheets, 0.5 to 1 cm thick, up to 10 cm across, on rock or sponges. The consistency is firm and rubbery. When living, the tunic is translucent, pale yellow mottled with white (Pl. 1H), the zooids light orange and visible where the tunic is somewhat transparent. The zooids remain yellow in formalin and the fixative takes a yellow color. The oral siphons open in rings (hence the species name) at the smooth upper surface of the colony. The cloacal openings are grouped in the center of these circles.

The oral apertures of zooids have 6 rounded lobes. The cloacal siphons are asymmetrical with 3 dorsal lobes longer than the 3 ventral ones, so the apertures are oblique at the tip of the tubes. The zooids are perpendicular to the colony surface, long and thin when the post-abdomen is fully developed with gonads, but much shorter when the zooids are breeding with a regressed post-abdomen. There are 8 longitudinal muscle bands on each side of the thorax. The first row of stigmata is dorsally curved and contains about 22 perforations. The other rows have 20 stigmata or less. The dorsal languets are short, obviously displaced to the left side. The abdomen is longer than the thorax even in relaxed zooids (Figs. 6A, B). The esophagus is long and cylindrical, the short stomach is placed at 2/3 of the abdomen length. It is asymmetrical with 4 swellings (Figs. 6C, D). The rectum begins with 2 caeca. The post-abdomen is not separated by a constriction from the abdomen. When the ovary is present, the male gonads have generally disappeared (Fig. 6A) and the post-abdomen is shorter, the ovary lying at some distance from the gut loop. When the testis is developed, few male follicles are located in the posterior half of the post-abdomen (Fig. 6B). The embryos are incubated all along the oviduct, and only the mature tadpoles reach the thoracic cloacal cavity. The tadpoles are small, 500  $\mu\text{m}$ , with 3 very short adhesive papillae and 4 pairs of ectodermal ampullae. They have an ocellus and an otolith and 3 rows of stigmata which are already pierced (Fig. 6E).

**Remarks:** This species is closely related to *Pseudodistoma aureum* (Brewin, 1957) which has similar gut and gonads. But the present species has zooids arranged in circular systems and the cloacal siphon has a characteristic shape.

*Pseudodistoma megalarva* new species

Figs. 6F–J, Pl. 2A

**Holotype:** MNHN: A1 Pse 27—Indonesia, North Sulawesi, Biaro Island, 2°08.48'N; 125° 21.15'E, 12 m.

**Description:** Collected on the shaded side of a patch reef, the colonies were joined cushions 2 to 5 cm across. They had a translucent test through which bright orange zooids could be seen (Pl. 2A). The colony surface was smooth, without sediment.

The zooids are long and thin, the post-abdomen is much longer than the thorax and abdomen together (Figs. 6F, G, H). Both apertures are short with 6 rounded lobes (Figs. 6G, H). There are 3 rows of about 20 long stigmata. The 2 rapheal languets are short and clearly displaced on the left side. The thoracic musculature is weak. The digestive tract makes a tight, straight loop (Fig. 6I)

beginning with a long and narrow esophagus which enters dorsally into an asymmetrical, smooth-walled stomach (Fig. 6I). The rectum begins with an enlarged segment at the bottom of the gut loop. The pyloric gland has few curved tubules converging to a thin duct which opens into the posterior part of the stomach (Fig. 6I). The post-abdomen varies depending on the gonadal maturation stage. When the testis follicles are well developed, they lie in two irregular rows in the posterior half of the post-abdomen (Figs. 6G, H). The ovary appears far posterior (Figs. 6F, H). The oocytes develop along the post-abdomen. The embryos remain in the oviduct, below the abdomen (Fig. 6F), they are large, compressed into a long cylindrical shape. The tail forms a sharp angle before encircling the trunk. The trunk can reach 1.6 mm in length (Fig. 6J) justifying the species name. The sensorial vesicle, with an ocellus and an otolith, is located posteriorly. The 3 adhesive papillae are close to each other and also elongated. There are 4 ectodermal papillae on each side, the dorsal and ventral ones are divided (Fig. 6J), while the median ones are undivided.

Remarks: This species is characterized by the shape and size of the tadpoles and their incubation in the post-abdomen. It should be noted that the 3 adhesive papillae were not in a straight line, but this may have been due to contraction after fixation. The deep orange-red pigment is highly soluble in alcohol.

*Pseudodistoma poculum* new species

Fig. 7, Pl. 2B

Holotype: MNHN: A1 Pse 28—Federated States of Micronesia, Chuuk State, Kuop Atoll, oceanside reef, 7°00.00'N; 151°56.05 E, 30 m.

Description: The colonies (Pl. 2B) form a bush of ramified pedunculate lobes arising from a narrow base. Each lobe ends in a spherical head, up to 7 mm in diameter, with a top hollow, resembling a common cloacal aperture. On the internal side of this "cup" (from which the species is named), the cloacal siphons open independently. The oral apertures are regularly distributed on the external side of the head, circled by a ring of red tunic, without inclusions. Between the siphons the tunic contains fine sediment particles giving a white design between red spots. The stalks are up to 3 cm long with a maximum diameter of 3 mm. They are isodiametrical, ramified, completely encrusted with sand and contain the post-abdomens. They also have diverse epibionts on their surface.

The zooids are very long (Fig. 7A). Both siphons have 6 short lobes. The distance between the siphons varies, according to the location of each zooid in the colony (Figs. 7B, C). The cloacal siphon is short. The branchial sac has 3 rows of about 10 stigmata. The abdomen and thorax are of equal length and the same diameter (Figs. 7B, C). The gut is a cylindrical tube interrupted half way down the abdomen by a rounded stomach without folds (Fig. 7D). The post-abdomen is extremely long and thin (Fig. 7A). The gonads are limited to the cardiac extremity with no more than 10 testis follicles and an ovary containing one large oocyte (Fig. 7E). The larvae are small, the trunk 400  $\mu$ m long. Only one tadpole incubates at a time in the cloacal cavity. It is oval, the tail shorter than a half

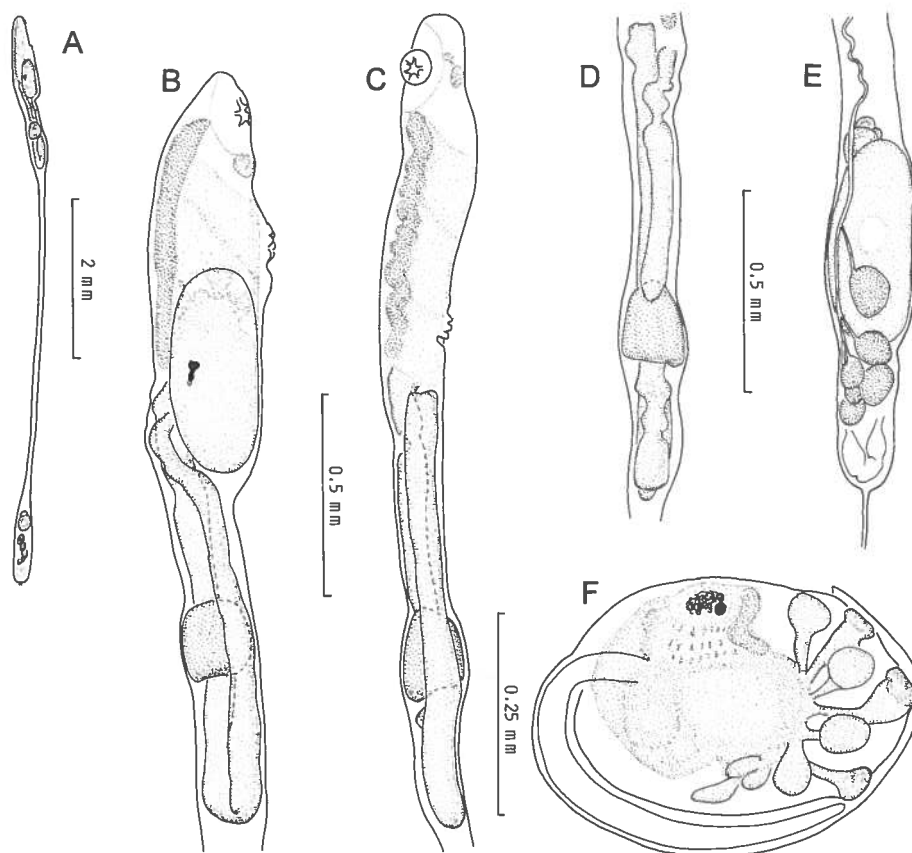


Figure 7. *Pseudodistoma poculum* n. sp.: A, zooid; B, C, thorax and abdomen of different zooids; D, detail of the gut; E, detail of the gonads; F, larva.

perimeter of the trunk (Fig. 7F). There are 3 adhesive papillae and 4 pairs of ectodermal vesicles (Fig. 7F). Ventrally some digitations are also present (Fig. 7F). The sensory vesicle is proportionally large. The branchial sac of the oozoid already has 3 rows of stigmata. In formalin, the tadpoles are pigmented in orange-brown, they were probably red when living.

Remarks: This species differs from all other *Pseudodistoma* species by the colony shape, the deep depressions at the top of the lobes resembling a common cloacal cavity, which does not exist in *Pseudodistoma arborescens* Millar, 1967.

#### Family: Didemnidae

#### *Trididemnum cyclops* Michaelsen, 1921

Synonymy: see Kott, 1980: 10; 1982: 111; Monniot & Monniot, 1987a: 20, fig. 2 c-i; pl. IV g; F. Monniot, 1990: 520, New Caledonia.

Material Examined: MNHN: A2 Tri 106 and A2 Tri 100—Palau, Koror State, Rock Islands, 7°20.19'N; 134°32.12'E, 1 m; Indonesia, north Sulawesi, Manado, 1°34.10'N; 124°47.93'E, 1 m.

The pad-like colonies have varied colors according to the respective abundance of symbiotic unicellular algae and calcareous spicules. Collected on sea grass, *Halimeda* and other algae, this species likes shallow, well lit habitats. It is principally characterized by a short dorsal lobe at the oral siphon and the shape of the tadpole with only 2 adhesive papillae.

Geographic Distribution: This species has a wide distribution in all tropical shallow waters of the Indian, western, and central Pacific Oceans.

*Trididemnum polyorchis* new species

Fig. 8, Fig. 9A, B

Holotype: MNHN: A3 Tri 111—Palau, Koror State, outside Krist reef, 7°10.7'N; 134°22.1'E, 8 m.

Description: The colony was pinkish brown and cream in life, with a "leopard" design, several cm across and 2 mm thick. This species is encrusting, hard to break, with a rounded outline. There are irregular systems of zooids, with oral siphons surrounding small common cloacal apertures. The spicules are crowded throughout the entire tunic except at the uppermost surface layer of the colony which is spicule-free. The cloacal channels are narrow, poorly developed and the colony cannot be delaminated.

The zooids are extremely small, 200  $\mu$ m for the thorax and 300  $\mu$ m for the gut loop. The oral siphon is tubular and narrow (Fig. 8A). The cloacal aperture is sessile and circular and exposes a small part of the dorsal side of the branchial sac. There are 3 rows of stigmata between the anterior and posterior unperforated areas. The lateral thoracic organs form large cups above the second row of stig-

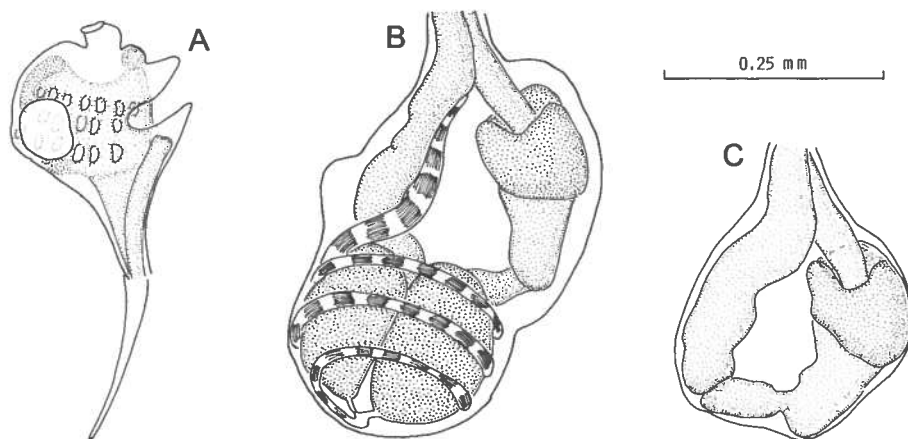


Figure 8. *Trididemnum polyorchis* n. sp.: A, thorax; B, abdomen; C, detail of the gut.

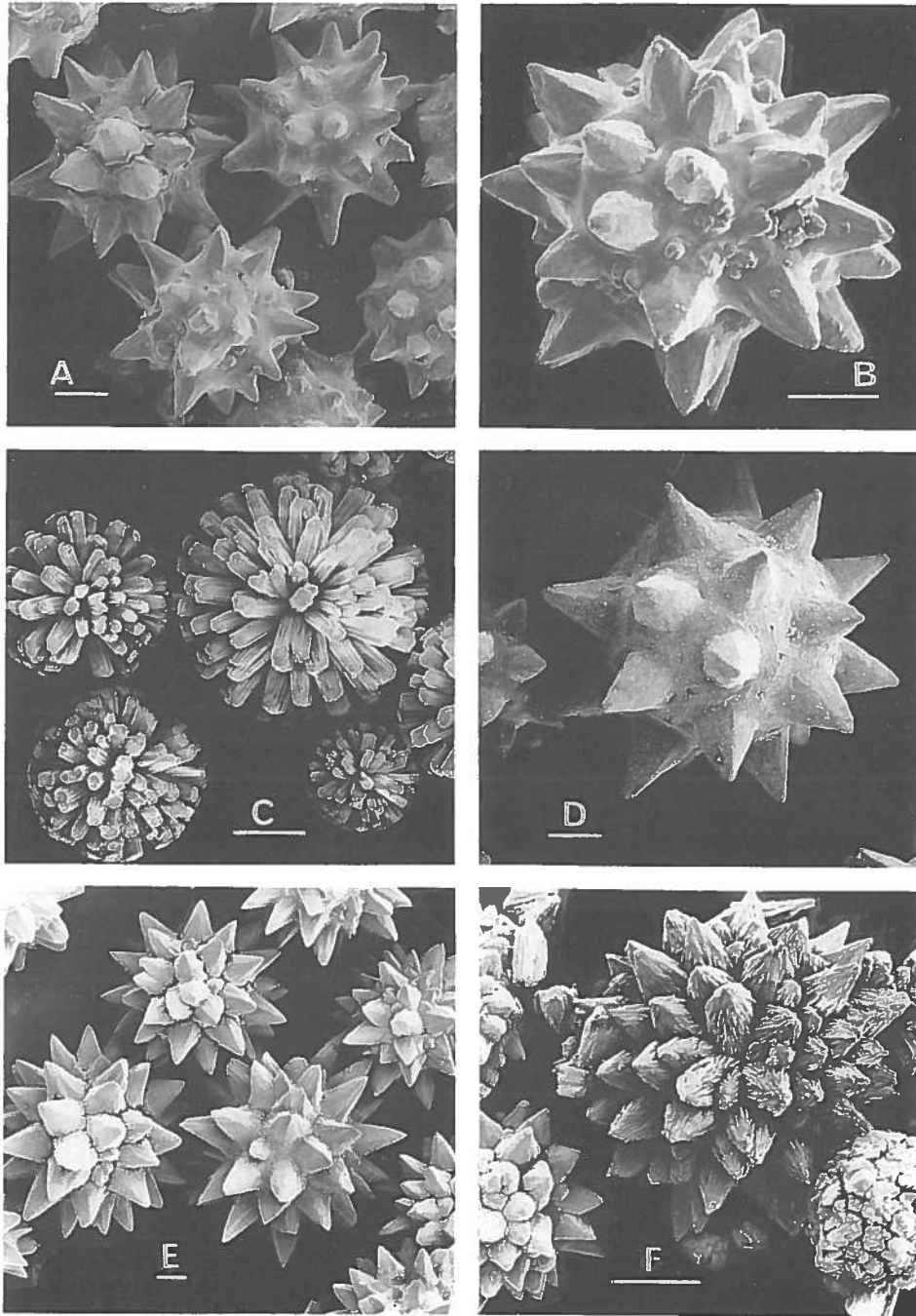


Figure 9. Spicules. A, B, *Trididemnum polyorchis* n. sp. C, *Didemnum biglutinum* Monniot, 1994. D, *Didemnum guttatum* n. sp. E, *Didemnum linguiferum* n. sp. F, *Didemnum nigrum* n. sp. Scale bars: 10 $\mu$ m.

mata (Fig. 8A). The retactor muscle is long. The abdomen lies at a right angle under the thorax. The gut is a wide loop (Fig. 8C). The testis, as large as the gut loop, is made of 2 or sometimes, 3 very protruding follicles, encircled by 3 to 4 loose coils of the sperm duct (Fig. 8B). The ovary was not developed in the studied colony. No larvae were found.

The spicules are rather large compared to the size of the zooids. They have an average diameter of 40  $\mu\text{m}$  and a maximum size of 50  $\mu\text{m}$ . They are star-shaped with numerous short conical rays (Figs. 9A, B).

Remarks: This *Trididemnum*, collected by J. Faulkner's group, is the second species of the genus having more than one testis lobe. *T. vostoki* Romanov, 1989, from Peter the Great Bay, in the Japan Sea, has larger zooids, different spicules and colony shape, and numerous coils of the sperm duct.

*Didemnum apuroto* Monniot & Monniot, 1987  
Pl. 2C

*Didemnum apuroto* Monniot & Monniot, 1987a: 27, Polynesia; F. Monniot, 1995: 300, New Caledonia.

Material Examined: MNHN: A2 Did C 306—Federated States of Micronesia, Chuuk lagoon, 7°22.30'N; 151°50.64'E, 9 m.

The colonies are white, encrusting on ramified bryozoans and algae (Pl. 2C). They are soft, very thin. When fixed the zooids appear as small protuberances at the colony surface. The zooids and larvae are similar to those from Polynesia and New Caledonia, they are very small. The spicules are crowded throughout the thin tunic.

Geographic Distribution: This species described from Polynesia and found in New Caledonia and Micronesia is probably more widespread but it is difficult to distinguish from other white didemnids.

*Didemnum biglutinum* F. Monniot, 1995  
Fig. 9C, Pl. 2D

*Didemnum biglutinum* F. Monniot, 1995: 300, fig. 1, pl. I A and III D; New Caledonia.

Material Examined: MNHN: A2 Did C 295—Palau, Koror State, Rock Islands, Ngerkuul Pass, 7°19.22'N; 134°29.74'E, 10 m.

The colonies are encrusting thin sheets, inflated underwater, of a greenish light grey color, with black spots (Pl. 2D). In formalin they are dark brown. The common cloacal apertures are irregularly raised in chimneys of translucent tunic without pigment cells or spicules. The zooids are in the upper part of the colonies. There is a layer with crowded spicules between the zooid layer and the thin fibrous sheet without spicules against the substratum. The whole tunic is tough, but flexible. The pigment is mostly in irregular specks in the upper part of the tunic.

The zooids are small and difficult to extract from the tunic. The oral siphon is very short with 6 round lobes. The cloacal aperture forms an horizontal slit, as



a result of the contraction. The thoracic organs are round and placed above the third transversal branchial sinus. The retractor muscle is moderately long, beginning close to the posterior end of the endostyle. There are 6 stigmata in a row. The abdomen is folded under the thorax. The gut loop is wide, the stomach is anterior, followed by a post-stomach, mid-intestine and rectum well defined. The spherical testis follicle clearly protrudes from the middle of the gut loop, encircled with 7 to 8 coils of the sperm duct. The ovary is normally placed between the testis and the stomach. The larvae are small, 550  $\mu\text{m}$ . They only have 2 adhesive papillae with thin and long stalks. They have 4 pairs of digitiform ectodermal papillae on each side, the dorsal pair larger than the others. The larva has no buds; its branchial sac is well developed with 3 rows of stigmata. The ocellus and otolith are present. The tail is short, in half a circle around the trunk.

The spicules are small, 33  $\mu\text{m}$  in maximum diameter. They have many acicular rays gathered in balls (Pl. 1C).

Remarks: This species differs from other tropical *Didemnum* by its larva with 2 adhesive papillae and four pairs of ectodermal ampullae. *Didemnum pitipiri* Monniot & Monniot, 1987a has a different color, a large oral siphon, and 6 pairs of ectodermal ampullae in its larva. *Didemnum risirense* Nishikawa, 1990 from Northern Japan has only 3 pairs of larval ectodermal ampullae.

Geographic Distribution: New Caledonia, Palau.

#### *Didemnum fragilis* (Sluiter, 1909)

*Didemnum fragilis* Sluiter, 1909: 56, Malaysia; Monniot & Monniot, 1987a: 30, fig. 8, FH, pl. 1, H, Polynesia; F. Monniot, 1995: 310, New Caledonia.

Material Examined: MNHN: A2 Did C 326—Palau, Koror State, Big Drop-Off, 7°06.8'N; 134°15.6'E, 15–25 m.

This species is bright white, encrusting, soft but with crowded spicules. The zooids have a large thorax with a wide cloacal aperture without a languet. The intestine forms a twisted loop. The larvae have a characteristic appearance; rather large with the trunk about 750  $\mu\text{m}$  long. The 3 adhesive papillae are urn-shaped between 4 pairs of long ectodermal ampullae. The stigmata are developed early in the oozoid. The spicules are made of very numerous needles in balls.

Geographic Distribution: Malaysia, New Caledonia, Polynesia, Palau. The species probably has a wide distribution in the tropical central and western Pacific Ocean, but is difficult to collect.

#### *Didemnum guttatum* new species

Figs. 9D and 10, Pl. 2E

Holotype: MNHN: A2 Did C 229—Indonesia, north Sulawesi, west of Talisei Island, 1°51.87'N; 125°04.08' E., 1 m. MNHN: A2 Did C 279—Papua New Guinea, Eastern Fields Atoll (Coral Sea), 140 km SW of Port Moresby, 10°02.48'S; 145°36.28'E., 23 m.

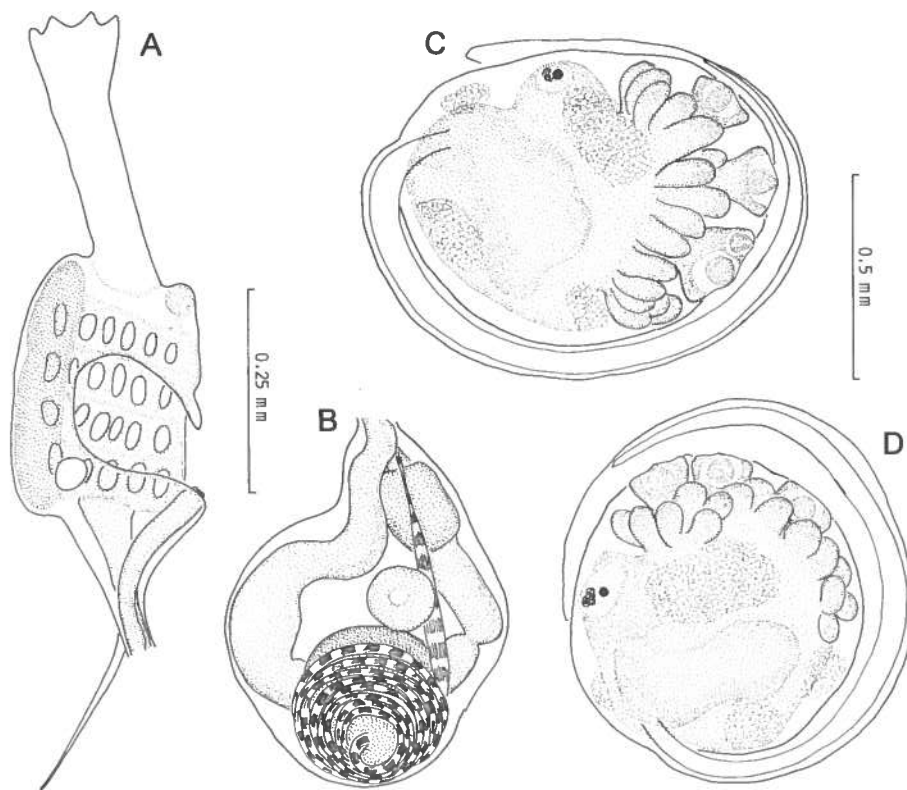


Figure 10. *Didemnum guttatum* n. sp.: A, thorax; B, abdomen; C, D, larvae.

**Description:** The colonies are encrusting, up to 4 mm thick and several centimeters across, with an irregular margin. The surface is marbled and rough. Unicellular green algae were present in patches at the colony surface. The color was white and grey or brown (Pl. 2E). The common cloacal openings are round. The spicules are crowded throughout the test. The zooids are numerous, the cloacal channels are narrow and limited to the thorax level. Abundant dark cells, accumulated in clumps, are present in the deepest part of the colony.

The zooids have a greenish color in formalin. The oral siphon is particularly long, ending in 6 short lobes (Fig. 10A). The cloacal aperture is a transverse slit, its dorsal margin is produced into a short languet (Fig. 10A). There are 6 stigmata in the first of the 4 rows. The thoracic organs are protruding, circular, and placed above the 4th stigmata row, near the endostyle (Fig. 10A). The retractor muscle extends from the posterior extremity of the esophago-rectal neck. The abdomen is not folded under the thorax. The gut loop is wide. The stomach, in a very anterior position, is especially small (Fig. 10B) and the intestine does not exhibit well separated segments. The gonads are in the gut loop, but, when mature, the undivided testis overlaps the mid-intestine (Fig. 10B). It is covered with 7 to 8

coils of the sperm duct. The ovary lies between the testis and the stomach. The larvae are incubated in the test below the zooids, but when mature, they can be found at the colony surface. They are large, some with a trunk 1 mm in length. The tail makes  $\frac{3}{4}$  of the body circle. The tadpoles have characteristic pigment patches justifying the species name (Figs. 10C, D). These pigments are green in formalin. There are 3 odd patches: one dorsal, one round ventral, and one in a crescent under the tail attachment. There is also one patch on each side, posterior to the sensory vesicle. The 3 adhesive papillae are short and wide, circled by a ring of numerous, rather irregular ectodermal ampullae, (Figs. 10C, D). The larvae are not gemmiparous.

The spicules (Fig. 9D) are regular, stellate with a few conical sharp rays arising from a compact center. Their diameter reaches 70  $\mu\text{m}$ .

The main characters of the species are the wrinkled surface, the larval structure, and the pigmentation. Collected at only 1 m depth in Sulawesi, it was partly covered with symbiotic algae, which seemed absent from the colonies found at 23 m in New Guinea.

*Didemnum linguiferum* new species

Figs. 9E, 11

Holotype: MNHN: A2 Did C 307—Indonesia, north Sulawesi, near Manado town.

Description: The colonies are thin, flat, encrusting, about 10 cm in extent and 1 to 2 mm thick. In formalin the surface of the colony is reddish, marbled with white, with star-shaped common cloacal apertures. The pigment is restricted to the surface layer in the tunic, but red cells are abundant in the thorax, especially the branchial sac, and some pigment is also found above the testis. The common cloacal cavities are wide and the colony is easily torn in two sheets at the thoracic level. The spicules are dense throughout the colony.

The zooids have a narrow thorax, that is larger than the abdomen folded under it. The oral siphon is tubular with 6 short lobes (Figs. 11A, B). The oral tentacles are numerous. The cloacal aperture is large, exposing a large part of the branchial sac. A small languet, simple or bifurcated, is located at the upper rim of the opening (Figs. 11A, B). On each side the lateral organs are large lamellae located vertically on the rim of the cloacal aperture at the level of the third row of stigmata (Figs. 11A, B). There are 6 stigmata in the 2 first rows of the branchial sac. The retractor muscle is along the short esophago-rectal waist. The abdomen lies horizontally. The esophagus is very short, so the spherical stomach is located at the beginning of the gut loop. It is followed by the common segments of the intestine found in the genus (Fig. 11C). The intestinal loop is wide and contains a white mass which does not stain with hemalum. The undivided testis lies besides the intestinal loop, its top covered by 5 to 7 turns of the sperm duct (Figs. 11A, D). The larvae reach 800  $\mu\text{m}$  in length. The tail is  $\frac{3}{4}$  the length of the trunk. There are 3 adhesive papillae circled by about 30 elongated ectodermal ampullae

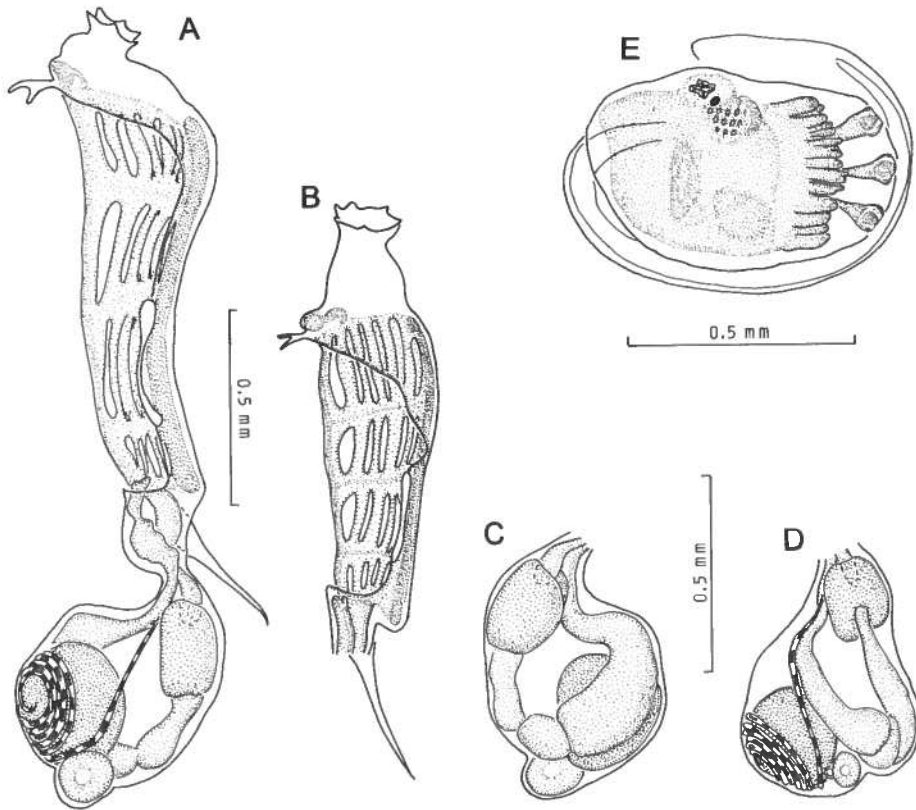


Figure 11. *Didemnum linguiferum* n. sp.: A, zooid; B, thorax of another zooid; C, D, details of the gut; E, larva.

(Fig. 11E). The larva is not gemmiparous. Below the ocellus and otolith, 3 rows of stigmata can be seen.

The spicules (Fig. 9E) are stellate, of a large size up to 80  $\mu$ m, with numerous pyramidal rays.

Remarks: This species differs from other *Didemnum* with a cloacal languet and undivided testis in the following manner. From examination of the type specimens, *D. chartaceum* Sluiter, 1909 and *D. asteropum* (Sluiter, 1895) have spicules with shorter rays and more stigmata in a row. *D. ligulum* F. Monniot, 1983 has more stigmata in a row, different spicules and a gemmiparous larva. *D. misakiense* (Oka & Willey, 1892) has a different colony structure and the larva is not described. *Didemnum obscurum* F. Monniot, 1969 has more stigmata in a row, strong rapheal muscles, fewer epidermal ampullae in the larva and smaller spicules.

*Didemnum molle* (Herdman, 1886)

*Diplosomoides molle* Herdman, 1886: 310, Indonesia.

*Didemnum molle*: Kott, 1980: 2 and 1982: 98 and synonymy, Indo-Pacific; Millar, 1988: 829, Maldives Islands and Madagascar; Lafargue & Vasseur, 1989: 64, Mayotte; F. Monniot, 1995: 316, fig. 10, New Caledonia.

Material Examined: MNHN: A2 Did C 226—Indonesia, north Sulawesi, near Manado, 1°23.50'N; 124°44.60'E, 10 m. Specimens from Seychelles and Vietnam are also present in the MNHN collections.

The colonies always have the same urn shape with a terminal cloacal aperture and secrete abundant mucus. The color is highly variable corresponding to the respective proportions of the spicules, brown pigment cells and symbiotic algae. Larvae are present in the colonies from Sulawesi collected in May. Colonies also contained parasitic copepods and a pontonine shrimp.

Geographic distribution: The species is common from the Indian Ocean to the western Pacific, down to 50 m depth and more. It is generally found in well lit habitats.

*Didemnum moseleyi* (Herdman, 1886)

*Leptoclinum moseleyi* Herdman 1886: 272, Philippines.

*Didemnum moseleyi*: Kott, 1981: 169 and synonymy; Kott & Goodbody, 1982: 520, Hong Kong; Vasseur, 1985: 149, Polynesia; Monniot & Monniot, 1987a: 37, Polynesia; Lafargue & Vasseur, 1989: 64, Mayotte; Nishikawa, 1990: 100, Japan. Material Examined: MNHN: A2 Did C 308—Federated States of Micronesia, Chuuk Lagoon, NW Uman Reef, 7°18.50'N; 151°51.50'E, 25 m.

The pink-red colonies are encrusting, hanging on vertical and overhanging surfaces, appearing to “drip” downward. They are several centimeters across and 1.5 mm thick. The pigment turns light brown in formalin and the colony is tan and white with dark spots made by the oral apertures. The consistency is hard, the colony is brittle, and breaks easily. There are two superimposed layers of tunic densely filled with spicules and separated by wide cloacal channels around elongated thoraces.

The zooids have a wide funnel-like oral siphon with 6 triangular lobes. The cloacal opening is wide, without a languet. The lateral organs are small and located at the postero-ventral corner of the thorax. The branchial sac is wider at the upper side with 6 stigmata in the first half row. The abdomen lies perpendicular to the thorax. The intestinal loop is narrow and curved. The testis is covered with 6 to 7 coils of the sperm duct. The larvae are small, with a length of 400 µm, and some are pigmented at the posterior part of the trunk.

The spicules are stellate with numerous pointed lobes. In addition, much larger spicules with few rays are scattered throughout the colony.

Geographic Distribution: The species is common in the Indo-Pacific.

*Didemnum nigrum* new species

Figs. 9F, 12

Holotype: MNHN: A2 Did C 311—Philippines, Cebu Province, Olongo Island, off Santa Rosa village, 10°15.00'N; 124°01.07'E, 30 m.

Description: The colony has a deep opaque black color in formalin. It is tough, rubbery; the surface is smooth. The common cloacal openings are lobed, their margins without spicules. The colony is irregular in outline, with some parts folded on itself. The maximum length is 12 cm and the maximum thickness 3 mm. The internal structure is peculiar. When sectioned, there is a very thin, soft and black superficial spicule-free layer above a thin spicular layer containing the oral siphons and cloacal languets of the zooids. This hard surface test is separated from the thick basal test by wide common cloacal channels surrounding the thoraces. The abdomens of the zooids lie in the upper part of a thick vesicular and black tunic, totally devoid of spicules. The larvae are present in this layer. Against the substratum, the colony has a continuous thin layer of spicules, similar to the surface layer. The black color of the tunic is diffuse but also is concentrated in small round pigment spots.

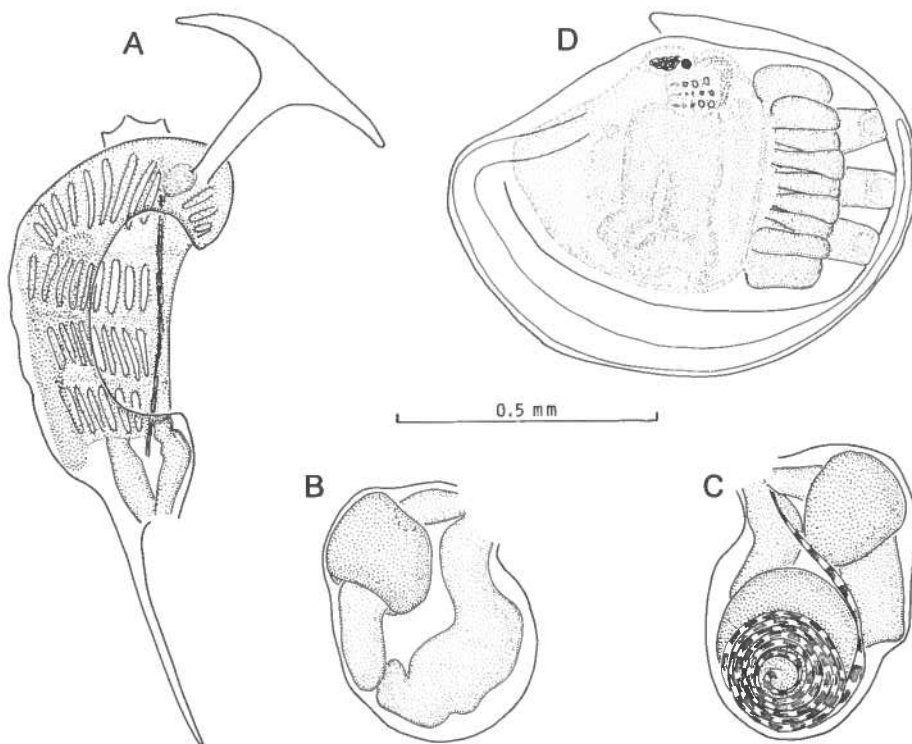


Figure 12. *Didemnum nigrum* n. sp.: A, thorax; B, detail of the gut; C, abdomen; D, larva.

The zooids are difficult to extract from the tunic. The oral siphon is tubular with 6 sharp lobes. The cloacal aperture is wide, uncovering a large part of the branchial sac. T-shaped languets are present in all zooids, larger near the common cloacal apertures (Fig. 12A), with a narrow base and muscular fibers in the large lobes. The lateral thoracic organs are circular, protruding above the 3rd row of stigmata. The branchial sac is black or very dark purple. There are 10 stigmata in the first row, fewer in the others and the whole sac is triangular. Two strong muscular bundles follow the rapheal line (Fig. 12A). The retractor muscle is located along the esophago-rectal waist. The abdomen (Figs. 12B, C) lies at a right angle under the thorax. The body wall, digestive tract and gonads are black. A lighter crescent is seen inside of the intestinal loop on the right side. The testis is large and flat, covered by 6 to 7 turns of the sperm duct (Fig. 12C). The larvae (Fig. 12D) are incubated in the vesicular deepest part of the colony. They are very dark and opaque. The trunk measures 750  $\mu\text{m}$ . There are 3 narrow adhesive papillae on stout peduncles, circled by about 20 ectodermal vesicles. The larva is not gemmiparous.

The spicules (Fig. 9F), distributed in one layer are spherical, 45  $\mu\text{m}$  in diameter, and have many short rays.

*Didemnum parau* Monniot & Monniot, 1987

Fig. 14A, Pl. 2F

*Didemnum parau* Monniot & Monniot, 1987a: 39, fig. 12 A-D, pl. II G

Material Examined: MNHN: A2 Did C 309—Papua New Guinea, Duke of York Islands, Makada Island, 4°06.28'S; 152°25.45'E, 10 m.

The colonies (Pl. 2F) are encrusting, snowy white, rather irregular in outline and inflated under water. The test is entirely filled with spicules but remains flexible. It is pulled off in one sheet as the common cloacal cavity is narrow.

The zooids have the smaller thoraces than abdomens but seemed to be in a resting state in the observed colony. The oral siphon has 6 pointed lobes. The cloacal aperture is narrow, without a languet. The lateral thoracic organs are small, located above the third transverse branchial sinus. The branchial sac contains 6 stigmata in the first two rows, 5 stigmata in the third row, 4 stigmata in the fourth row. The retractor muscle, of a medium size, extends from the esophageal peduncle. The abdomen is almost spherical. The twisted gut loop is included in abundant mesenchymatous tissue. A single testis follicle is developed in only a few zooids, in the primary gut loop. The sperm duct is empty and coiled several times. One larva was found in the deepest layer of the colony. The trunk is 500  $\mu\text{m}$  in length and the tail makes  $\frac{3}{4}$  of a turn around it. There are 3 adhesive papillae with very thin stalks, and 4 pairs of stout ectodermal ampullae. The 3 rows of stigmata are already differentiated. This larva is not gemmiparous.

The spicules are small 30  $\mu\text{m}$ , globular, with crowded radial needle-like rays (Fig. 14A).

Remarks: This description fits very well the typical description of *D. parau* described from Polynesia. The colony is thicker here, but is obviously in a resting

state, the zooids are not feeding. The single larva is somewhat larger but very similar. The spicules are very characteristic.

Geographic Distribution: Known only from Polynesia and Papua New Guinea.

*Didemnum perlucidum* F. Monniot, 1983

Fig. 13, Pl. 2G

*Didemnum perlucidum* F. Monniot, 1983a: 29, fig. 12, pl. IID, Guadeloupe; Monniot, Monniot & Laboute, 1985: 486, Tahiti; Monniot & Monniot, 1987a: 40, Polynesia; F. Monniot, 1995: 321, fig. 14 A,B, pl. IV E, New Caledonia.

Material Examined: MNHN: A2 Did C 228—Indonesia, north Sulawesi, Bangka Island, 1°44.77'N; 125°09.26'E, 1 m.

The colony (Pl. 2G) is large, encrusting, thin but with irregular swellings. The cloacal apertures are wide and round. The zooids are crowded. The colony is rather solid in spite of its brittle appearance due to the extension of the cloacal channels. The superficial layer of the test extends only to the level of the oral siphons. The zooids are inserted in groups in test pillars connecting both sides of the colony. The larvae are incubated in the thin basal test layer.

The zooids have a long thorax, but the oral siphon is wide and short with 6 sharp lobes (Fig. 13A). The cloacal aperture is large exposing most of the branchial sac (Fig. 13A). The body wall covers only the oral area and the endostyle. The anus is not covered by the posterior part of the body wall. The lateral thoracic organs are horizontal, below the level of the fourth row of stigmata (Fig. 13A). The stigmata are elongated, 6 to 8 were counted in the first row. The retractor muscle is thin and long (Fig. 13A). The gut loop forms a folded loop. The unique testis follicle is circled by 7 to 8 coils of the sperm duct (Fig. 13B). The larvae measure about 500 µm in length. The 3 well separated adhesive papillae are lined by 4 long divergent ectodermal vesicles on each side. The 3 rows of stigmata are differentiated in early stages of development of oozoids (Fig. 13C).

The spicules have a regular stellate shape with few conical rays.

Geographic Distribution: The origin of *D. perlucidum* is unknown. It is a fouling species that colonized many harbors in the Atlantic (Brazil, West Indies, Senegal) as well as the Indian Ocean (Maldiv Islands, Zanzibar), and the Pacific (New Caledonia, Polynesia) and now Indonesia.

*Didemnum poecilomorpha* new species

Figs. 14B, 15, Pl. 2H

*Didemnum viride*: Kott, 1982: 101 fig. 3–5, Palau, Philippines.

Holotype: MNHN: A2 Did C 230—Indonesia, north Sulawesi, west side of Talisei Island, 1°51.52'N; 125°03.84'E, 40 m. MNHN: A2 Did C 264—Palau, Ngerong, 7°06.90'N; 134°22.78'E, 12 m.

Description: The colonies form large encrusting sheets, of 3 mm maximum thickness, with a brown and white mottled surface, a design reminiscent of a thin



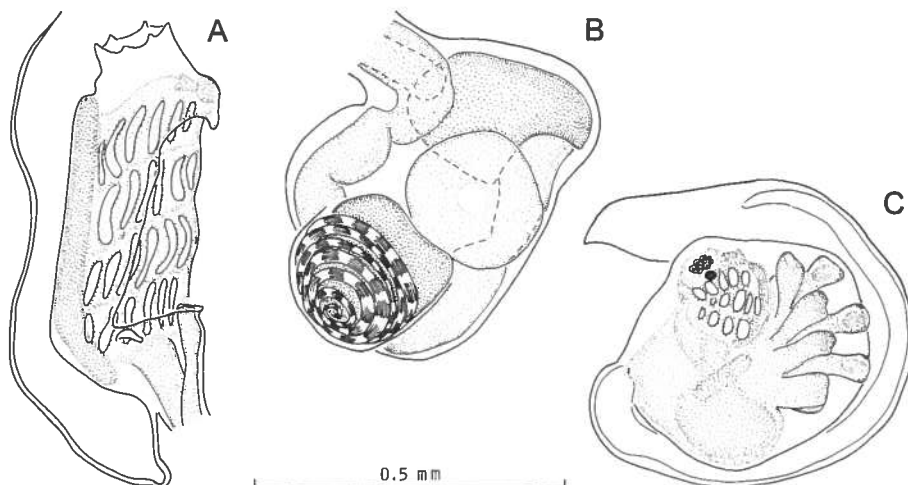


Figure 13. *Didemnum perlucidum* F. Monniot, 1983: A, thorax; B, abdomen; C, larva.

veinous network, giving the specific name (Pl. 2H). In formalin the color turned greenish and faded. The surface design is very similar to that of *Didemnum guttatum* n. sp. Unicellular algae are embedded in the superficial layer of the test. Dark green inclusions are scattered in the deepest part of the colonies. The colonies are tough as a result of the narrow cloacal canals, restricted to the thoracic level, in a dense spicular tunic.

The zooids are small, with a maximum length of 500  $\mu$ m for the thorax and 300  $\mu$ m for the abdomen. The oral aperture is tubular with 6 pointed lobes. The cloacal aperture is narrow (Figs. 15A, D, E). The thoracic organs are protruding, located above the third transverse sinus, close to the endostyle in fully developed zooids (Fig. 15E). The branchial sac has 6 stigmata in the 2 first rows. The esophago-rectal waist is long and the retractor muscle becomes isolated at its posterior part. The digestive loop is wide, not bent, with a small anterior stomach (Figs. 15B, F). A dark pigmented crescent lies inside the loop. The testis is spherical above the mid intestine and covered by 6 to 9 coils of the sperm duct (Figs. 15B, F). The larvae are very characteristic. They are almost spherical. The trunk, 680  $\mu$ m in length, is coated with symbiotic unicellular algae all around the trunk, except just above the sensory vesicle, and in the front part above the adhesive papillae (Fig. 15G). With its 3 adhesive papillae and 6 pairs of digitiform ampullae, the anterior part of the larva is separated from the oozooid body by a strong constriction (Fig. 15C). There is no rastrum with symbiotic algae, and no buds.

The spicules (Fig. 14B) are crowded throughout the test. They have numerous short pointed rays. Their shape is very uniform throughout the colony and the average diameter is 55  $\mu$ m.

Remarks: Kott (1982) examined specimens from Palau and Philippines which she identified as *Didemnum viride* (Herdman, 1906), however her specimens are

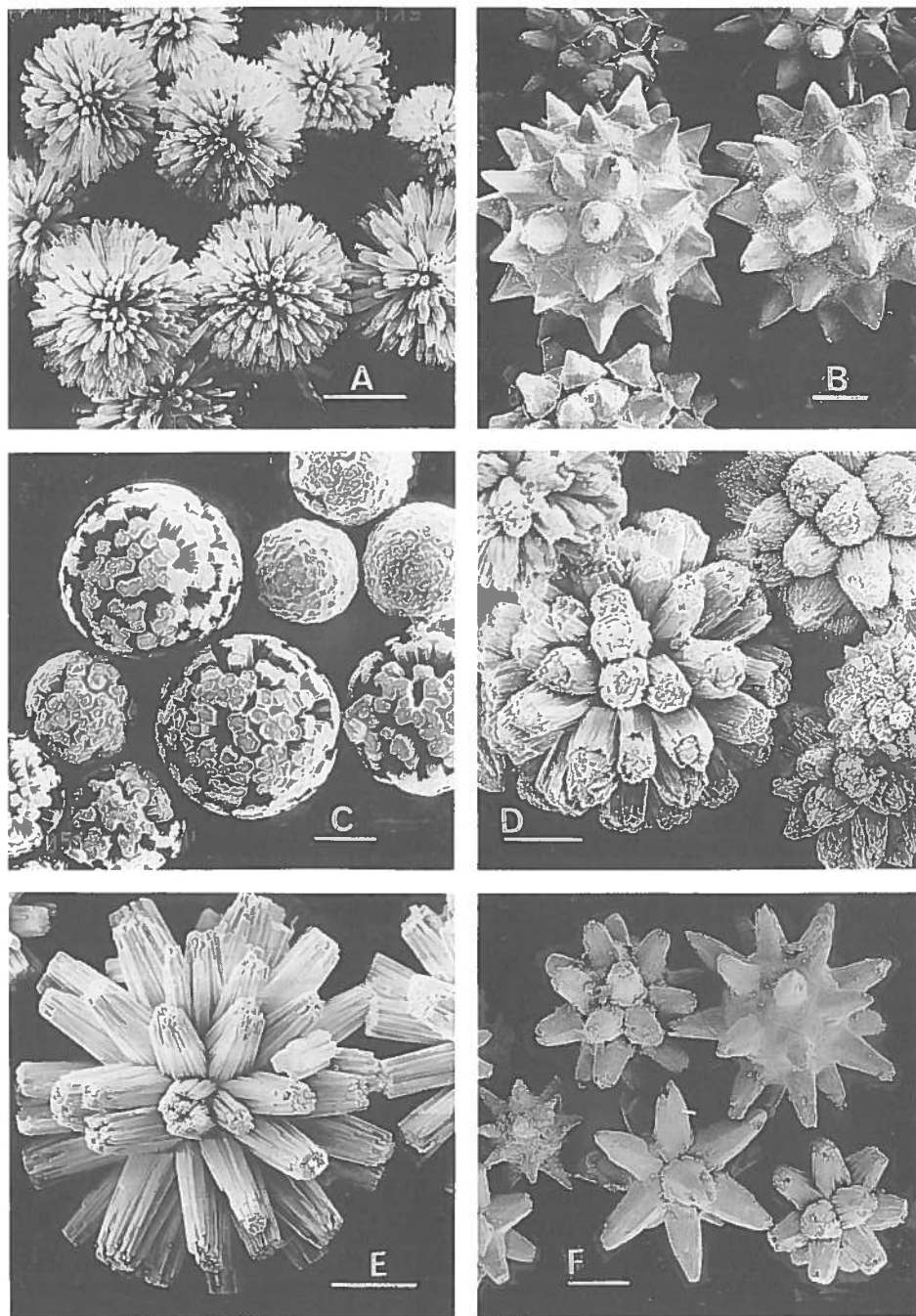


Figure 14. Spicules. A, *Didemnum parau* Monniot & Monniot, 1987. B, *Didemnum poecilomorpha* n. sp. C, *Didemnum rubeum* n. sp. D, *Didemnum stercoratum* n. sp. E, *Didemnum* sp. A. F, *Didemnum* sp. B. Scale bars: 10 $\mu$ m.

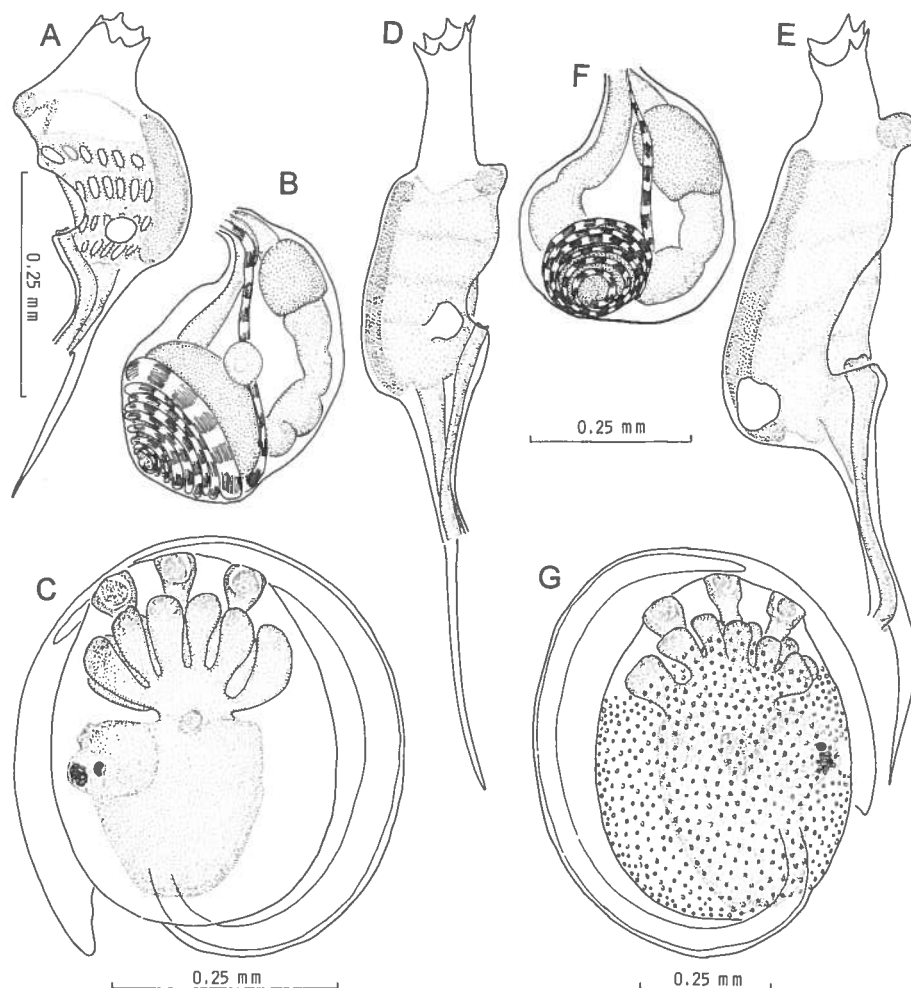


Figure 15. *Didemnum poecilomorpha* n. sp.: A, B, thorax and abdomen; C, larva in the same colony (symbionts not figured); D, E, F, thoraces and abdomen in another colony; G, larva

similar to *Didemnum poecilomorpha*. We have examined, on loan from the British Museum, the type specimen of *D. viride* from Ceylon. Its characters are very similar to the specimens of *D. viride* that we examined from Polynesia, but are quite different from Kott's specimens.

*Didemnum psammathodes* (Sluiter, 1895)

Synonymy: see F. Monniot, 1995: 324, New Caledonia

Material Examined: MNHN: A2 Did C 267—Papua New Guinea, Port Moresby, Bootless Inlet, north of Motupore Island, 9°30.86'S; 147°16.63'E, 10 m.

The colonies are grey, encrusting, with fecal pellets incorporated in the tunic and few spicules. The zooids have the same morphology as in other specimens from different oceans and the larvae are the same.

Geographic Distribution: This fouling species is widely distributed in all warm seas of all oceans.

***Didemnum rubeum* new species**

Figs. 14C, 16, Pl. 3A

Holotype: MNHN :A2 Did C 296—Federated States of Micronesia, Chuuk Atoll, Anaw Channel (channel through barrier reef on North Side of atoll), 7°34.09'N; 151°40.66'E, 10 m.

MNHN: A2 Did C 297 and 298- Palau, Rock Islands, Ngerkuul Pass, 7°19.22'N; 134°29.74'E, and Airai Channel, 7°21.03'N; 134°30.95'E, 10 m.

Description: The living colonies are bright red or pinkish red, encrusting rocks in large sheets reaching 20 cm across and 2 to 5 mm in thickness (Pl. 3A). Under water they are inflated, with regular swellings on the surface with terminal common cloacal apertures. The colonies are white inside, resulting from the densely packed spicules, especially in the basal layer against the substratum. The colonies contract when touched. This is due to the very large common cloacal cavity extending at the level of the thoraces.

The superficial layer of the tunic containing the unicellular symbiotic algae and the zooids themselves turn green in formalin. The zooids are large and per-

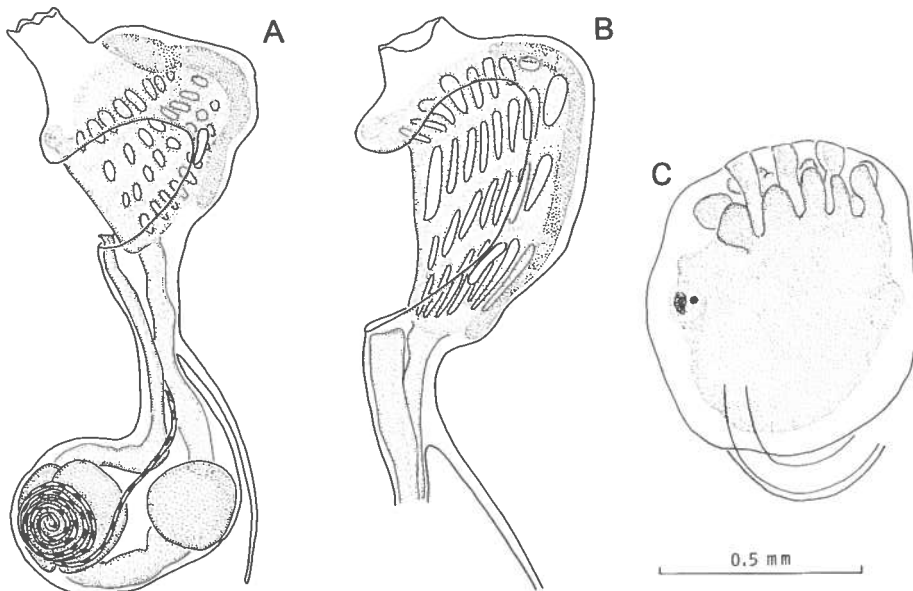


Figure 16. *Didemnum rubeum* n. sp.: A, zooid; B, thorax; C, larva.

pendicular to the colony surface. The oral siphon is short with 6 lobes. The cloacal aperture is wide, without a languet (Figs. 16A, B), except for a small prolongment of the upper part of the siphon in zooids encircling the common cloacal apertures. The lateral thoracic organs are near the rim of the cloacal aperture between the 3rd and 4th rows of stigmata (Figs. 16A, B). The retractor muscle is long and stout (Fig. 16A). The branchial sac has 8 stigmata in the first row (Figs. 16A, B). The abdomen is not folded under the thorax (Fig. 16A). The digestive loop has no secondary curve. The gonads are located on the gut loop. The two testis follicles are very close to each other (Fig. 16A), this is difficult to see without staining. They are encircled by 6 coils of the sperm duct. The ovary is located on the side of the testis. The larvae (Fig. 16C) are incubated in the dense layer of the tunic below the zooid level. They are deeply pigmented and their structure is difficult to observe. They have 3 adhesive papillae and 4 ectodermal ampullae on each side, with an irregular outline. These larvae are not completely developed and it is possible that the ectodermal ampullae divide later.

The spicules (Fig. 14C) of variable sizes appear spherical as they are made of crowded flat ended rays of equal length. The largest diameter is about 30  $\mu\text{m}$ .

Dark pigment cells are scattered everywhere among the spicules in the tunic.

This species differs from all other *Didemnum* species with two testes by the presence of reddish symbiotic algae and the deeply pigmented larva, as well as by the structure of the colony with common cloacal openings at the top of surface swellings.

***Didemnum stercoratum* new species**

Figs. 14D, 17, Pl. 3B

Holotype: MNHN: A2 Did C 313—Philippines, Cebu, Mactan Island, Magellan Bay, 10°18.71'N; 124°00.72'E, 1 m.

Description: The colonies form thin crusts 2 mm thick and several centimeters across, around mangrove roots or on sea weeds. The color is cream, tan or yellow in life (Pl. 3B), white in formalin. They are soft and flexible. The surface is divided into many polygonal areas by deep furrows as in a pavement. The oral apertures are located on each side of the furrows and sometimes on the elevated areas. The spicules are crowded in the upper layer of the colony containing the thoraces and less numerous in the abdominal layer with a few in the basal test that contains abundant fecal pellets (hence the species name). The cloacal canals are well developed around groups of thoraces.

The zooids have a long thorax when relaxed and the abdomen is at a right angle. The oral siphon is wide, long, with 6 triangular lobes (Fig. 17A). The cloacal aperture is large, without languet; it does not uncover the entire branchial sac (Figs. 17A, B). The lateral thoracic organs are protruding small round lamellae at the level of the third transverse sinus (Figs. 17A,B). The branchial sac has 6 long stigmata in the first two rows, 5 in the third, 4 in the fourth row. Rapheal muscles are present (Fig. 17B). The esophago-rectal waist is long and has a retractor muscle longer than the thorax. The abdomens lie horizontally under the

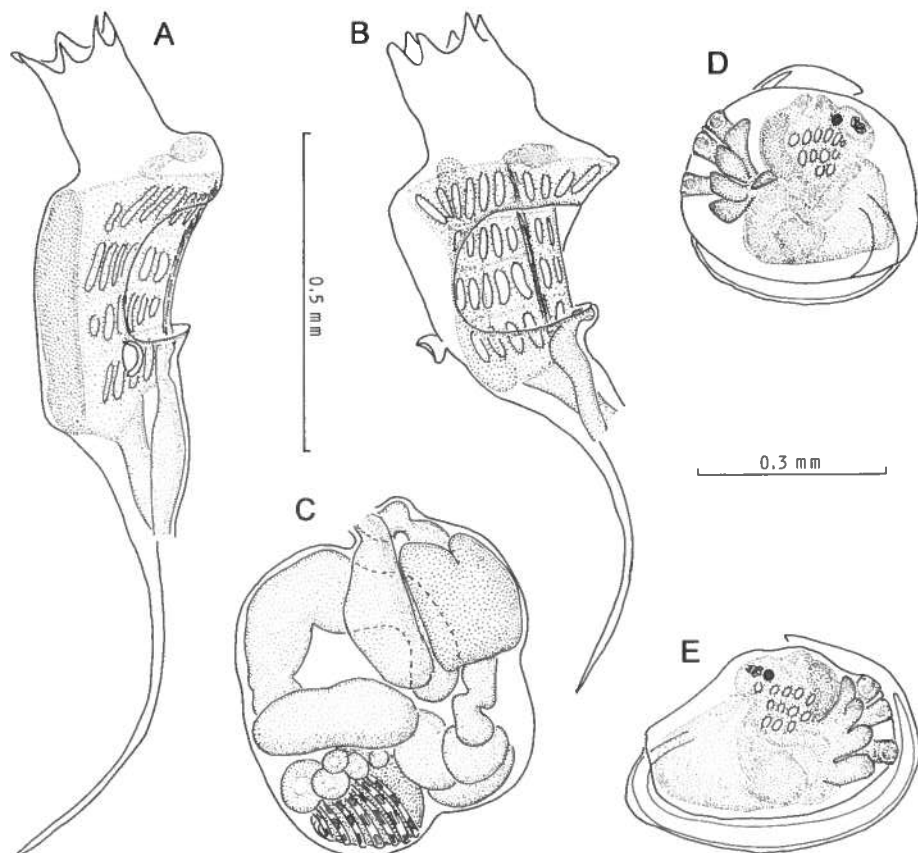


Figure 17. *Didemnum stercoratum* n. sp.: A, B, thoraxes; C, abdomen; D, E, larvae.

common cloacal cavity. The intestinal segments are not well defined, except the stomach, and the intestine loop is folded (Fig. 17C). The single testis is in the intestinal loop and covered with 5 to 7 coils of the sperm duct (Fig. 17C). The ovary is against the testis. The larvae (Figs. 17D, E) are incubated in the abdominal layer of the colony. They are small, 0.4 mm with 3 adhesive papillae and 4 pairs of ectodermal ampullae, and separated from the oozoid by a constriction. Ocellus and otolith are present above the branchial sac that already has 3 rows of stigmata. The gut is also partially differentiated and horizontal. The larvae are not gemmiparous.

The spicules are stellate, made of numerous fused needles. Their diameter can reach 40  $\mu$ m (Fig. 14D).

Remarks: Macroscopically, this species resembles of *Didemnum perlucidum* F. Monniot, 1983, but is more opaque and colored. It differs by several anatomical characters including the spicule shape, the lateral thoracic organs, the shape of the gut, and the presence of abundant fecal pellets in the basal tunic.

*Didemnum psammathodes* also has abundant fecal pellets, but they are distributed throughout the colony. Its spicules are rare and different from the present species.

*Didemnum* sp. A

Fig. 14E

Material Examined: MNHN: A2 Did C 305—Federated States of Micronesia, Chuuk State, Kuop Atoll, 7°00.10'N; 151°56.20'E, 30 m.

The colony is pink, several centimeters in length, and encrusting branches of black coral. The surface is smooth and shiny, oral or common cloacal apertures could not be seen. The colony is brittle, densely filled with small spicules, but not very hard. The common cloacal channels are narrow, limited to the thoracic level.

The zooids are small, they are mature with testis and ovary, but the guts are empty and the thoraces seem to be aged buds. The oral siphon is short with only scalloped fringing lobes. The cloacal siphon is circular, either sessile or sometimes produced into a short tube. The branchial sac has 10 oval stigmata in the first row on each side. The lateral thoracic organs were not seen. The retractor muscle parts from the anterior part of the esophago-rectal waist. The gut forms a twisted, narrow, short loop. There is an undivided testis at the side of the gut circled by 7 coils of the sperm duct. The ovary lies between the testis and the stomach. On the right side of the abdomen, in the gut loop, is a dark crescent. Only one well developed larva was observed, located in the basal part of the colony. It has 3, well separated adhesive papillae and 4 pairs of ectodermal ampullae. It is not gemmiparous. The thorax is well developed with 3 rows of stigmata.

The spicules, small and crowded everywhere, with an average diameter of 40  $\mu$ m (Fig. 14E), are spheres made of rod-like rays.

It is surprising to find in a rather large colony such numerous mature zooids that do not seem to feed. If the thoraces look like buds, there were no remaining old thoraces and no abdominal buds. More material would be necessary to find out whether the thoracic structure described here is the normal adult one and if this is the case, it will be a new species.

*Didemnum* sp. B

Fig. 14F, Pl. 3C

Material Examined: MNHN: A2 Did C 303—Philippines, Cebu, south east Mac-tan Island, underwater cave, 10°15.62'N; 123°59.11'E, 10 m.

This ascidian is encrusting, bright orange at the surface with white rings around the common cloacal apertures (Pl. 3C). The colony is 1.5 mm thick in formalin, but is inflated underwater. Under the microscope, the surface layer does not have dense spicules, as are found throughout the remainder of the tunic, but rather small groups of spicules which give a spotted aspect. The oral apertures are visible as white spots. The colonies are easily removed from the substrate. The

common cloacal cavities are wide and the colonies are easily split in two at the thoracic level.

The zooids are large. The oral siphon is wide, cylindrical, with 6 triangular sharp lobes. The cloacal aperture is wide, with no languet, but does not uncover the whole branchial sac. The lateral thoracic organs are protruding at the level of the 3rd transverse sinus. The branchial sac is wide with 8 to 10 stigmata in the first row and 8 stigmata in the posterior rows. The retractor muscle is long, inserted anteriorly along a very long esophago-rectal peduncle. The abdomen lies at a right angle to the thorax. The primary loop of the intestine contains the gonads: a large testis with 7 coils of the sperm duct and, aside, the ovary with one large oocyte. No mature larvae were found in the colony studied.

The spicules reach 40  $\mu\text{m}$  in diameter, they are stellate with few long pointed rays (Fig. 14F).

Remarks: No described species allies all characters grouped here, such as small groups of spicules in the superficial spicular layer, a large number of stigmata, and a long esophago-rectal waist. But due to the absence of larvae and only one colony observed, the species cannot be named.

*Diplosoma multitestis* new species

Fig. 18, Pl. 3D

Holotype MNHN: A2 Dip A 109—Papua New Guinea, Eastern Fields Atoll (Coral Sea), 140 km southwest of Port Moresby, 10°00.66'S; 145°39.90'E, 20 m.

Description: The translucent colonies appear blue underwater with white rings around the oral apertures (Pl. 3D). The colonies are inflated, with few large common cloacal apertures. They form 10 cm patches. The colorless but more opaque zooids are slightly visible. The consistency of the tunic is jelly-like. The type colony forms a cushion of 45 mm in diameter and 20 mm in thickness. It has 3 common cloacal openings.

The zooids are large, at least 2 mm for the thorax and 1 mm for the abdomen, this size varying with the size of the gonads. The oral siphon remains opaque white in formalin. This is due to very dense micropapillae. The remaining body wall is totally transparent. At the rim of the oral siphon are 6 denticles (Fig. 18A), sometimes 7 or 8, often missing. The tentacles are numerous, at least 24, in 3 orders of size. The cloacal siphon is narrow, circled by a ring of muscles; it is located either in the middle of the thorax (Fig. 18A) or at its base, in front of the fourth row of stigmata. There is a large anterior unperforated area in the branchial sac (Fig. 18A). The stigmata are long, numerous, with an average of 25 in the first row. The endostyle is narrow. The esophago-rectal waist is short and narrow, without retractor muscle (Fig. 18A). The base of the thorax is straight. The abdomen is much smaller than the thorax which is folded under it (Fig. 18A). The gut loop is wide with a tubular esophagus, a cordiform stomach (Figs. 18B, C, D), posteriorly prolonged in a enlarged post-stomach. The olive shaped mid-intestine extends, after a constriction into an enlarged rectum without caeca separated by a constriction from the tubular rectum. The anus is bilabiate (Figs. 18B,



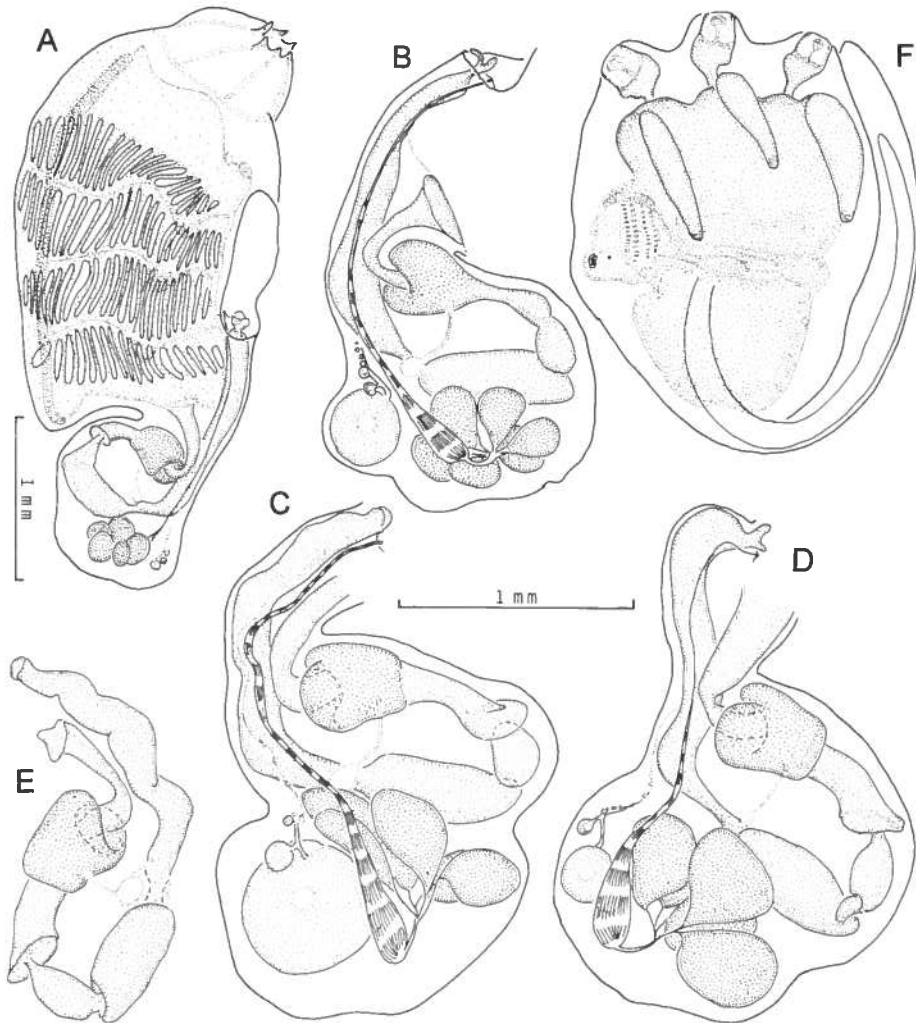


Figure 18. *Diplosoma multitestis* n. sp.: A, thorax; B, C, D, abdomens; E, detail of the gut; F, larva.

C, D). The pyloric gland tubules converge to an ampulla against the intestine, connected to the stomach by a long duct crossing the gut loop (Fig. 18E). The gonads are not located inside the gut loop but in a pouch of the abdominal body wall. The testis follicles, from 5 to 7, are arranged in an irregular rosette (Figs. 18B, C, D). The sperm duct is straight and opens against the anus (Figs. 18B, C, D). When the testis is well developed, the ovary is small with few oocytes, located between the testis and the rectum. Only one large oocyte matures at a time. The embryos develop in the basal layer of the colony. The tadpoles (Fig. 18F) are colorless, with a large (2 mm) trunk. The tail is a quarter of the body circle. The 3 anterior adhesive papillae are well separated. Three long ectodermal papillae

are folded backwards on each side. The sensory vesicle contains an ocellus and otolith. The branchial sac of the oozoid is well developed with 4 rows of stigmata. The embryonic abdomen is elongated between a large anterior ball like structure, bearing the papillae and another spherical posterior vesicle in which the tail is inserted. The larva is not gemmiparous. There are no symbiotic algae in this species.

Remarks: This new species differs from *Diplosoma multifidum* (Sluiter, 1909) by the colony systems, the large number of stigmata and the absence of pigment cells. It also differs from *D. multifidum* Millar, 1975, which has a large cloacal opening and a much smaller, gemmiparous larva.

*Diplosoma similis* (Sluiter, 1909)

Material Examined: MNHN: A2 Dip A 103—Indonesia, north Sulawesi, 1°45.10'N; 124°58.87'E, 8 m.

This ascidian was found in soft thin crusts on *Acropora* corals. The color is typically green with an intense blue glint. It is strongly adherent to the substrate and brittle. It mostly inhabits shallow bottoms, less than 10 meters deep. The colonies from Manado did not have larvae, but they are never frequent in this species.

Geographic Distribution: The species is distributed across all the Indian, and the western and central Pacific Oceans.

*Diplosoma virens* (Hartmeyer, 1909)

*Leptoclinum virens* Hartmeyer, 1909: 1456, n. nov. for *Diplosoma viride* Herdman, 1906.

*Diplosoma virens*: synonymy: Kott, 1980: 22 and synonymy; Kott, 1981: 193; 1982: 114; Vasseur, 1985: 151; Lafargue & Vasseur, 1989: 64; F. Monniot, 1994: 10, New Caledonia

Material Examined: MNHN: A2 Dip A 105—Palau, Koror State, Rock Islands, saltwater river, 7°14.67'N; 134°24.43'E, 1 m.

Geographic Distribution: This species is widespread in the tropical Indo Pacific Ocean, extending to Natal.

*D. virens* had mature colonies in July in Palau.

*Lissoclinum badium* new species

Figs. 19A, B, 20A, Pl. 3E

Holotype: MNHN: A2 Lis A 109—Papua New Guinea, Eastern Fields Atoll (Coral Sea), 140 km southwest of Port Moresby, 10°01.47'S; 145°38.49'E, 10 m. MNHN: A2 Lis A 107—Palau, Channel, 7°17.5'N; 134°27.8'E.

Description: The colonies are yellow and brown exteriorly, white internally in the basal part. The surface has large swellings at the top of which are very wide common cloacal apertures (Pl. 3E). The oral apertures are seen as dark brown

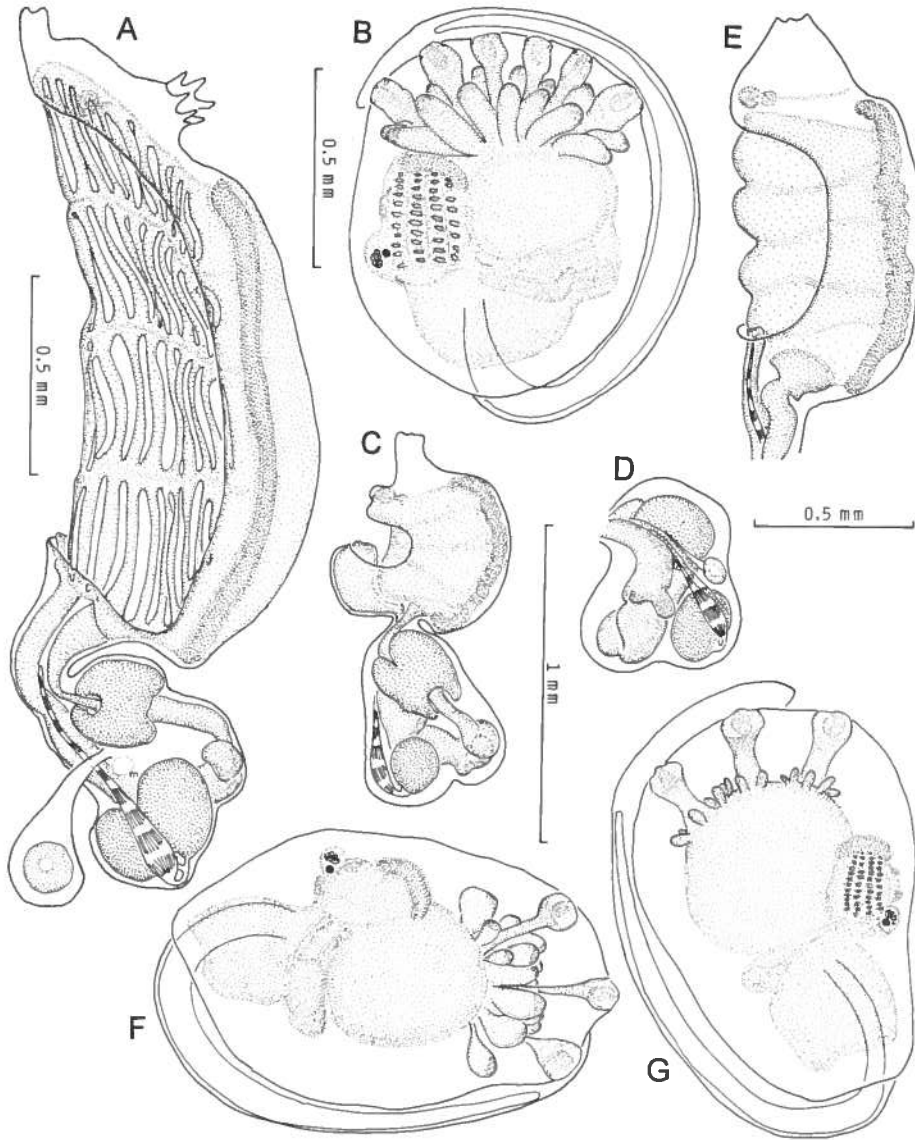


Figure 19. *Lissoclinum badium* n. sp.: A, zooid; B, larva. *Lissoclinum nebulosum* n. sp.: C, zooid; D, gonads; E, thorax; F, G, larvae.

spots. The upper part of the colony is soft and inflated, the basal layer is harder, with crowded spicules. The cloacal channels are wide and the zooids are arranged in groups in pillars of tunic. The larvae are incubated in the upper layer of the hard basal part. The zooids are deeply pigmented dark brown.

The zooids (Fig. 19A) are large (more than 2 mm) and very difficult to extract from the tunic. The oral siphon is short with 6 lobes. The cloacal aperture is wide

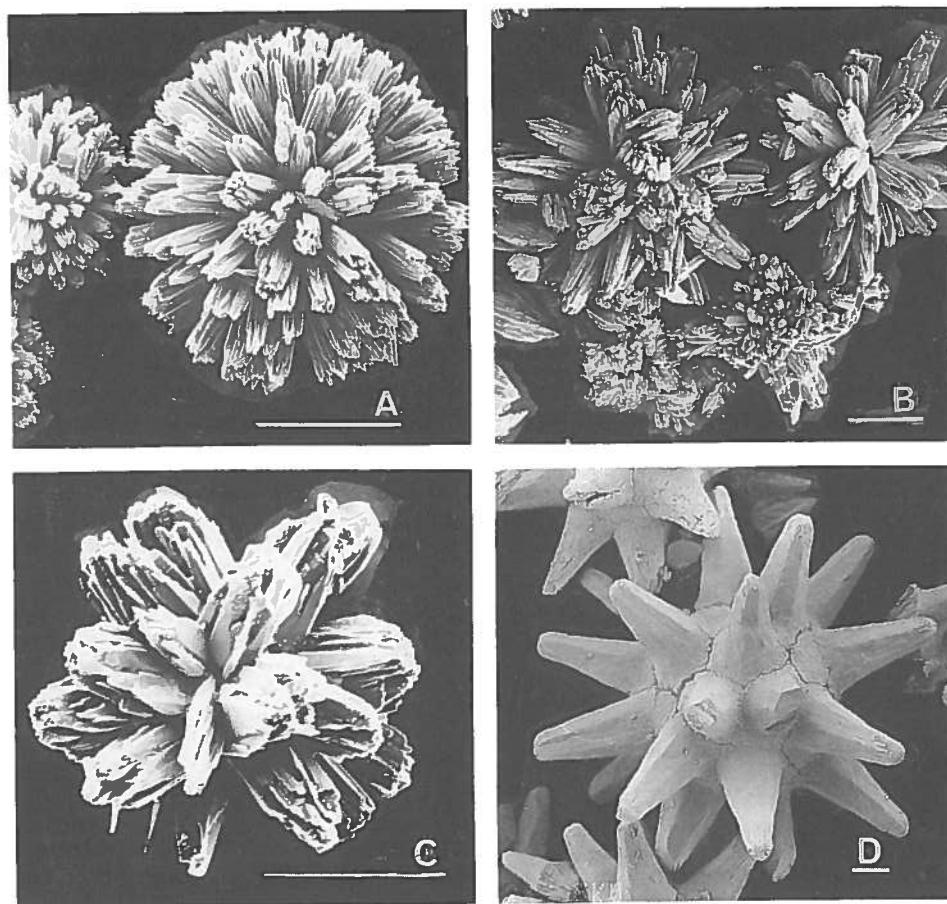


Figure 20. Spicules. A, *Lissoclinum badium* n. sp. B, *Lissoclinum nebulosum* n. sp. C, *Lissoclinum tunicatum* n. sp. D, *Atriolum quadratum* n. sp. Scale bars: 10µm.

(Fig. 19A). A very small languet is inserted at its upper rim, close to the neural ganglion. The thorax is long with 10 stigmata in the first row. The lateral thoracic organs are small near the edge of the cloacal aperture, close to the endostyle. The body wall and the branchial tissue, as the abdomen, are invaded by large brown pigment cells. The esophago-rectal waist is short, without a retractor muscle (Fig. 19A). The gut is divided into several compartments, with a spherical stomach. The testis lies against the gut loop with 2 follicles (Fig. 19A). The spermduct is straight. The larvae are almost spherical, 1 mm for the trunk. There is a ring of 5 to 9 adhesive papillae and the same number plus one ectodermal ampullae on each side (Fig. 19B). The branchial sac already has 4 rows of stigmata, and the gut, located vertically between 2 large vesicles (Fig. 19B). The larvae are not gemmiparous.

The spicules are small balls of numerous radially arranged needles (Fig. 20), the largest are 35  $\mu\text{m}$ . This species has a raspberry smell, noted by the collectors.

Remarks: *Lissoclinum japonicum* Tokioka, 1958 has similar larvae with numerous adhesive papillae, and 2 testis follicles in the abdomen. It differs from the present species by the absence of a small cloacal languet, the shape and the color of the colonies.

*Lissoclinum nebulosum* new species

Figs. 19C-G, 20B, Pl. 3F

Holotype: MNHN: A2 Lis A 118—Federated States of Micronesia, Chuuk Lagoon, Polle Island, 7°21.54'N; 151°35.63'E, 10–30 m. MNHN: A2 Lis A 119—other specimen.

Description: The colonies are soft, fleshy, encrusting sheets several centimeters across and about 4 mm thick. The color varies from grey to brown, irregularly marbled with white, giving a cloudy aspect (Pl. 3F) (suggested in the species name). The white patches, mostly around the zooids, are the result of a spicule accumulation, either immediately below the colony surface or deeper in the tunic. Spicules are in thick masses or only in capsules around the zooids and larvae. The common cloacal openings are large at the junction of the wide cloacal channels. The zooids and larvae are orange in formalin, this color progressively fades. The superficial layer of the colonies is jelly-like, the deepest parts of the tunic are fibrous and difficult to tear off.

In the more relaxed zooids, the thorax is 2 times longer than the abdomen, which lies perpendicular to it. The oral siphon has 6, very small pointed lobes (Fig. 19E), but no sphincter. The cloacal aperture is large and exposes a large part of the branchial sac. 24 oral tentacles are inserted on a ring. The lateral thoracic organs form transverse hollows in front of the second transverse branchial sinus. The branchial sac extends down the entire length of the thorax (Figs. 19C, E) with 12 stigmata in the first row. There is no muscular thoracic appendage. The abdomen is folded under the thorax. It is flat in the absence of gonads. When mature, the single testis is prominently protruding on the side of the gut loop (Figs. 19C, D). The sperm duct arises from the middle of the testis and follows the rectum. The ovary develops against the sperm duct, anteriorly to the testis. The eggs migrate posteriorly, to achieve their development isolated in the tunic, below the abdomen. The young embryos are rapidly enclosed in a spicular capsule. The tadpoles are large, up to 1.3 mm for the trunk. The 3 long adhesive papillae are widely separated extending from a large yolky vesicle. They are each surrounded at their base by a ring of ectodermal short ampullae (Figs. 19F, G). The number of these papillae varies in different larvae, from 18 to 20, and are irregularly spaced. The 4 rows of stigmata are already developed in the tadpoles and the gut is elongated between the anterior yolky vesicle and a clear posterior vesicle from which emerges the tail. The larva is not gemmiparous.

The spicules (Fig. 20B) are 55  $\mu\text{m}$  in maximum diameter, all sizes mixed. They consist of numerous needles; the length of the rays is not always equal.

Remarks: This new species, without symbiotic algae, differs from other *Lissoclinum* in having an undivided testis, no atrial languet and no retractor muscle, a larva that is not gemmiparous and a different arrangement of the larval papillae. The structure of the colony is also characteristic. It differs from the white *L. taratara* Monniot & Monniot, 1987, which has very peculiar spicules.

The type specimen of *Lissoclinum triangulum* (Sluiter, 1909) also has spicular capsules around the zooids and larvae, and a more angular but similar structure of the spicules. Nevertheless, the shape of the gut segments is different, and the tadpoles have fewer ectodermal ampullae and a body wall with large vesicular cells that do not exist in the species studied here.

*Lissoclinum patella* (Gottschaldt, 1898)

*Didemnooides patella* Gottschaldt, 1898: 653.

*Lissoclinum patellum*: Kott, 1980: 18 and synonymy.

*Lissoclinum patella*: Kott, 1982: 113; Monniot & Monniot, 1987a: 50, Polynesia; F. Monniot, 1992: 572, New Caledonia.

Material Examined: MNHN: A2 Lis A 104, 108, 105—Palau: Ngerong, 7°06.90'N; 134°22.78'E, 10 m; Ngercheu, 7°05.39'N; 134°16.24'E, 0.5 m; Rock Islands, Big Arch Lake, 7°15.81'E; 134°24.91'E, 1 m.

Geographic Distribution: This species is very common in tropical areas of the Indian and Pacific oceans. It has previously been recorded from the Palau Islands by Kott (1982).

*Lissoclinum tunicatum* new species

Figs. 20C, 21, Pl. 3G

Holotype: MNHN: A2 Lis A 121—Papua New Guinea, Eastern Fields Atoll (Coral Sea), 140 km southwest of Port Moresby, 10°00.66'S; 145°39.90'E, 72 m.

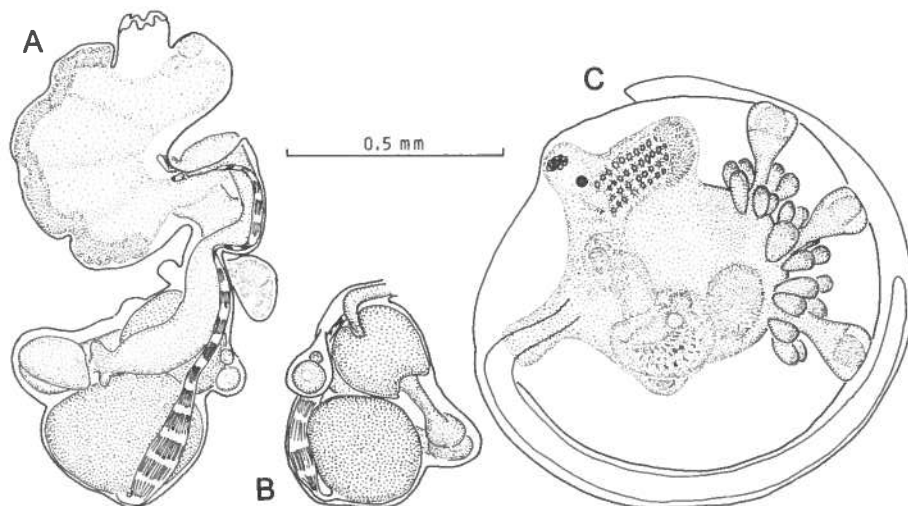


Figure 21. *Lissoclinum tunicatum* n. sp.: A, zooid; B, gonads; C, larva.

**Description:** The colonies are jelly-like, brown, surrounding octocorallian axes. The white spots visible in transparency are due to spicule capsules around the zooids (Pl. 3G).

The cloacal canals are wide, the common cloacal apertures are not visible on preserved material but in living colonies are seen to be large bordered with a transparent chimney of tunic.

The zooids are very contracted. They are well separated from each other in the colony, each enclosed in a layer of tunic containing small spicules. The oral siphon is tubular with 6 very short lobes. The cloacal aperture is bound by a muscular ring; it is sometimes large when not contracted but appears narrow after fixation (Fig. 21A). The lateral thoracic organs are small and difficult to see, making a horizontal slit above the second transverse branchial sinus. There is no retractor muscle. The number of stigmata in a row cannot be counted but they are numerous. The esophageal peduncle is short (Fig. 21A) and the abdomen is folded under the thorax. The stomach is heart-shaped and the different segments of the intestine are well individualized. The undivided testis is on the gut loop (Fig. 21B); spherical it may reach a very large size, as large as the entire abdomen. The sperm duct is straight. The ovary lies against the sperm duct in the gut loop (Fig. 21B). The larvae (Fig. 21C) are incubated in the tunic, near the parent zooids. They are enclosed in a spicular capsule. They measure about 1 mm. They have 3 well separated adhesive vesicles, with a crown of short ectodermal ampullae at the base of their stalk. An average of 20 ectodermal ampullae were counted in the tadpoles. The larvae are gemmiparous (Fig. 21C).

The spicules (Fig. 20C) have rays of irregular length, they are about 20  $\mu$ m in diameter.

**Remarks:** This species has many similarities to other *Lissoclinum* species with jelly-like colonies, few spicules and a gemmiparous larva. However, *L. abdominale* F. Monniot, 1982, *L. calycis* F. Monniot, 1992, *L. mereti* Monniot & Monniot, 1987, *L. punctatum* F. Monniot, 1992, *L. verrilli* (Van Name, 1902) have different spicules, no brown pigment and 4 pairs of larval ectodermal ampullae. *L. pacificense* Kott, 1981 also has different spicules and 6 pairs of larval ectodermal ampullae.

*Lissoclinum voeltzkowi* ? (Michaelsen 1920)

*Didemnum voeltzkowi* Michaelsen 1920: 54

*Lissoclinum voeltzkowi*: Kott, 1980: 13; 1981: 190; 1982: 112; F. Monniot, 1992: 579.

**Material Examined:** MNHN: A2 LIS A 102, and 103—Palau: Ngerong, sea grass, 7°06.90'N; 134°22.78'E, 0.5 m; S.W. Airai Channel, Ngermutidech, 7°18.74'N; 134°31.12'E, intertidal.

The colonies are soft, encrusting corals or weeds on sea grass beds. When living the color is grey and green. The color is irregular, a result of the relative number of spicules and brown pigment cells, and the abundance of the symbiotic unicellular algae. The surface can be smooth or wrinkled, with some papillae

located mostly at the thick edge of the colony. Generally the consistency is firm with a slippery surface. The colonies reach several centimeters across and 2 to 5 mm in thickness.

The cloacal cavities are large, surrounding groups of zooids and extending below the abdominal layer. Against the substrate is a dense, rather thick layer of tunic, crowded with spicules. Spicules are numerous everywhere, with variable sizes. The zooids open at the colony surface by slit-like apertures. The oral siphon has no lobes, its rim is plain or slightly raised in two lips. The cloacal aperture is wide with no languet. The lateral thoracic organs are circular protruding at the level of the second transverse sinus. There is no retractor muscle.

The branchial sac has 8 stigmata in each half row. The abdomen is much smaller than the thorax. The gut loop is narrow and the single testis follicle is below the intestine. The sperm duct originates posteriorly, runs over the testis follicle and parallel to the rectum. The ovaries were not developed in the colonies observed, and the zooids were totally immature. No larvae were present.

Remarks: Without ovaries and larvae, the identification of these colonies remains doubtful. The color and colony shape correspond to *L. voeltzkowi*, described from Australia, New Caledonia and Fiji. But *L. bistratum* (Sluiter, 1905) is a closely allied species, and it may be possible that additional species occur in the western Pacific.

The spicules of the Palau specimens are not exactly similar to those of *L. voeltzkowi*, nor to those of *L. bistratum*. The Palau specimens have fewer rays and they are thicker here. However, some variability has been observed from different geographical areas, so it is doubtful the Palau specimens could represent a new species based on this single difference.

Geographic Distribution: Madagascar, Philippines, Australia, Fiji, New Caledonia, Palau.

*Leptoclinides dubius* (Sluiter, 1909)

Pl. 3H

*Polysyncraton dubium* Sluiter, 1909: 69, pl. 4, fig. 3, pl. 7, fig. 10, Indonesia.

*Leptoclinides dubius*: F. Monniot, 1989: 681 and synonymy; Monniot & Monniot, 1991: 377, New Caledonia.

Material examined: MNHN: A2 Lep 31—Indonesia, north Sulawesi, west of Manado, 1°26.57'N; 124°44.48'E, 23 m.

The colonies are encrusting but fleshy, 5 to 8 cm across and 1 cm thick. Their color is pink (Pl. 3H) but they may be partially covered with bright green unicellular symbiotic algae. No symbiotic algae were found in the interior. The large common cloacal openings expose the brown-red internal color of the colonies. The spicules are only numerous in the basal part of the colony.

The characters of the zooids agree with the previous descriptions of this species; two tubular siphons with the testis follicles grouped in a bunch (not arranged in a rosette) and only circled by one complete coil of the sperm duct. Large sized larvae lie in the deepest part of the colony.



**Geographic Distribution:** The species has a wide geographic distribution in the western Pacific; Australia, Korea, Philippines, Malaysia, Indonesia. The species was collected down to 80 m depth.

***Leptoclinides oscitans* new species**

Figs. 22, 24A, Pl. 4A

**Holotype:** MNHN: A2 Lep 32—Indonesia, north Sulawesi, Ruang Island, 2°17.24'N; 125°21.84'E, 25 m;

MNHN: A2 Lep 47 and 48—Palau, Mutremdiu, Barrier Reef, 7°16.51'N; 134°31.55'E, Wonder Channel, 7°10.7'N; 134°22.1'E, Light House Channel, 7°17.5'N; 134°27.8'E, 10 m.

**Description:** This species was collected on a rocky bottom and was dark green, blue-black or grey, mottled orange, with darker grey patches in some places (Pl. 4A). The internal color was grey. The smooth surface is pierced by rounded common cloacal apertures raised on low swellings of the colony surface. The thickness varies from 2 to 7 mm. The spicules are restricted to the test layer surrounding the oral siphons. They are mixed with black ramified pigment cells. The entire test is particularly tough and fibrous, and in spite of their large size (1.5 mm), the zooids are very difficult to remove from the colony without damage.

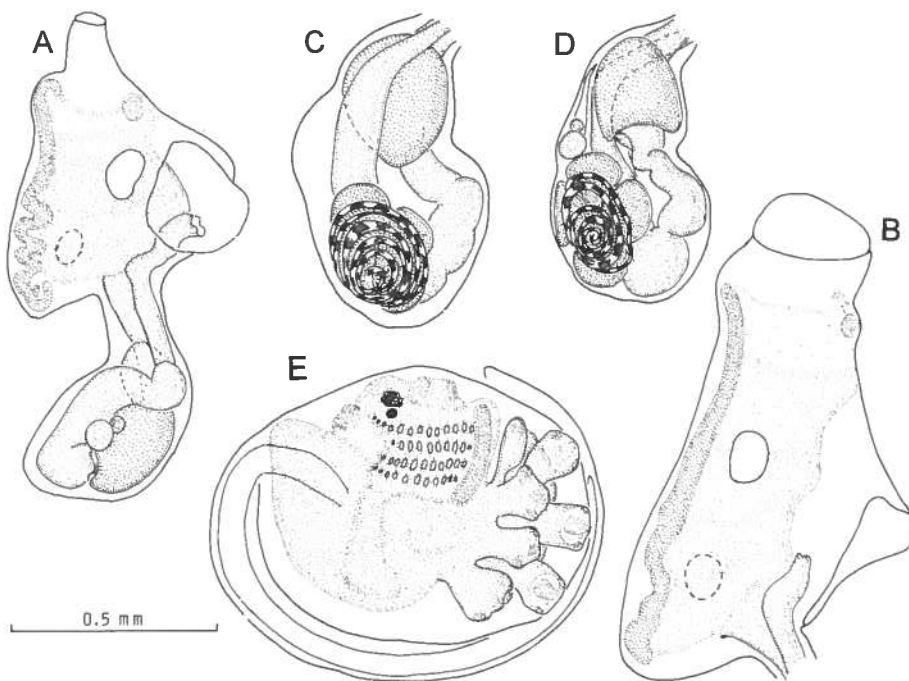


Figure 22. *Leptoclinides oscitans* n. sp. : A, zooid; B, thorax; C, D, abdomens; E, larva.

The oral and cloacal apertures have smooth edges without lobes. The cloacal aperture is not tubular, even in contracted animals, but is simple and sessile (Fig. 22A) similar to a yawn, hence the species name. The thoracic muscles are grouped in 6 longitudinal bundles on each side. The thoracic organs are not located at the same level on each side, but above the second branchial sinus on the left and above the third sinus on the right (Figs. 22A, B). There is no retractor muscle. There are at least 14 stigmata in the first row. The abdomen is smaller than the thorax (Fig. 22A) with a narrow gut loop. The testis (Figs. 22C, D) is divided into 3 to 5 follicles encircled by 4 to 6 coils of the sperm duct. The body wall contains black fusiform pigment cells. The trunk of the larvae measures 800 to 850  $\mu\text{m}$ . The 3 short stout adhesive papillae are diverging, and alternate with 4 pairs of ectodermal papillae with an enlarged triangular tip (Fig. 22E). Four rows of stigmata are already well developed in the tadpole, behind the ocellus and otolith.

The spicules (Fig. 24A) are large, reaching 90  $\mu\text{m}$  in diameter.

Remarks: The spicule rays are more numerous than in *Leptoclinides sulawesii* n.sp., but with the same chisel-shaped tips. The species differs from *Leptoclinides rufum* Sluiter, 1909 whose type has tubular cloacal siphons, rounded instead of ramified pigment cells, and a different larva.

*Leptoclinides reticulatus* (Sluiter, 1909)

Figs. 23, 24B, Pl. 4B

*Didemnum reticulatum* Sluiter, 1909: 60—Indonesia.

*Leptoclinides reticulatus*: Hastings, 1931: 92, Great Barrier Reef and New Zealand; Tokioka, 1967: 89, Palau and Gilbert Islands.

Material Examined: MNHN: A2 Lep 34—Papua New Guinea, Duke of York Islands, Mioko Island, 4°13.85'S; 152°28.16'E, 23 m.

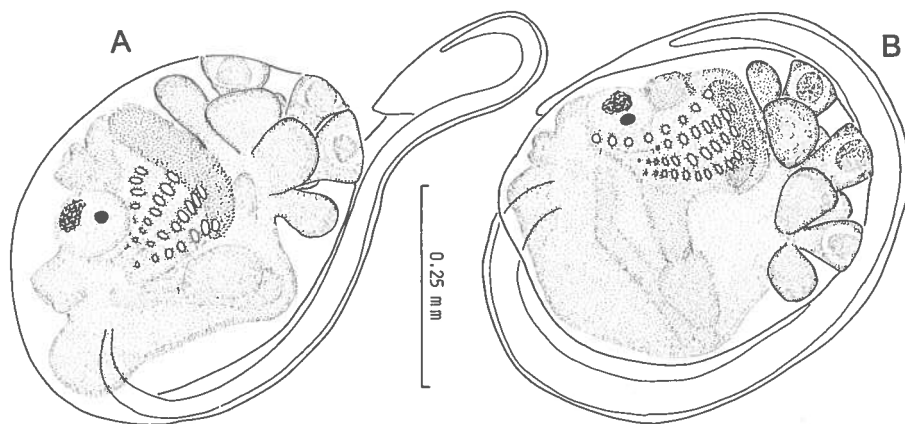


Figure 23. *Leptoclinides reticulatus* (Sluiter, 1909): A, larva of the type colony; B, larva of another colony.

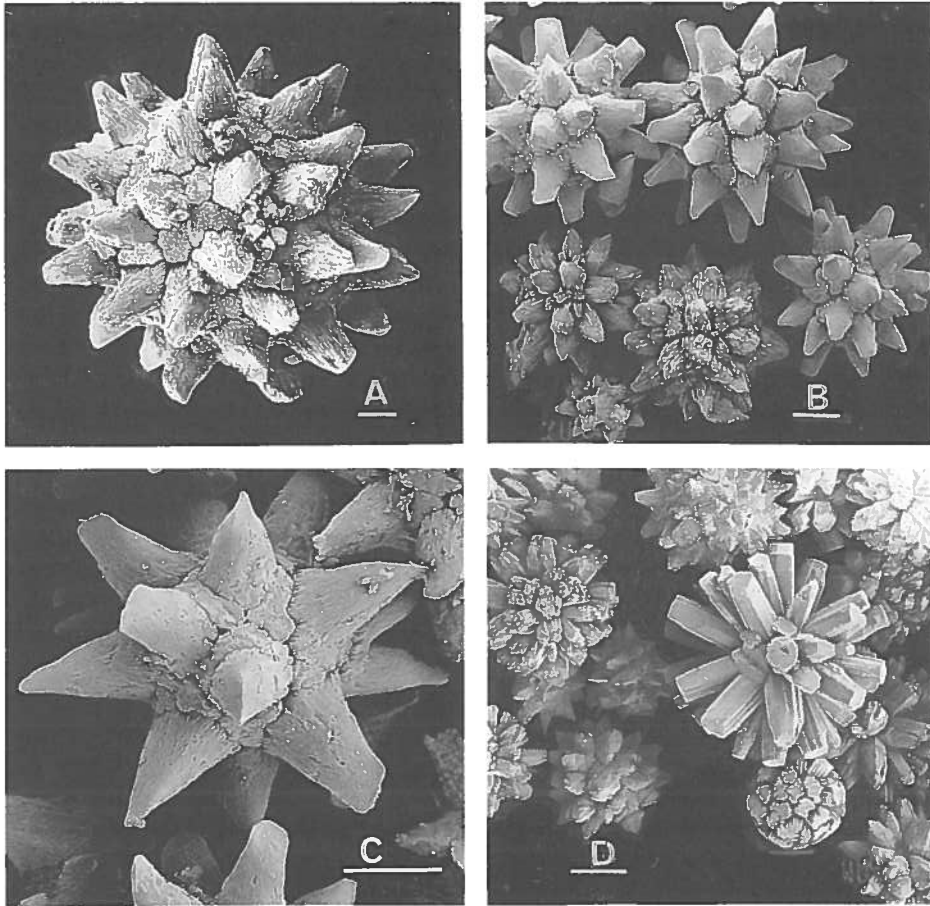


Figure 24. Spicules. A, *Leptoclinides oscitans* n. sp. B, *Leptoclinides reticulatus* (Sluiter, 1909). C, *Leptoclinides sulawesii* n. sp. D, *Leptoclinides uniorbis* n. sp. Scale bars: 10µm.

The colonies are encrusting on rocks, several centimeters across, 1 to 2 cm thick with an irregular outline. The upper surface is black, with golden rings around the oral openings and white rings on the rim of the common cloacal apertures at the top of low swellings (Pl. 4B). The underside of the colonies is white. The superficial layer of the colony is transparent and soft. Under this pellicle, the tunic is tough, and difficult to tear. It is densely filled with spicules and dendritic pigment cells. This layer cannot easily be separated from the bottom part of the colony. The cloacal channels encircling clusters of zooids extend below the zooid abdomens but are not very wide.

The zooids are difficult to remove from the tunic. The oral siphon is long, tubular, and without lobes. The cloacal aperture is located in front of the fourth row of stigmata, either sessile or on a short tube. The thorax is wide, with a wide

straight base. The stigmata could not be counted. The lateral thoracic organs are round above the middle of the fourth row of stigmata. There is no retractor muscle. The abdomen is folded under the thorax. The gut loop is narrow and slightly twisted. The stomach is small and spherical. There are 3 to 4 testis follicles encircled by 5 coils of the sperm duct. The larvae (Figs. 23A, B) are incubated below the zooids. They are rather small (450  $\mu\text{m}$ ) with 3 adhesive papillae, 2 ectodermal vesicles on each side, one dorsal and one ventral. The ocellus and otolith are present above the branchial sac with 4 rows of stigmata that are already developed.

The spicules (Fig. 24B) are stellate, with pointed rays. This species has similar characters as those of the type specimens which has been examined. It corresponds closely to the Tokioka's specimens from Palau, which are smaller but had a similar surface design. The basal layer of the colony was much thicker in our sample, possibly due to the presence of larvae at this stage of development.

Remarks: This species differs from *L. oscitans* n. sp., which has dark pigment cells and no cloacal tube because of the peculiar golden and white rings around the apertures. The larvae and spicules are different. *Leptoclinides sulawesii* n. sp. lacks black pigment cells, has a wide gut loop, more testis follicles and different spicules.

Geographic Distribution: Indonesia, Palau, Gilbert Islands, Papua New Guinea, New Zealand.

*Leptoclinides sulawesii* new species

Figs. 24C, 25A–C, Pl. 4C

Holotype: MNHN: A2 Lep 30—Indonesia, north Sulawesi, west of Manado, 1°23.52'N; 124°32.64'E, 38 m.

MNHN: A2 Lep 8 and 29—Palau, Wonder Channel, 7°10.7'N; 134°22.1'E, 12 m, and Mutremdiu, Barrier Reef, 7°16.51'N; 134°31.55'E, 12 m.

Description: Large encrusting sheets that reach more than 20 cm in length and 5 mm in thickness. In life, they are rusty orange (Pl. 4C) and translucent internally. The pigment quickly fades in alcohol, and becomes dark red in formalin. Numerous cloacal apertures protrude at the colony surface, lined by a ring of tunic devoid of spicules. The colonies are not shiny but the superficial layer does not contain spicules and is a deep orange color. There are no black pigment cells. The spicules are mostly restricted to the zooid level, and become sparse in the deepest fibrous layer in contact with the substrate. The larvae are incubated in the basal test. As in many *Leptoclinides* species, the zooids are extremely difficult to extract from the common test where they are crowded.

The thorax is elongated (at least 1 mm in length). Six muscular bundles extend longitudinally on each side. Both siphons are cylindrical and without fringing lobes (Fig. 25A). The oral siphon has a strong sphincter. The cloacal tube arises from the level of the third row of stigmata. The thoracic organs are located above the third branchial sinus (Fig. 25A). An unperforated area separates the prepharyngeal groove from the first row of stigmata. About 14 long stigmata were

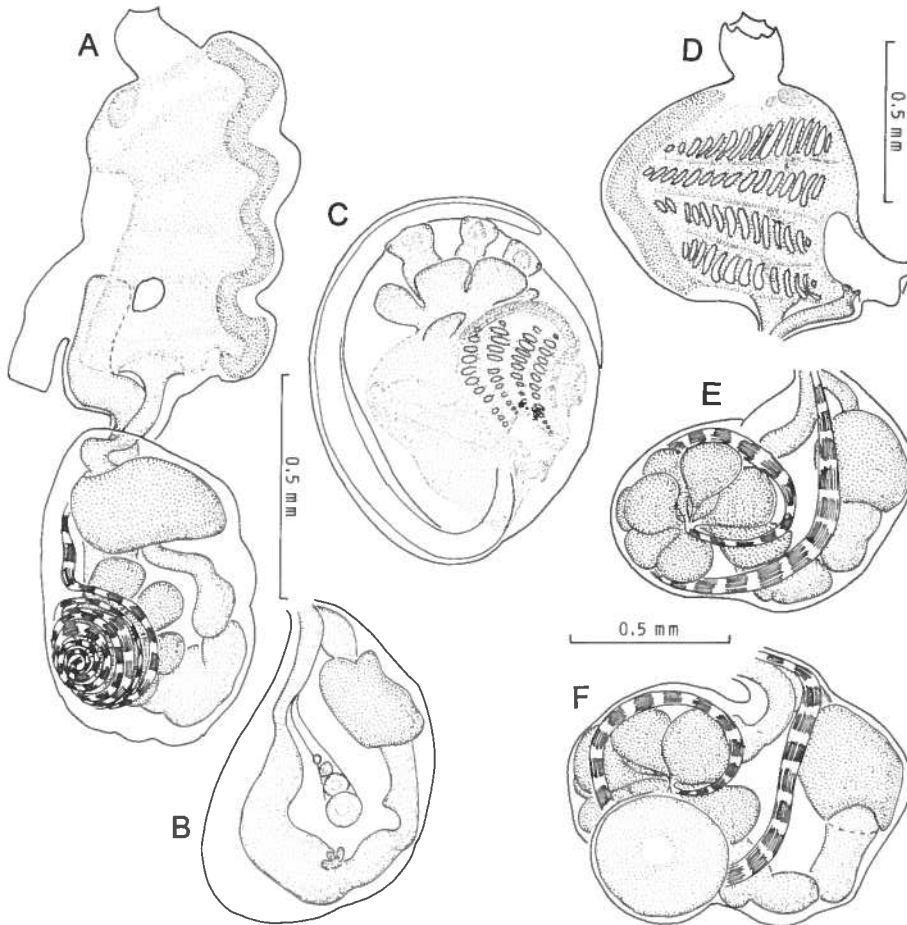


Figure 25. *Leptoclinides sulawesii* n. sp.: A, zooid; B, abdomen; C, larva. *Leptoclinides uniorbis* n. sp.: D, thorax; E, F, abdomens.

counted in the first row. The esophago-rectal peduncle is short and narrow (Fig. 25A). There is no retractor muscle. The gut loop is wide with a short esophagus, a large stomach (Fig. 25B), an annular post-stomach. The rectum is enlarged but does not form caeca, it is not clearly separated from the mid-intestine. The gonads are normally located on the side of the gut loop. Testis and ovary were found in separate zooids. Three to 5 testis follicles are in a circle surrounded by 7 coils of the sperm duct (Fig. 25A). The larval size is variable with an average length of 850  $\mu$ m for the trunk. The 3 adhesive papillae are sided by only 3 pairs of wide ectodermal ampullae (Fig. 25C). The 4 rows of stigmata are clearly visible, there is no bud.

The spicules (Fig. 24C) are stellate, with few rays. The rays have chisel-shaped tips. Their diameter is about 45  $\mu$ m, rarely 50  $\mu$ m.

Remarks: This species differs from *Leptoclinides cuspidatum* (Sluiter, 1909) which has 4 pairs of larval ectodermal ampullae. *Leptoclinides rufum* (Sluiter, 1909) has many fewer stigmata and dark pigment cells remaining in fixative. *L. sulawesii* does not correspond to any New Caledonian species (F. Monniot 1989) or to other Indo-Pacific type species that we have studied. It differs from *L. oscitans* n. sp. by the cloacal aperture, the spicules, the pigment cells and the larva.

For comparison, the type and paratype of the Indonesian species *Leptoclinides doboense* (Sluiter, 1913) described under the name *Polysyncraton doboense*, deposited in the Senckenberg Museum at Frankfurt have been examined. The colonies are encrusting, about 10 cm across. The cloacal canals form surface grooves in a polygonal design. The superficial layer of the colony contains the zooids, separated from the basal layer by the cloacal canals. The spicules are not numerous in the very fibrous test; they are large and stellate. The zooids have 8 longitudinal thoracic muscles on each side. There are 10 stigmata in the first row. There are generally 3 testis follicles and 6 coils of the sperm duct. The larvae are small but not completely differentiated.

Kott (1981) redescribed a true *Polysyncraton* species from Fiji under the name *Polysyncraton doboense* Sluiter, 1913, which is completely different from Sluiter's sample.

*Leptoclinides uniorbis* new species

Figs. 24D, 25D–F, Pl. 4D

Holotype: MNHN: A2 Lep 35—Federated States of Micronesia, Chuuk Lagoon, Lematol Bay between Polle and Pata Islands, 7°21.45'N; 151°35.53'E, 10 m.

Description: The colonies are large orange sheets, several cm across and 2 to 3 mm thick, with an irregular outline. The large round common cloacal apertures open at the top of swellings (Pl. 4D). The zooids are irregularly spaced. The colonies are made of several layers. On the upper surface layer and against the substrate, the test forms a crust with very crowded spicules. Between these two thin sheets extends the zooid layer, with fewer, but still numerous spicules. This layer is pierced with large meandering canals which also penetrate the tunic below the abdomens. The colonies are easy to collect as the underside is wrinkled but smooth. When fixed in formalin the red pigment dissolves and the fixative become deeply-colored.

The zooids have long tubular oral siphons ending in 6 denticles (Fig. 25D). The thorax is wide and square with a distinct angle at the end of the endostyle. The cloacal siphon is a tube at the level of the fourth row of stigmata. The thoracic musculature is weak and the cloacal cavity very reduced (Fig. 25D), thus it is easy to count the 18 stigmata in the first row. The lateral thoracic organs are circular, small, and located at the base of the cloacal siphon. There is no retractor muscle. The abdomen is not always folded under the thorax. The esophago-rectal waist is short. The digestive loop is wide with well differentiated regions. The testis is made of 6 to 8 follicles arranged in a compact rosette (Figs. 25E, F). The sperm duct describes only one coil and runs along the rectum (Figs. 25E, F). The ovary

develops against the testis with one large oocyte maturing at a time. The larvae were not seen.

The spicules have a maximum diameter of 40  $\mu\text{m}$  with numerous rays (Fig. 24D) with tips in points or cut.

Remarks: This species differs from *Leptoclinides dubius* (Sluiter, 1909) by the very regular distribution of the testis follicles in a rosette, and the gut being a simple flat loop. It differs from *Leptoclinides multilobatus* Kott, 1954 which has 20 testis lobes, a very large stomach and spicules at the colony surface only.

*Atriolum quadratum* new species

Figs. 20D, 26, Pl. 4E

Holotype: MNHN: A2 Atr 9—Federated States of Micronesia, Chuuk Atoll, barrier reef, channel (Salat Pass) on the south east side of the atoll, 8 m.

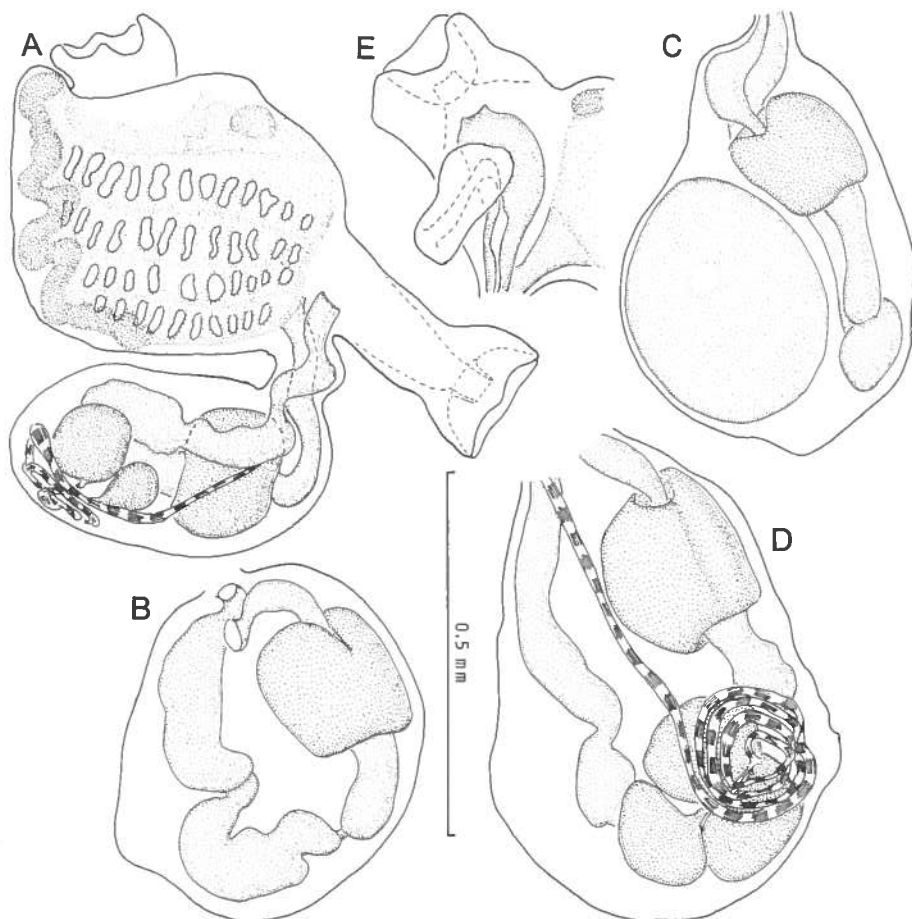


Figure 26. *Atriolum quadratum* n. sp.: A, zooid; B, detail of the gut; C, D, abdomens; E, growth of the brood pouch.

**Description:** The colonies form large encrusting sheets, 2 to 3 mm thick, with surface swellings each with a terminal circular common cloacal opening (Pl. 4E). The color is grey or pale violet-blue. The colonies are inflated under water. The general consistency is flexible but tough. The spicules are crowded in the superficial layer of the colony and more sparse inside.

The zooids are crowded. The abdomens are folded under the thoraces. The oral siphon is tubular with 6 shallow lobes. The oral tentacles, at the base of the siphon, are very numerous, in 4 orders of size. There is a large imperforate area between the prepharyngeal band and the branchial sac (Fig. 26A). There are 12 stigmata in each of the 4 rows. An imperforate area lies along each side of the dorsal line. The 3 rapheal languets are slightly displaced to the left side. The cloacal siphon is tubular, very long, at the base of the thorax. It has an internal velum at its tip (Fig. 26A). The small cup-like thoracic organs are placed on the beginning of the cloacal siphon, above the esophageal opening. The thoracic musculature is weak, longitudinal. A brood pouch, small and empty in the figure (Fig. 26E), is located at the base of the cloacal siphon on the right side of the thorax. The esophagorectal waist is short and begins far from the base of the endostyle (Fig. 26A). The shape of the thorax (siphons excluded) is rectangular, the abdomen is located at its postero-dorsal angle. There is no retractor muscle. The abdomen is much smaller than the thorax (Fig. 26A). The esophagus is tubular, the stomach spherical without plications. There is a cylindrical post-stomach, separated from the intestine by a constriction. The mid-intestine is tubular, a little wider than the posterior intestine when empty. A distinct bend is located between the mid-intestine and the posterior intestine (Figs. 26B, C). The testis is made of 3 to 5 follicles, located above the mid-intestine, surrounded by 4 coils of the sperm duct (Fig. 26D). The ovary, with one large oocyte, takes the place of the testis when the latter has disappeared (Fig. 26C). No embryos were found in the brood pouch. The majority of the zooids of the large colony studied were in a male phase, although a few had an ovary and the start of a brood pouch.

The spicules are large, the largest reach 100  $\mu\text{m}$ , with few long pointed rays (Fig. 20D).

**Remarks:** This species differs from *Atrium robustum* Kott, 1983 in having several testis follicles. It differs from *Atrium marsupialis* F. Monniot, 1989 in its different spicules, thorax and cloacal siphon. The shape of the gut is also different. The esophago-rectal waist is shorter here, and displaced dorsally.

Even without larvae, *A. quadratum* is obviously different from the other two species of *Atrium*. The species name comes from the square shape of the thorax.

Family: Polycitoridae

*Polycitor circes* Michaelsen, 1930

*Polycitor circes* Michaelsen, 1930: 495, fig.2; Kott, 1990a: 169 and synonymy.

Material Examined: MNHN: A3 Pol A 17—Indonesia, north Sulawesi, mouth of Teluk Korakora inlet, 1°43.97'N; 124°58.03'E, 33 m.



Several lobes reaching 6 cm in height and 3 cm in diameter arise from a common base. Zooids open on the upper surface in circular systems. The test is translucent and firm. The oral and cloacal siphons have 6 lobes. The branchial sac has at least 15 rows of stigmata. The stomach wall has numerous narrow longitudinal plications. The gonads lie in the gut loop with numerous testis follicles and a central ovary. The larvae are large, the trunk 2.5 mm long, with 3 anterior adhesive papillae triradially arranged, and no ectodermal vesicles. Embryos are incubated all along the oviduct.

**Geographic Distribution:** This species is recorded from the western Pacific, Australia and the Philippines.

*Eudistoma amplum* (Sluiter, 1909)

Fig. 27, Pl. 4F

*Polycitor amplus* Sluiter, 1909: 21.

*Eudistoma amplum*: Kott, 1990a: 194 and synonymy.

**Material Examined:** MNHN: A3 Eud 77, 78, 84, 86, 96, 97, 98, 100, 102, 103, 104, and 105—Palau: Airai Channel, 7°19.24'N; 134°31.28'E, 1 m; east Babeldoab, Ngersuul, 7°24.51'N; 134°35.89'E, 0.5 m; Ngeruktabl marine lake, 7°16.80'N; 134°25.92'E, 0.5 m; Venture marine lake, 7°19.21'N; 134°29.33'E, 1 m; Wonder Channel, Rock Islands, 7°22.30'N; 134°02.15'E, intertidal; Mutremdiu, Barrier Reef, 7°16.51'N; 134°31.55'E; West reef 7°19.4'N; 134°13.9'E, 1 m;—Federated States of Micronesia, Chuuk lagoon, north side of Dublon Island, 7°23.30'N; 151°52.25'E, 0.5 m and Polle Pinnacle, 7°21.54'N; 151°35.63'E, 1 m;—Papua New Guinea, New Ireland, Kalili Harbor, 3°26.37'N; 151°56.01'E;—Philippines, Cebu Province, Olongo Island, off Santa Rosa village, 10°14.99'N; 124°01.07'E, 9 m.

The colonies from all localities are similar. They are circular encrusting cushions 1 cm thick, and up to 9 cm across with a rubbery but smooth surface, with embedded sand. The color varies from dark green to tan or maroon. There is a star or honeycomb pattern at the surface due to the zooid arrangement in circles (Pl. 4F). Many green or brown spheres of varied sizes are found in the tunic at the colony surface and between the zooids.

The zooids (Fig. 27A) may reach 1 cm in length, they extend from the colony surface to the substrate. They are arranged with the oral openings in circles with cloacal openings in the center. The tissues are colorless except the orange stomach and greenish oocytes; the larvae are colorless. Both siphons have 6 pointed lobes. The body wall is thick with very numerous longitudinal and transverse muscle fibers regularly spaced. This strong musculature extends onto the long abdomen. The oral tentacles are very numerous in several circles. In addition the anterior internal part of the oral siphon is covered with minute papillae. The branchial sac has long stigmata, about 25 on each side in the first row. The rapheal languets are very short. The abdomen is very elongated, and ends in one or several ramified vascular processes. The stomach is large, asymmetrical; the intestine forms a loop and its ascending limb is bent against the stomach (Figs. 27A, B). The rectum

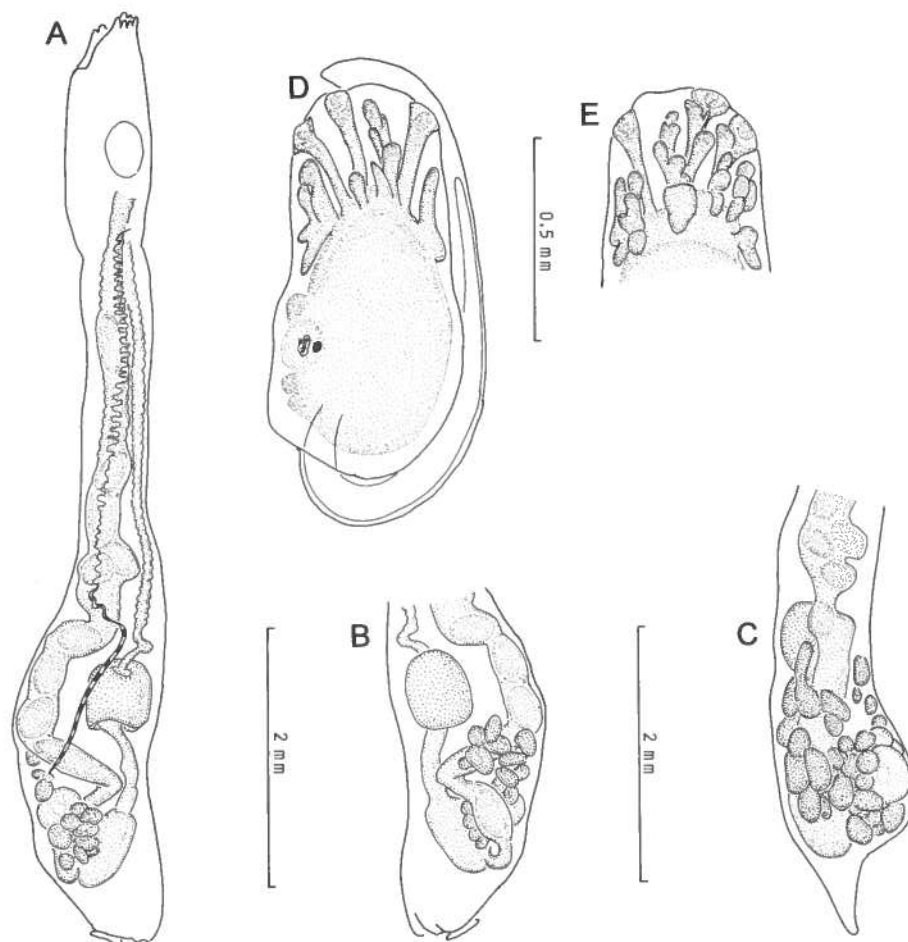


Figure 27. *Eudistoma amplum* (Sluiter, 1909): A, zooid; B, C, abdomens; D, larva; E, detail of larval papillae.

starts behind the posterior loop by an annular enlargement. The pyloric gland facing the stomach also extends anteriorly and posteriorly onto the intestine. The pyloric duct enters the stomach at the junction of the intestine. The testis follicles are numerous, in a bunch inside the gut loop (Figs. 27B, C). The ovary is central. One or two larvae are incubated in the cloacal cavity. The trunk is 900  $\mu\text{m}$  long (Fig. 27D). There are 3 adhesive papillae, irregularly spaced. The young tadpoles have only odd swellings between the adhesive papillae, the mature larvae have 3 large concentric rows of irregular papillae on each side, anteriorly (Fig. 27E).

**Geographic Distribution:** The species was already known from Palau, the Banda Sea, Kei Islands, Truk, Ponape and Majuro Islands and Queensland in Australia.

*Eudistoma fasciculum* new species

Fig. 28A–C, Pl. 4G

Holotype: MNHN: A3 Eud 83—Palau, Koror State, Mutremdiu lagoon (on barrier reef), 7°16.16'N; 134°31.74'E, 18 m.

Description: The colonies are made of several coalescent heads which join to form balls 6 to 8 cm in diameter around living branches of *Acropora*. Each lobe of the colony has a short stalk arising from a common base. There is no sand in the tunic but yellow-green spherical plant cells are present. The consistency is

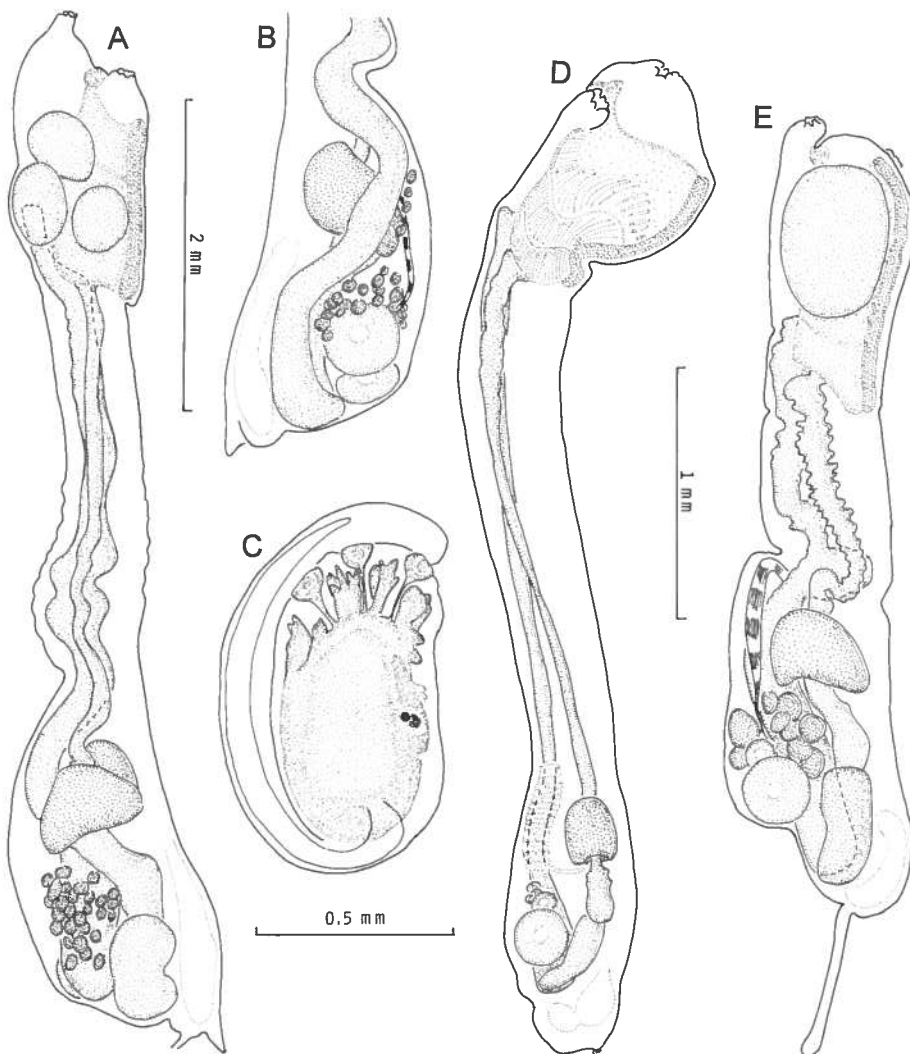


Figure 28. *Eudistoma fasciculum* n. sp.: A, zooid; B, posterior part of the abdomen; C, larva. *Eudistoma gilboviride* (Sluiter, 1909): D, E, zooids.

tough. The color is brown-orange, with green (Pl. 4G). The siphonal lobes are slightly protruding at the upper surface of the lobes. No systems were observed. The opaque tunic in living specimens becomes more transparent after fixation.

The zooids are long, up to 8 mm in length for the less contracted ones. They have posterior abdominal vascular processes. Both siphons are short (Fig. 28 A). The oral siphon has 6 triangular lobes. At its base are 4 brown spots, which disappear in fixatives. The 6 cloacal lobes are round. The thoracic musculature consists of numerous longitudinal and transverse fibers regularly crossed. The 3 rows of long stigmata occupy the entire branchial sac without unperforated areas. The abdomen is contracted by 2 strong muscular bundles, ending at some distance from the posterior extremity of the zooids. The orange stomach is posterior with an irregular outline; the typhlosome is raised in a ridge and on the opposite side the upper part of the stomach has 2 humps (Fig. 28A). The gut loop is wide and contains very numerous testis follicles (Fig. 28A). The ovary is central with several oocytes (Fig. 28B). The larvae (Fig. 28C) are incubated in the cloacal cavity. Among 4 or 5 embryos in a zooid, only one reaches maturity in a time. The tail of the tadpole is not exactly encircling the anterior papillae but is a little displaced to the left side. The 3 adhesive papillae have thin and long stalks. They are separated by 4 pairs of ectodermal ampullae, irregular in shape, their tip produced into pointed lobes (Fig. 28C). The larval trunk is 0.8 mm in length.

Remarks: This species is similar in appearance to *Eudistoma laysani* (Sluiter, 1900) and *Eudistoma olivaceum* (Van Name, 1902). The structure of the colony is the same. The zooids in our species have a more developed musculature and a thicker body wall. *E. laysani* has smaller zooids, smaller larvae, weak abdominal musculature and lacks thoracic dark pigment spots. *E. olivaceum* has different pigment spots which remain in fixatives, and a smaller and different larva.

*Eudistoma gilboviride* (Sluiter, 1909)

Figs. 28D, E, Pl. 4H

*Polycitor gilboviridis* Sluiter, 1909: 6, Indonesia.

*Eudistoma gilboviride*: Kott, 1990a: 206, Queensland, Australia.

Material Examined: MNHN: A3 Eud 88 and 101—Palau, Koror State, Light-house Channel, 7°17.03'N; 134°27.82'E; 12 m.—Papua New Guinea, Madang, Rasch Passage, 5°09.27'S; 145°49.82'E, 3 m.

The colonies are stalked, with an average of 2 cm in height, with the zooids opening on the flat top of the lobes. The general color is dark green, but large pale yellow irregular patches are seen on the upper surface (Pl. 4H). The tunic is hard with dark pigment cells. The zooids are not pigmented except the orange stomach and dark pigment cells around the most mature larvae, the eggs are yellow. The zooids are parallel to each other, perpendicular to the flat surface of the colony where they open; they are not grouped in systems.

The zooids (Figs. 28 D, E) have 6 lobes at each cylindrical siphon. The thoracic musculature is made of many thin fibers, extending in thin ribbons along the abdomen. The branchial sac has 3 rows of long stigmata. The abdomen is

long, enlarged in the posterior part where the post-stomach and intestine form a wide loop. The testis follicles are not very numerous and do not fill the posterior gut loop. The ovary is located alongside the testis follicles. There is only one larva being incubated in the thoracic cloacal cavity. The 3 adhesive papillae have short stalks and are bordered with 4 pairs of ectodermal papillae. Their trunk measures 650 to 770  $\mu\text{m}$ .

Remarks: These characters and especially the color and shape of the colonies correspond well to the previous descriptions with the exception that Kott (1990a) mentions colonies with zooids in small systems. The green color of the colony marbled with yellow is very characteristic.

Geographic Distribution: *Eudistoma gilboviride* has been recorded in Indonesia, Queensland, and now in Palau and New Guinea.

*Eudistoma incrustatum* new species

Figs. 29A–C, Pl. 5A

Holotype: MNHN: A3 Eud 76—Indonesia, north Sulawesi, Manado, 1°23.56'N; 124°32.62'E, 43 m.

Description: Completely encrusted with sand, the colony is a brown color, no systems are visible (Pl. 5A). Both test and zooids are dark brown. The colony is tough but gelatinous internally. The zooids are well spaced and vertically arranged.

Almost all zooids of the colony are contracted. Both siphons are tubular, of equal length and have 6 rounded lobes around the apertures. The thoracic musculature consists of numerous longitudinal fibers in a continuous coating. The branchial sac has no anterior unperforated area (Fig. 29A) and the first row has more than 30 long stigmata. The less contracted abdomens reach 2.5 times the thorax length. The asymmetrical stomach is voluminous and posterior. The gonads are located in the gut loop, behind the stomach (Figs. 29A, B). The small testis follicles are so numerous that they sometimes extend in a pouch below the mid-intestine. The ovary is central. One larva is incubated in the thoracic cloacal cavity, rarely two. They are highly pigmented, not well developed and their structure is particularly difficult to study. They strongly contract when dehydrated. The tail forms only half a circle. The 3 adhesive papillae, in the median line, are of unequal length, flattened laterally (Fig. 29C). There are very numerous ectodermal ampullae seen as small vesicles extending in more than the anterior half of the trunk, and along the ventral side (Fig. 29C).

Remarks: Externally this species resembles *Eudistoma snakabri* Tokioka, 1954b whose type specimen has been examined, however some differences are obvious. *E. snakabri* has protruding test papillae at the colony surface, a different shape of the gut, different ectodermal ampullae in the larvae (Fig. 29D). A large unperforate space is anterior to the rows of stigmata.

The pigment in *E. incrustatum* is darker, much more abundant in the body wall and the larvae. All attempts to clear this pigment remained unsuccessful.

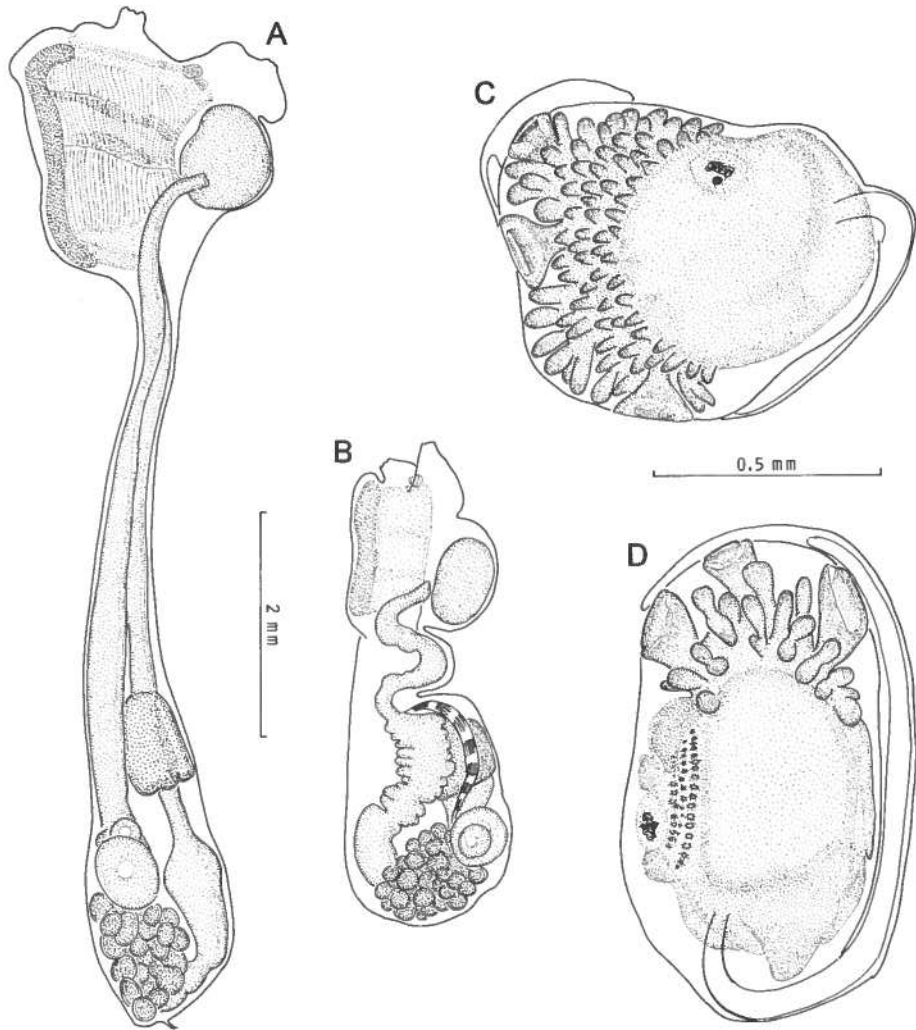


Figure 29. *Eudistoma incrustatum* n. sp.: A, B, zooids; C, larva. *Eudistoma snakabri* Tokioka, 1954: D, larva.

*Eudistoma laysani* ? (Sluiter, 1900)

Material Examined: MNHN: A3 Eud 89—Papua New Guinea, Madang, 5°08.44'S; 145°48.15'E, 2 m on mangrove roots.

The colonies are translucent white heads with short stalks, crowded together, forming balls on mangrove roots. The diameter reaches 2 cm. As the zooids are not fully mature and without larvae, the species identification remains somewhat uncertain.

Geographic Distribution: *Eudistoma laysani* has a wide distribution in the western tropical Pacific: Hawaii, Palau, Philippines, New Caledonia and Australia.

*Eudistoma reginum* Kott, 1990

Fig. 30, Pl. 5C, D

*Eudistoma reginum* Kott, 1990: 228, Queensland, Australia.

Material Examined: MNHN: A3 Eud 73,74,75,81,85 and 107—Indonesia, north Sulawesi, Manado, 1°23.52'N; 124°32.64'E, 18 m, and 1°45.10'N; 124°58.87'E, 60 m—Palau, east Babeldaob, Ngarsuul, 7°24.51'N; 134°35.89'E, intertidal; Koror State, Rock Islands, Topkukau, 7°15.94'N; 134°27.01'E, 1 m; shallow Bay, 7°19.4'N; 134°29.6'E; marine lake north of Ngel Channel entrance, 7°18.3'N; 134°29.1'E, 9 m..

The colonies form low cushions, measuring up to 20 cm across and 1 cm in thickness. They are brown or dark purple (Pl. 5C, D), with sometimes few encrusted particles on the surface and inside the test. In formalin, the color turns dark brown. The consistency is rubbery and the colonies are hard to tear. The zooids systems are obvious at the upper surface of the colonies, where circular depressions contain a ring of oral openings and a central concavity with cloacal apertures. The tunic is vacuolar and contains numerous crystalline surface inclusions, hardly soluble in acetic acid, polarising the light, which may mean that they are calcium oxalate. Several kinds of pigment cells coexist in the test: dark circular ones and others more clear and fusiform.

All zooids are shortened by contraction. Both siphons are cylindrical, the oral one with 6 sharp rounded lobes, the cloacal siphon with, sometimes, 8 lobes. The body wall has numerous and regularly spaced thoracic longitudinal muscles which form strong ribbons along the abdomen. The body wall is thick. The oral tentacles, in 3 orders of size, are inserted on a line. A large unperforated area separate them from the branchial sac. The branchial sac has 3 rows of long stigmata (Fig. 30A), the first one dorsally curved. There are about 20 to 25 stigmata in the first row. The dorsal languets are displaced on the left side. The abdomen is long. The gut loop is very characteristic (Figs. 30A, B, E, F). The short brown stomach is asymmetrical with 2 dorsal swellings separated by a longitudinal groove (Fig. 30F). After a short and narrow cylindrical segment, the post-stomach is inflated in a ball, sometimes more voluminous than the stomach (Figs. 30E, F). The zooids seem to have two stomach pouches. The first part of the ascending limb of the intestine is enlarged in two caeca. The pyloric gland is well developed, the tubules extending down the rectum to the level of the stomach (Fig. 30F). The tubules have some swellings near the short common duct entering the posterior side of the stomach. A large clear pyloric vesicle is sometimes located inside the gut loop, close to the beginning of the ascending limb of the intestine. Numerous round testis follicles form a dense mass posterior to the stomach (Fig. 30A). The ovary is central. Generally, two thin and long conical stolonetic vessels arise inde-

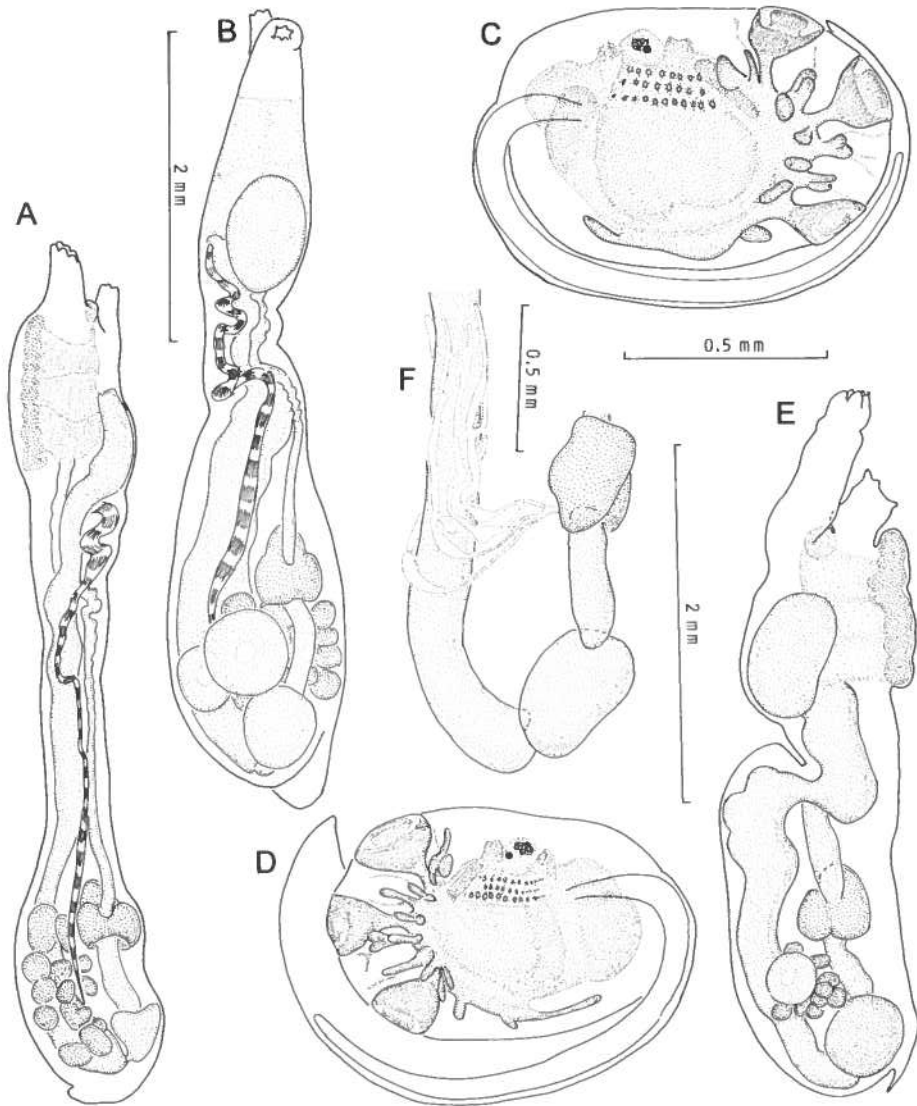


Figure 30. *Eudistoma reginum* Kott, 1990: A,B, zooids from Palau; C,D, larvae from Palau; E, zooid from Sulawesi; F, detail of the pyloric gland.

pendently from the enlarged posterior part of the abdomen. Only one embryo matures in the thoracic cloacal cavity. The tadpole is large. It is characterized by 3 stout adhesive papillae (Figs. 30C, D) deeply pigmented in dark brown. On each side of the tail attachment, two lateral swellings are also pigmented. The ectodermal anterior papillae are variable, sometimes branched, some alternate with the adhesive papillae, others are lined on each side (Figs. 30C, D).



Remarks: specimens from Heron Island (Australia), identified by Kott and deposited in the Queensland Museum, were examined. They are very similar to the samples collected at Palau and Indonesia.

Geographic Distribution: Queensland, Indonesia, Palau.

*Eudistoma rubiginosum* new species

Fig. 31, Pl. 5B

Holotype: MNHN: A3 Eud 112—Federated States of Micronesia, Chuuk lagoon, north Fefan Island, 7°22.30'N; 151°50.64'E, 24 m.

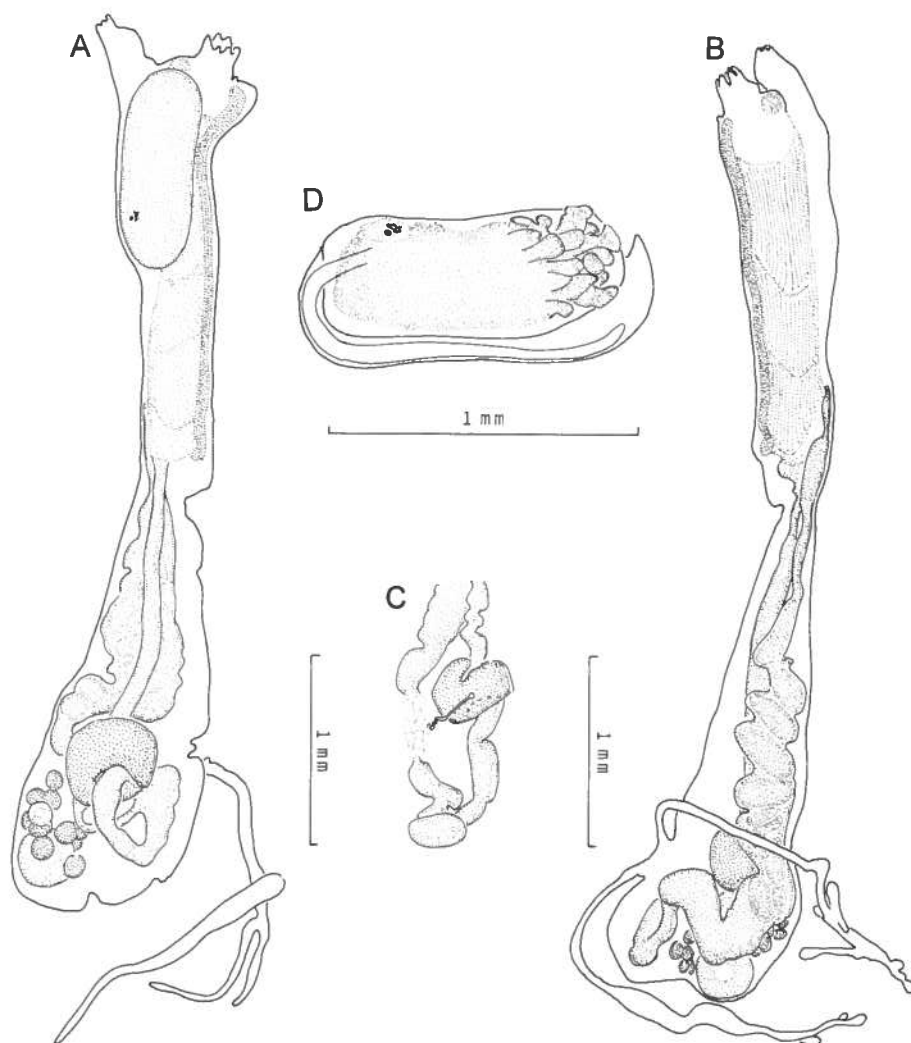


Figure 31. *Eudistoma rubiginosum* n. sp.: A, B, zooids; C, detail of the gut; D, larva.

**Description:** The colonies are flat cushions, long or circular of about 5 cm in maximum dimension and 1 cm thick. The color in life was ochre-yellow (Pl. 9B) which turned uniformly rusty throughout in formalin. The smooth surface shows systems of about 8 zooid oral apertures in a ring and grouped cloacal apertures in the center. The tunic is tough, filled with fecal pellets and small orange vesicles. There are also small inorganic particles.

The zooids reach 5 mm in length when partially relaxed. Both siphons are tubular, the cloacal the longest; each has 6 lobes. The body wall is opaque with numerous muscle fibers. The branchial sac is long (Figs. 31A, B), without unperforate areas but with long stigmata. The rapheal languets are displaced to the left side. About 30 stigmata on the right side and 25 on the left side were counted in the first row, which is curved dorsally. The abdomen has a long esophagus and rectum. The stomach is far posterior, followed by a narrow cylindrical segment, a short ampulla leading to an enlarged mid-intestine curved before reaching the rectum (Fig. 31C). The pyloric gland consists of few large tubules facing the stomach. The common pyloric duct crosses the gut loop and enters the stomach wall at mid length (Fig. 31C). The gonads are located inside the gut loop, below the stomach. They consist of a cluster of spherical testis follicles and a central ovary. Only one larva is incubated at a time in the thoracic cavity. The trunk is long and the tail is the same length. There are 3 adhesive papillae in the median line and 5 pairs of bifurcated ectodermal ampullae (Fig. 31D). The ocellus and otolith are located posteriorly. No other organs could be seen.

The peculiarity of this species is the abundant fecal pellets mixed with orange inclusions filling the tunic which give the uncommon rusty color to the colony (species name). Another peculiarity is the pyloric duct entering the stomach half way along instead of posteriorly.

The secondary curve of the intestine seems indicative of the species and not the result of a contracted state.

*Eudistoma toealensis* Millar, 1975  
Fig. 32, Pl. 5E

*Eudistoma toealensis* Millar, 1975: 222, Kei Islands, Toeal.

**Material Examined:** MNHN: A3 Eud 72, 79, 82—Indonesia, north Sulawesi, Manado, 1°23.13'N; 124°34.22'E, 1 m;—Palau, Peliliu Island, dock area, 6°59.10'N; 134°13.30'E, intertidal and Ngercheu, 7°05.39'N; 134°16.24'E, intertidal.

Numerous lobes in a bunch arise from a common base. They have a cylindrical stalk and an enlarged head containing the thoraces. The test is translucent without encrusting material on the lobes. The orange-red pigmented zooids give an orange color to the colonies (Pl. 5E). The heads are unequal, and measure about 1 cm in length and 1 cm in diameter. The basal mass on which they raise is covered with epibionts and sand. The test is gelatinous and soft on the heads and inside the colony, but superficially harder on the stalks and the common base. The zooids are irregularly crowded everywhere except in the heads where they are parallel.

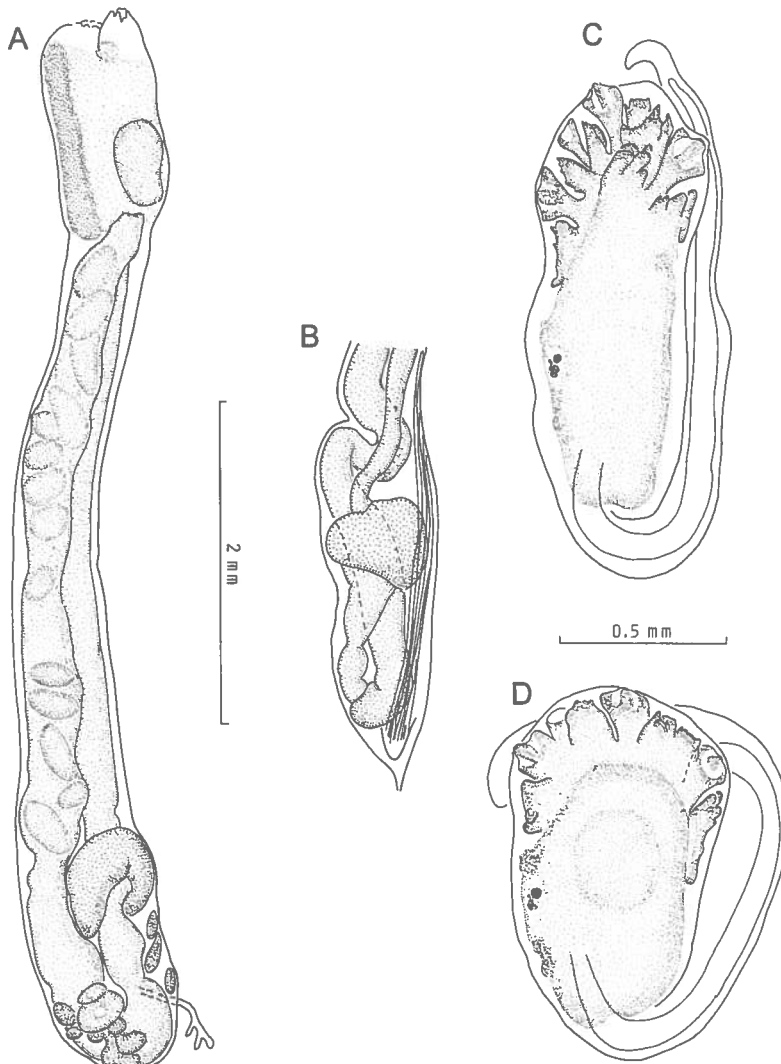


Figure 32. *Eudistoma toetalensis* Millar, 1975: A, zooid; B, detail of the stomacal region; C, D, larvae.

The zooids are large, up to 1 cm in length. Both siphons are short with 6 lobes (Fig. 32A). The lobes are slightly protruding at the colony surface. The thoracic muscles make a regular network, the transverse fibers are as strong as the longitudinal ones. The branchial sac is narrow but up to 20 stigmata were counted on the right side. They are less numerous on the left side. The abdomen has no special characters (Figs. 32A, B). The stomach is large and the ascending limb of the intestine makes a short curve at its level. The gonads are located inside the gut loop. Two to 4 embryos are incubated in the cloacal cavity at different

development stages. Stolonical vessels, often branched, project from the side of the posterior part of the abdomen. The mature tadpoles are elongated (Figs. 32C, D), the trunk reaching a length from 1.1 to 1.3 mm. The 4 conical adhesive papillae are intercalated between 4 or 5 large ectodermal ampullae, each deeply and irregularly divided, the ventral one extending longitudinally. The shape of the papillae and their number are variable (Figs. 32C, D).

Remarks: These specimens differ from the closely related *Eudistoma laysani* (Sluiter, 1900) by their larger zooids and a different structure and size of the larvae.

The type specimen of *Eudistoma toealensis* deposited in the Copenhagen Zoologisk Museum has been examined. The colony is very similar to ours, with a thick base containing crowded zooids and fecal pellets, and raised lobes in an oblique position as described by Millar. This structure may be the result of an influence of the substrate during the growth of the colony. The larvae of the type vary in size and in shape, even in a same lobe of the colony. They are long with 3 to 5 adhesive papillae which are not regularly spaced, and not equally developed, and irregular ectodermal ampullae are along each side. The variability observed for the Sulawesi specimens was also found in the type.

Geographic Distribution: This species seems limited to very shallow substrates in Indonesia and Palau.

#### *Eudistoma* sp.

Material Examined: MNHN: A3 Eud 109—Papua New Guinea, Duke of York Islands, Mioko Island, 4°13.85'S; 152°28.16'E, 23 m.

The colonies are opaque, dark purple with black spots which correspond to the zooid apertures. The surface is smooth. The tunic is tough and rubbery. The colonies are stalked, 1 to 5 cm in diameter and 1 to 3 cm in height. In formalin the pigment diffuses and the fixative takes a red color. No sand is present in the colony but only some rare fecal pellets.

The zooids have a strong musculature and are deeply retracted inside the colony. The body wall is opaque, dark purple. Both siphons have 6 lobes and are equal in size. The number of stigmata in a row could not be counted. The abdomen is long. The stomach is asymmetrical, short, located at  $\frac{3}{4}$  of the abdominal length in the less contracted zooids, it seems to have 2 lateral swellings. The post-stomach is narrow and cylindrical as the mid-intestine, both separated by a constriction. The posterior intestine begins without caeca in the descending limb of the gut, anterior to the loop and remains isodiametrical along its length. At the stomach level the rectum is bent, this does not seem to be due to the contracted state of the zooids. The gonads are simultaneously present in the gut loop, with few testis lobes and a central ovary. A protruding egg is often present above the ovary. Mature tadpoles were not present. An undeveloped embryo is being incubated in the cloacal cavity of some zooids.

Remarks: The peculiar color and colony shape, the long rectum and the small number of testis follicles are not reminiscent of any described *Eudistoma* species.

However, the contraction and the presence of a single colony do not allow to identify the specimen to the species level.

*Exostoma ianthinum* (Sluiter, 1909)

Fig. 33, Pl. 5F

*Polycitor ianthinus* Sluiter, 1909:20

*Exostoma ianthinum*: Kott, 1990a: 234 and synonymy

Material Examined: MNHN: A3 Exo 1 to 7—Palau, Koror State, Turtle Island Basin, 7°18.47'N; 134°30.37'E, 12 m; Rock Islands, 7°18.48'N; 134°28.12'E, intertidal; Mutremdiu, 7°16.51'N; 134°31.55'E, intertidal; Wonder Channel, 7°10.7'N; 134°22.1'E, 1 m;—Federated States of Micronesia, Chuuk Atoll, Weno (Moen) Island, west reef, 7°25.29'N; 151°49.02'E, 4 m; Halimeda sand ridge east of Dublon Island, 7°22.95'N; 151°54.77'E, 45 m;—Papua New Guinea, Port Moresby, Bootless Inlet, south Motupore Island, 9°31.81'S; 147°17.05'E, 3 m.

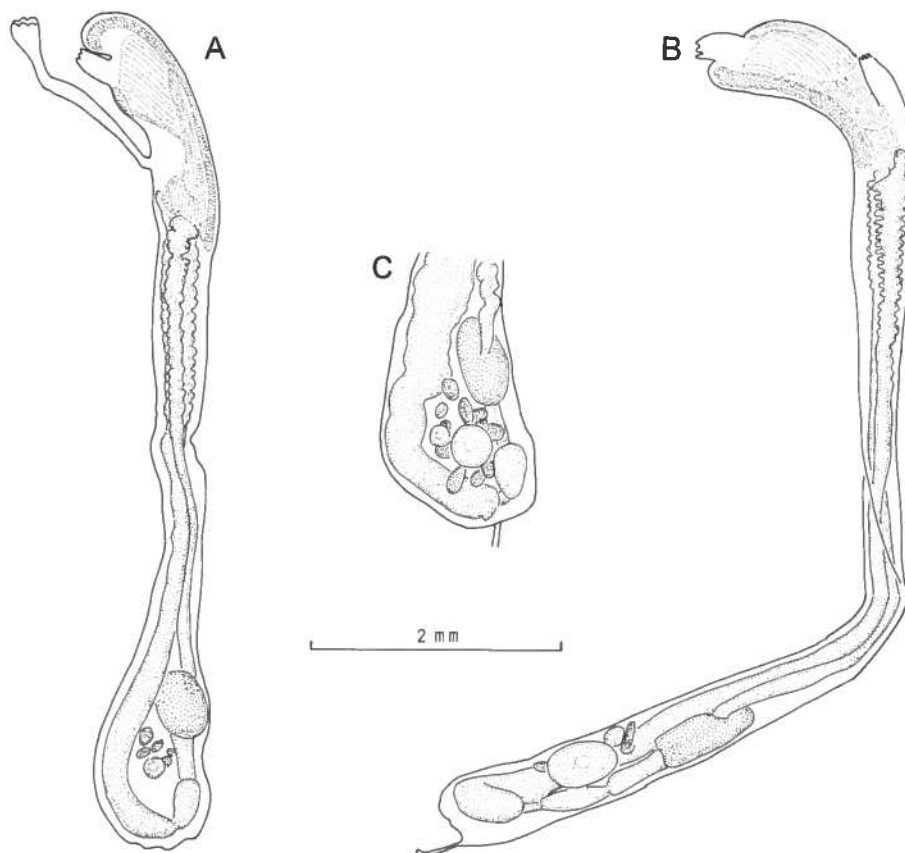


Figure 33. *Exostoma ianthinum* (Sluiter, 1909): A, B, zooids; C, gonad.

The colonies are large irregular masses up to 25 cm across, and 5 cm thick. The color varies from grey to brown, mottled. The colony surface is irregularly swollen and the oral apertures of the zooids are irregularly distributed. There are few very large openings of the cloacal cavities (Pl. 5F). The surface of the colony is wrinkled, rubbery. Sometimes thin epibionts are attached in patches to the colony surface.

The tunic is tough, opaque and dark brown in formalin. The zooids are irregularly spaced, oriented in all directions. The oral siphon has 6 rounded lobes. The cloacal siphon is long and cylindrical, issued from the postero-dorsal part of the thorax (Figs. 33A, B). It has also 6 lobes. The branchial sac is elongated below an unperforated area. There are about 20 stigmata in the first row. An unperforated area also extends at the base of the branchial sac. The esophagus is very long. The stomach is followed by a posterior stomach. In some zooids a longitudinal crest is located on each side of the typhlosole. The mid-intestine is narrow before entering the posterior intestine that is much wider but without caeca (Fig. 33C). The pyloric gland consists of tubules around the part of the rectum facing the stomach. Male gonads were developed in a cluster of testis follicles behind the stomach, inside the gut loop. No larvae were found in these colonies.

Remarks: The species is characterized by its wide and extensive cloacal cavities, and the zooid structure.

Geographic Distribution: The species was already known from the tropical western Pacific (Palau, Philippines, Indonesia and New Guinea).

*Hypodistoma deerratum* (Sluiter 1895)

Pl. 5H

*Distoma deerrata* Sluiter, 1895: 167.

*Hypodistoma deerrata*: Kott, 1990a: 106 and synonymy.

Material Examined: MNHN: A3 Hyp B1 and 2—Papua New Guinea, Madang, Tab Island on barrier reef, 5°10.21'S; 145°50.37'E, 12 m; Boisa Island, 4°00.07'S; 144°57.7'E, 18 m.

The colonies are massive lobes, 15 to 20 cm in extent, with a large volcano-like aperture 2 cm in diameter (Pl. 5H). The surface has grey, tan, or brown translucent smooth undulations encircling hollow rounded parts. The zooids are restricted to the upper layer of the colony, the center consists of a firm core of tunic. Large cloacal channels extend between these two parts. The zooids are distributed in groups.

Both siphons are long and tubular. They have 6 short lobes. We counted 14 to 20 stigmata in the first of the 3 rows of the branchial sac. A large unperforated area lies between the tentacles and the branchial sac. The rapheal languets are short, displaced to the left side.

The stomach has a smooth wall. The digestive loop contains the gonads: a central ovary and few small testis follicles. The abdomen ends in a long vascular appendage. One larva is incubated in a brood pouch appended to the base of the thorax. When mature, this larva has a well developed thorax with differentiated

siphons, a large unperforated area in front of 3 rows of stigmata. The adhesive vesicles are large, very flat, and attached to an abdominal extension. Very thin filiform papillae arise from this part.

**Geographic Distribution:** This species was previously known from western north Australia to Queensland, and now is also known from the Philippines Islands and Torres Strait.

*Cystodytes aucklandicus* ? Nott, 1892

Pl. 5G

*Cystodytes aucklandicus* Nott, 1892: 323, New Zealand; F. Monniot, 1988: 215 Fig. 8, pl.I B-C, New Caledonia.

**Material Examined:** MNHN: A3 Cys 19—Federated States of Micronesia, Chuuk Atoll, oceanside reef channel west of Pis Island, 7°38.97'N; 151°41.22'E, 53 m.

The colonies (Pl. 5G) are encrusting, brown, rubbery, about 5 mm thick, in patches reaching 40 cm across. The zooid apertures are arranged in circular systems. The dark pigment cells are more abundant in the deepest part of the tunic than in the upper layer, which contains some patches of poorly formed spicules.

The zooids have the abdomen enclosed in a capsule made of disk-shaped spicules with indentated margins. Both siphons have 6 lobes. The 6 testis follicles are in a circle. Larvae are not present.

This specimen corresponds well to the samples of *C. aucklandicus* collected in New Caledonia for the color, the spicule shape and arrangement, the shape of the colony and the zooids. As the larvae are missing, the place of incubation cannot be determined, and the specific identification remains uncertain. Nevertheless the spicule shape is very characteristic.

**Geographic Distribution:** The species described from New Zealand has been recorded in New Caledonia (F. Monniot, 1988). It very likely has a wider range than the present records suggests. We believe its presence in Australia is probable, despite Kott's (1990a) estimate that there is only one species of *Cystodytes* there.

*Cystodytes punctatus* ? F. Monniot, 1988

*Cystodytes punctatus* F. Monniot, 1988: 222, fig. 11, pl.2A B. New Caledonia.

**Material Examined:** MNHN: A3 Cys 80, and 81—Palau, Mutremdiu, Barrier Reef, 7°16.51'N; 134°26.71'E, 20 m;—Federated States of Micronesia, Chuuk State, Ushi Island passage, 7°40.40'N; 151°49.50'E, 30 m.

The colonies are of firm consistency, lobated and vitreous with white spots due to the zooids being enclosed in capsules of spicules.

The zooids have short siphons with 6 lobes. The thoracic musculature is weak, mostly longitudinal. There are 2 unperforated areas anterior and posterior to the branchial sac. The stigmata are elongated and very numerous. The abdomen is elongated, linked to the thorax by a narrow and long esophago-rectal waist. The stomach, colored in orange in life, is olive-shaped in the middle of the abdomen. The post-stomach is dilated in a ring before the constriction leading to

the intestine. The testis is made of long follicles arranged in a rosette inside the gut loop. The ovary is not developed and no larvae were found.

The disk-shaped spicules have a thin rim.

This sample looks exactly like the colonies collected in New Caledonia and described as *C. punctatus*. All zooid characters correspond closely, but this species is mainly distinguished from other *Cystodytes* by the larval structure. However, the absence of larvae here does not allow us to be absolutely certain of the specific identification.

*Cystodytes solitus* F. Monniot, 1988

*Cystodytes solitus* F. Monniot, 1988: 223 fig. 12A-C.

Material examined: MNHN: A3 Cys 82, and 83—Palau, Rock Islands, Ngerkuul Pass, 7°19.22'N; 134°29.74'E, 7 m and Kaibaku Cave, 7°19.47'N; 134°29.42'E, 9 m.

The colonies form encrusting sheets several cm across and 1 cm thick, lavender or purple in color. The tunic is tough and translucent with white calcareous spicules arranged around the abdomens of the zooids. The colony surface is smooth. The oral siphons are arranged in circles whose centers have groups of individual cloacal openings. Dark pigment cells are scattered in the entire thickness of the tunic.

The zooids appear very differently according to their state of relaxation. Both siphons are tubular, with 6 round lobes, but the cloacal siphon is much longer than the oral one. There are about 20 to 24 oral tentacles in 3 orders of size. A large unperforated area lies in the upper part of the branchial sac. The first of the 4 rows of stigmata contain 22 to 28 stigmata each and are bent dorsally. The rapheal languets are rather short and slightly displaced to the left side. The thoracic musculature is weak with thin fibers. There is a strong constriction between the thorax and the abdomen. On the left side, the body is deeply depressed above the esophagus aperture. The body wall forms a horizontal fold above the upper part of the esophagus, on the right side of the body. The abdomen is long in relaxed animals. The esophagus is narrow, the stomach is located just below the middle of the abdomen length. The gut loop is wide. The rectum begins with an enlarged part at the end of the descending limb of the gut. The testis follicles are arranged in a circle at the bottom of the gut loop. The sperm duct starting from the center of the rosette is straight. The ovary is anterior to the testis. A muscular bundle extends along the abdomen. Only one large larva is incubated in the cloacal cavity, but there is no brood pouch. The external epithelium of the larvae contains numerous dark pigment cells, lacking in the zooids. There are 3 adhesive papillae encircled by a rod made from 4 pairs of ectodermal ampullae. The larval trunk measures 1.2 mm.

**Geographic Distribution:** The species described from New Caledonia, and now known from Palau, certainly has a larger distribution in the western tropical Pacific Ocean.



*Nephtheis fascicularis* ? (von Drasche, 1882)

Fig. 34, Pl. 6A

*Nephtheis* (?) Gould, 1852: pl. 52, fig. 621, Philippines.*Oxycorynia fascicularis* von Drasche, 1882: 177, Caroline Islands.*Colella thomsoni* Herdman, 1886: 94, pl. 10–13, Philippines.*Nephtheis malayensis* Sluiter, 1909: 36, pl. 3, fig. 8–10, Indonesia.*Nephtheis centripetens* Sluiter, 1909: 38, pl. 2, fig. 17, pl. 3, fig. 12, pl. 8, fig. 4, Indonesia.*Nephtheis faciformis* Sluiter, 1909: 39, pl. 3, fig. 3–4, pl. 7, fig. 2, Indonesia.

Material Examined: MNHN: A3 Nep 1 and 2—Indonesia, Banta Island, Komodo region—Papua New Guinea, Madang, Tab Island barrier reef, 5°10.21'S; 145°50.37'E, 10 m.

The colonies are groups of stalked lobes arising from a common base (Pl. 6A). The largest has a stalk 7 cm long and the head containing numerous zooids is 8.5 cm in length and 2.5 cm in diameter, tapering at its free extremity. The color is bright blue in life, dark blue or dark green in alcohol. The tunic is soft, trans-

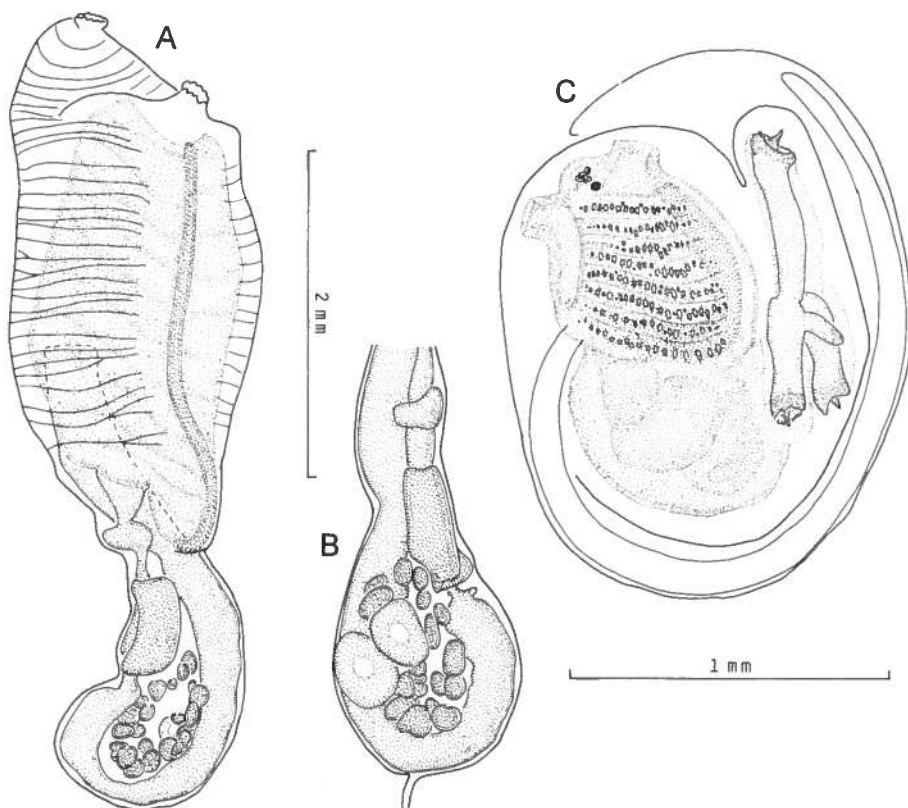


Figure 34. *Nephtheis fascicularis*? (von Drasche 1882): A, zooid; B, abdomen with gonads; C, larva

parent on the head, a little harder and opaque on the stalk. All zooids of the same colony are about the same size and the same development stage. Their ventral side is external, the abdomen internal.

The zooids are deeply pigmented by dark cells in a dense network of blood sinuses in the thoracic body wall, and by blue and dark opaque cells in all abdominal organs. Both siphons have their margin undulated by contraction (Fig. 34A). The oral siphon has a short velum anterior to the 8 tentacles. The thoracic musculature is mostly transverse with numerous bundles, regularly spaced, some of them anastomosed dorsally and ventrally (Fig. 34A). The branchial sac is wide with 14 to 25 rows of numerous long stigmata. It forms a postero-ventral pouch above the esophageal opening. The cloacal cavity is large and contains tadpoles. The abdomen is much smaller than the thorax. It is long, totally obscured by pigment cells. The gut loop is narrow, even at its posterior end. The esophagus has longitudinal irregular plications, with an enlarged quadrate segment in its middle (Fig. 34B). The stomach is olive shaped and smooth-walled. The intestine is not divided in regions and the anus has a thin smooth rim. The testis follicles are distributed on the whole gut loop. The ovary is central. The sperm duct follows the rectum with the oviduct. The latter crosses the esophagus entrance and opens at the bottom of the thorax. The heart is vertical in the gut loop and voluminous. The embryos begin their development in the oviduct and become free in the cloacal cavity when the tail is developed. In aged larvae, there are 3 adhesive papillae in a triangle and a branchial sac with 6 to 8 rows of stigmata (Fig. 34C).

Remarks: These specimens correspond to *Nephtheis fascicularis* as described from New Caledonia by F. Monniot (1988) or from Australia and the Phillipines by Kott (1990a). The type specimen of von Drasche (1882) has not been located. For the other synonymous species, the type and paratype specimens have been studied:

*Nephtheis thomsoni* (Herdman, 1886) has zooids similar to those of *N. fascicularis* Sluiter, 1909 and *N. centripetens* Sluiter, 1909 for all characters: musculature, branchial sac, digestive tract and gonads.

In *Nephtheis malayensis* Sluiter, 1909 the colonies are branched, with well developed stalks but very small and young zooids. The species cannot be precisely identified, with insufficient characters, but may be *N. fascicularis*.

*Nephtheis centripetens* Sluiter, 1909 is definitely a synonym of *N. fascicularis*, with a discolored type and deeply pigmented paratype. The number of rows of stigmata varies from 13 to 15 in both cases, and the esophagus has a smooth wall with a square enlargement in the middle as in *N. fascicularis*. The thoracic musculature is the same, as are the gonads and the larvae. The head of the colony is clearly separated from the stalk by a constriction (the sample labelled paratype comes from a station different from that of the type).

With *Nephtheis faciformis* Sluiter, 1909 a problem arises. In the sample labelled type, or lectotype from the Siboga station 310, the largest colony with a single lobe, well preserved, has no constriction between the head and the stalk. The zooids are relatively small but have 20 rows of stigmata. The esophagus is short, curved, isodiametric, with a smooth wall. The stomach is relatively short,

well separated from the intestine. The sample labelled paratype from the Siboga station 49A has zooids with only 13 to 15 rows of stigmata, a long esophagus with a smooth wall and an enlarged pouch, in its middle.

The variability in the number of rows of stigmata, length of the abdomen and general pigmentation is difficult to establish with specimens preserved for a long time in alcohol or formalin and collected in different parts of the world. The morphology of the zooid may be different with different sizes of the colonies. The study of large populations would be necessary to establish if there is only one species or more.

Geographic Distribution: Indonesia, the Philippines and Caroline Islands, as well as western, northern and eastern Australia and New Caledonia. The present collection does not extend the known range of this species.

*Archidistoma diminuta* (Kott, 1957)

*Clavelina diminuta* Kott, 1957: 89, W Australia.

*Pycnoclavella diminuta*: Millar, 1963: 715 fig. 21, NW Australia; Kott, 1972: 170, fig. 13, 14, S Australia; Kott, 1990a: 73, fig. 24, pl. 6a-f, Australia and Philippines. ? *Archidistoma rubripunctum* F. Monniot, 1988: 200, fig. 2 C,D, New Caledonia. Material Examined: MNHN: A3 Arc A9—Federated States of Micronesia, Chuuk Atoll.

The colony, in bad condition does not contain larvae, but has well developed gonads covering the whole gut loop, behind the stomach. Its appearance in life is unknown. This colony corresponds to the species defined by Kott (1990a). Some characters of her definition of *A. diminuta* indicate that *Archidistoma rubripunctum* F. Monniot, 1988 may be a synonym. On the contrary, *A. richeri* F. Monniot, 1988 is a distinct species characterized by its smaller size, a less wide thorax, and the presence of numerous larvae incubated inside the oviduct.

Kott (1990a) placed this species in the genus *Pycnoclavella*, a decision with which we disagree. The genus *Pycnoclavella* established by Garstang (1891) for *P. aurilucens* from the British Channel, has after him, as major characteristic, the presence of a basal mass of tunic "traversed in all directions by stolonial tubes, some of which even extend and branch in the esophageal region of the zooids, where they remain sterile or, more rarely, give rise to new buds" (p. 53). Garstang considered this genus to be intermediate between *Clavelina* Savigny, 1816 and *Stereoclavella* Herdman, 1891b, a distinction corresponding to a more or less large extension of the basal common tunic. However, these two genera have been synonymized (Brunetti 1987, Kott 1990a). The definition of the genus *Pycnoclavella* has been largely modified by Trason (1963) who studied in detail the mode of budding and the larva of the Californian species *P. stanleyi* Berrill & Abbott, 1949. *P. aurilucens* and *P. stanleyi* differ morphologically in the larval structure, *P. aurilucens* lacking epidermal papillae and *P. stanleyi* having a crown of papillae. Trason (1963) showed that the budding does not originate from chambers at the tip of the stolons, as in *Clavelina lepadiformis* after Brien & Brien-Gavage (1927), but rather by strobilization of the zooid and regeneration of one or several stro-

biles. For Trason (1963) this was the main character of the genus which she considered to be intermediate between the Polyclinidae and the Polycitoridae.

Trason (1963) also described the structure of the larva which possesses adhesive papillae of the type: "tubular invaginated papillae" according to Cloney's terminology (1977) and similar to those described by Trason (1957) in the Polyclinidae *Euherdmania claviformis*.

Millar (1953, 1963) used *Pycnoclavella* without mentioning his reasons for using this generic name.

Kott (1990a) described a new family, the Pycnoclavellidae, with *Pycnoclavella* as the type genus of the family, which also included the monotypic genus *Euclavella* Kott, 1990a. The principal characters of the family concern the structure of the larval adhesive papillae, and the mode of budding, in reference to the work of Trason (1963). The other defining characters concern the proportions of the different parts of the body, or characters all of which representing exceptions in the family.

Is there any real significance to differences in the budding and in the larva? The budding of *P. aurilucens*, type of the genus, is described as producing at the same time stolons and buds. It does not appear very different from the budding of *Clavelina* (Garstang 1895). Garstang (1895) in his work describing budding in Tunicata did not mention the genus *Pycnoclavella*, despite having described it several years earlier. Pérès (1953) redescribing the Mediterranean specimens confirmed the duality of the mode of budding. Brien (1970) described a regeneration of the thorax of *Clavelina lepadiformis* from sectioned abdomens. It is common to observe regenerations of damaged zooids in *Clavelina* which have lost their thorax, or from regressed zooids which reorganise after unfavorable conditions. The potential for both budding or regeneration coexists in *Clavelina* and is more or less expressed according to the species or the conditions of life of the colonies.

The structure of the larval adhesive papillae in all ascidian families was studied in detail by Cloney (1977, 1978, 1990) and 9 different kinds of papillae described. A tenth condition, the absence of papillae, can be added. In the Stolidobranchia, the Molgulidae and the Pyuridae have only one kind of papillae while the Styelidae two kinds. In the Phlebobranchia all have the same papillae except the Perophoridae. Among the Aplousobranchia, only the Didemnidae seem homogenous. The Polycitoridae and Polyclinidae possess 4 kinds of papillae in different genera. The *Eudistoma* (Polycitoridae) have 3 kinds of papillae; the genus *Euherdmania* has papillae similar to those of *Pycnoclavella* and for a species: *E. dumosa* F. Monniot, 1987, an other kind of papillae.

The structure of the adhesive papillae was histologically studied in 28 species and this represents one per thousand of the described ascidian species. Ten different structures were defined. Consequently it seems questionable to consider a single kind of papilla as a character justifying a generic division and to further base the creation of a new family, particularly when this type of papilla is also found in another family. To separate the genera, we use instead the branchial development: 2 rows of stigmata in *Archiascidia* which correspond to the 2 larval primary rows; 3 rows of stigmata in *Archidistoma* which correspond to the division

of the first primary row only, and in *Clavelina* division of the two larval rows of stigmata and multiplication by the anterior and posterior sides of the branchial sac.

Geographic Distribution: Previous records include western, southern, eastern, and northern Australia, New Caledonia, Philippines.

*Clavelina arafurensis* Tokioka, 1952

Fig. 35E, Pl. 6B

*Clavelina* (*Synclavella*) *arafurensis* Tokioka, 1952: 97, fig. 5, Papua New Guinea, Pearl Oyster Bed, Melville Bay; Nishikawa, 1984: 116, Truk (Chuuk) Island; Kott, 1990a: 38, fig. 7, pl. 1, e-f, W. Australia, Philippines.

Material Examined: MNHN: A3 Cla 68—Palau, Koror State, Rock Islands, Ngerkuul Pass, 7°19.13'N; 134°29.87'E, 10 m.

The colony consists of 1 to 7 zooids grouped in a cylinder of common test (Pl. 6B). The groups are united at their base by a network of stolons. In life, the tunic is transparent and the thoraces are translucent, black or purple, with two opaque yellow-green patches on both sides of the oral siphon. This design and color seem characteristic of the species, as figured by Kott (1990a, pl. 1, e, f). The color disappears in fixatives.

In the Palau specimens we counted 14 rows of stigmata—12—16 indicated by Kott (1990a), 16 by Tokioka (1952). Tokioka described and figured a rather elongated stomach with 10 to 12 plications. Kott (1990a) describes a "large roomy" stomach with "4 or more sometimes irregular rounded folds apparently artifacts". Our specimens show a pyriform stomach with thick swellings (Fig. 35E) and, as noted by Kott (1990a), a neat post-stomach.

Geographic Distribution: The species was previously recorded in all the western Pacific and western Australia.

*Clavelina meridionalis* (Herdman, 1891)

Figs. 35A–D, Pl. 6C

*Podoclavella meridionalis* Herdman, 1891a: 603, Australia, Port Jackson.

*Clavelina meridionalis*: Kott, 1990a and synonymy: 48, western and eastern Australia.

Material Examined: MNHN: A3 Cla 67—Indonesia, north Sulawesi, Manado.

This species has large isolated zooids (up to 8 cm) (Pl. 6C), attached to the substratum by very short and stout rhizoids. The body is horn-like, without separation in thorax and abdomen. The siphons are apical, widely open. The oral siphon opens perpendicularly to the body axis and the cloacal aperture is directed upwards. Both siphons are short without lobes, with a denticulated rim. The tunic is transparent and the body wall opaque brown-purple. There are gold yellow patches around the oral siphon and between the siphons; their disposition is variable according to the specimens. The tunic is covered with epibionts, including small algae, didemnid colonies and hydrozoans. After fixation, all colors disap-

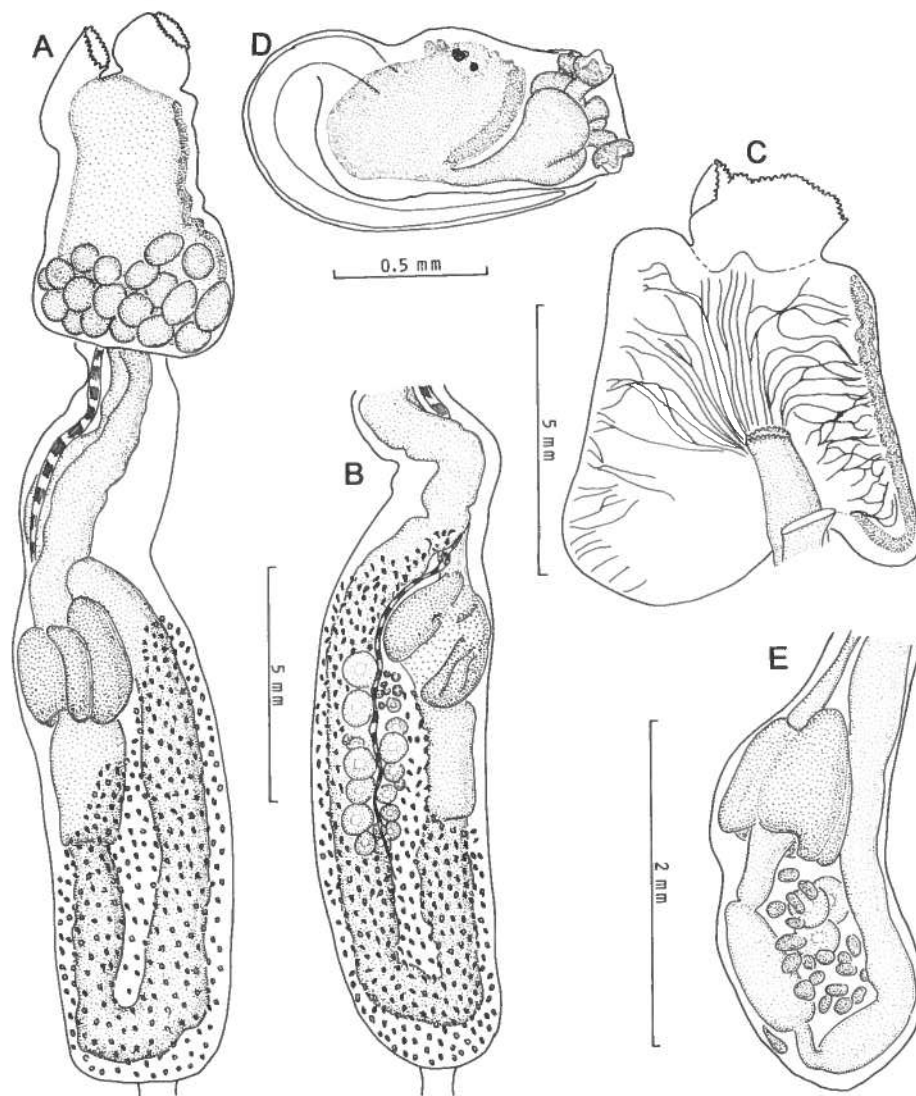


Figure 35. *Clavelina meridionalis* (Herdman, 1881): A, zooid; B, posterior part of the abdomen; C, thoracic muscles; D, larva. *Clavelina arafurensis* Tokioka, 1952: E, posterior part of the abdomen.

pear. In many specimens the basal tunic has one or several test cylinders, hard and opaque, which represent the tunics of eldest zooids.

The zooid is divided in 3 parts which proportions cannot be measured when contracted: the thorax, the abdomen, and a long thick opaque process going down to the base of the tunic. The variable length of this process may exceed that of the thorax and abdomen, and seems to depend on the number of successive zooids.

We have not been able to establish a muscular formula, the tissues being too thick and contracted. In a specimen opened along the ventral side (Fig. 35C), parallel dorsal fibers can be seen. In the anterior half of the thorax is located an anastomosed network of transverse fibers joining the dorsal longitudinal fibers. In the posterior part, these fibers do not seem to join the longitudinal fibers. They are well developed on the left side of the body; they are very thin on the right side, where the larvae are incubated. The muscles extend along the abdomen. A dozen short and stout tentacles are located behind a velum. The prepharyngeal band has two high membranes. The dorsal tubercle has the shape of a coffee-bean with a straight aperture. The dorsal lamina consists of at least 27 languets. In the anterior and posterior parts of the branchial sac we observed incomplete rows of stigmata formed from the dorsal lamina with perforation of round stigmata before the development of transverse vessels starting from the dorsal lamina. In the middle part of the branchial sac, the transverse vessels appear from the endostyle to multiply the number of rows of stigmata. The transverse vessels have internal high blades; 0.2mm. We counted more than 50 long stigmata in a half row. In the less contracted parts of the branchial tissue, the stigmata measure 0.30 to 0.45 mm.

The abdomen (Figs. 35A, B) is cylindrical and is 3 to 4 mm in diameter. It is separated from the thorax by a definite constriction. The esophagus does not have differentiations. It has 3 large folds on the right side and the left side is more or less plicated. The post-stomach is well differentiated. The intestine begins before the curve of the gut loop. The anus possesses numerous round lobes. The ovary is located on the left side of the body (Fig. 35B). The testis forms small follicles scattered around the intestine which even overlie the stomach on the right side. The sperm duct arises from the bottom of the gut loop, crosses the ovary seeming to divide it into two parts, and ends near the anus. The oviduct is dilated in the right cloacal cavity where numerous larvae are incubated. The heart is very large and occupies the whole right side of the abdomen up to the stomach level. The larvae 1.25 mm long, have 3 adhesive papillae in a triangle (Fig. 35D).

This species seems to always have solitary zooids. Sometimes, young zooids are settled close to the base of adult individuals, but no relations exist between the zooids.

Remarks: Five species of *Clavelina* are known to have isolated zooids. *C. miniata* Watanabe & Tokioka, 1973 actively buds, but the newly formed zooids part very early from the mother zooid, even before the siphons are open, and a cluster of zooids results. In *C. dagysa* (Kott, 1957), *C. oliva* Kott, 1992b, and *C. viola* Tokioka & Nishikawa, 1976 colonies may occur. Only two species: *C. meridionalis* (Herdman, 1891a) and *C. ostrearium* (Michaelsen, 1930) have exclusively solitary individuals.

Our specimens do not perfectly correspond to any description of these species. *C. dagysa* and *C. ostrearium* have a characteristic uniform blue color, remaining in fixatives. These two species have also the abdomen prolonged down to the base of the tunic. The anus of *C. viola* has two plain edges, it is lobated in *C. meridionalis*. *C. oliva* and *C. meridionalis* have variable colors either in a same area (*C. meridionalis*) or in different seas (*C. oliva*). After Kott (1990a), the species

are distinguished by their size, 20 cm for *C. meridionalis* and 2.5 to 5 cm for *C. oliva*.

The musculature of *C. oliva* contains as many fibers issued from the siphons as from the ventral side, while *C. meridionalis* has a transverse musculature mostly issuing from the endostylar area. These characters seem very variable, and for these two species there is no agreement between the muscle formula given in the text by Kott (1990a) and her drawings. The exact disposition of the muscles seems to be a good character to separate the *Clavelina* species, but very difficult or impossible to observe in contracted specimens.

The stomach of *C. meridionalis* seems to be closer to the posterior end of the gut loop than to the thorax. The stomach has 3 marked folds. On the contrary, in *C. oliva* the stomach is located in the middle of the abdomen with well marked folds in the type specimen (Kott, 1990a, fig. 17C) or no folds at all in another specimen.

Our specimens are intermediate between these two species for both the size and the anatomical characters. They have anastomoses of the transverse muscular fibers and this was not described in any species. In our opinion, the variability in the *Clavelina* species is not sufficiently known, and we presently include the specimens of this collection in the species *C. meridionalis sensu lato*.

Geographic Distribution: Widely distributed around Australia; Indonesia.

*Clavelina obesa* ? Nishikawa & Tokioka, 1976

Fig. 36, Pl. 6D

*Clavelina obesa* Nishikawa & Tokioka, 1976: 73, Japan.

Material Examined: MNHN: A3 Cla 65—Palau, Koror State, Ngerkuul Pass, 7°19.13'N; 134°29.87'E, 10 m.

The colony settled on limestone consists of a cluster of zooids linked by stolons. The stolons arise from the zooids at any part of the body. In life, the animals are of a pale blue with an iridescent white crescent dorsally around the cloacal siphon (Pl. 6D). The gut appears white in photographs, a color probably due to gut contents. The cloacal siphon is the longest one. On the upper side are 3 dark spots; at the top of the endostyle, above the neural ganglion and at the base of the cloacal siphon. The branchial sac has a dark line along the dorsal lamina and a dark line along the endostyle (Pl. 6D). The tunic is perfectly transparent; after fixation it becomes a little irregular with some low papillae near the siphons.

The largest zooid has a thorax 9 mm long and abdomen 8.5 mm long and a vascular stolon 6 mm long. The musculature is mostly oblique with 13 to 16 bundles, branched and anastomosed. The muscles do not reach the dorsal line of the body. They fuse with the musculature of the opposite side along the endostyle (Fig. 36A, B). There are no longitudinal muscles either on the thorax or the abdomen. The oral siphon has a strong circular musculature, while very few fibers encircle the cloacal siphon. The 12 tentacles are short and stout. The prepharyngeal band is a single protruding rod. The dorsal tubercle has not been clearly



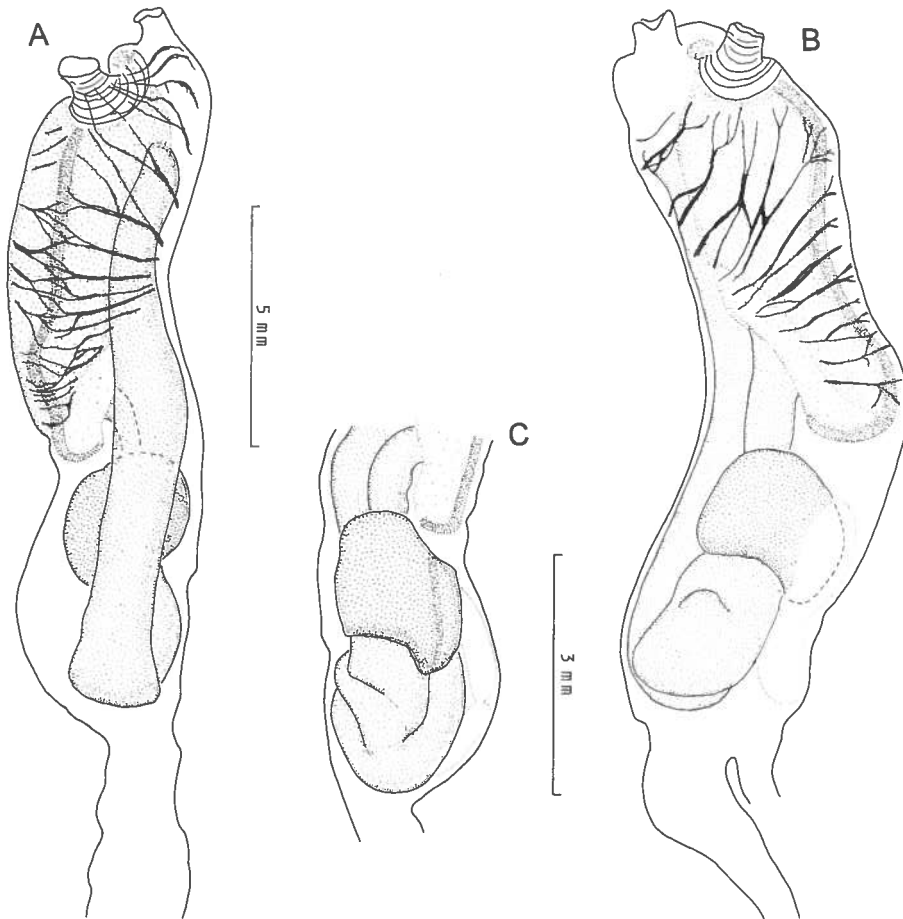


Figure 36. *Clavelina obesa?* Nishikawa & Tokioka, 1976: A, B, both sides of the thorax; C, detail of the stomach.

seen. There are 14 sharp dorsal languets, of reduced length posteriorly. The 15 rows of stigmata are separated by high transverse laminae. There is a large unperforated area at the posterior end of the branchial sac (Fig. 36A). The esophagus is cylindrical. The globular stomach has a well-marked typhlosole. The post-stomach has an irregular outline (Fig. 36C). The intestine is full of sediment and it has not been possible to determine exactly at which level of the thorax the anus opens. None of the zooids have gonads. The heart is voluminous and extends beyond the stomach.

Remarks: This colony has some similarity to *Clavelina obesa* Nishikawa & Tokioka, 1976 with a few exceptions. The color is a little different: "When alive, the zooids were shining in bluish white through the transparent test and looked at a distance as if they were luminescent" (Nishikawa & Tokioka 1976, p. 73). A white crescent around the cloacal siphon is not mentioned. The muscle distribu-

tion and the gut shape are identical. The anus of *C. obesa* is rather posterior at 3 or 4 rows of stigmata from the esophagus opening, but it seems to be more anterior in the Palau specimens. *C. obesa* is said to have 4 longitudinal grooves on the stomach wall, distinct in young zooids, "but in some larger specimens some of these plications may become much less distinct and almost obscure" (Nishikawa & Tokioka 1976, p. 73). They were not observed in the present specimen. Nishikawa & Tokioka suggested that the small papillae around the siphons may be a specific character of *C. obesa*, but we are not certain that the swellings of the test of the Palau specimens exactly correspond to what the Japanese authors saw.

The Palau specimens differ from all other Indo-Pacific *Clavelina* species, by the muscle distribution, the shortness of the gut and the structure of the colony.

Geographic Distribution: *Clavelina obesa* has only been previously recorded from the type station in the Japanese Takegasima Island facing the Kii Channel.

*Clavelina robusta* Kott, 1990

Figs. 37A–C, Pl. 6E

*Clavelina robusta* Kott, 1990a: 61, fig. 20, pl.4g and synonymy.

Material Examined: MNHN: A3 Cla 61—Indonesia, north Sulawesi, west of Manado, 1°23.74'N; 124°32'41'E, 10 m.

The colonies from Sulawesi were overhanging in coral reefs 1 mile off shore. The general color of the zooids was of a dark green, translucent, with yellow rings around the siphons (Pl. 6E). The zooids, 2 cm in length, are almost entirely separated from one another, joined basally in a common test which contains the abdomens and vascular ampullae. The basal tunic is thick and resistant; that surrounding the thoraces is soft, but thick.

The thorax is a little longer than the abdomen. The siphons are close to each other, the oral one double the width of the cloacal. The thoracic musculature (Fig. 37A) is made of parallel longitudinal fibers the half of which comes from the oral siphon, the others originating from the endostylar region. In the middle part of the thorax, the bundles are well formed. Anteriorly and posteriorly, the muscles are branched. The general disposition is characteristic but the number of muscles varies according to the thoracic regions and to the individuals. The muscles extend on the left side of the abdomen. They form 2 bundles at the base of the abdomen where each makes an anchoring mass in the tunic (Fig. 33B), as in the genus *Diazona*. The 24 tentacles in 4 orders arise from a high crest. The largest are clearly behind the crest where the latter describes deep curves (Fig. 37C). The prepharyngeal groove has two high blades parallel, without dorsal V. The dorsal tubercle is protruding and opens in a slit (Fig. 37C). The dorsal lamina is made of large languets in prolongation of the transverse vessels. The dorsal lamina is located in the center of a wide unperforated band. There are 20 to 24 long regular stigmata in a row. The transverse vessels are high; the posterior one is lower and does not reach the dorsal lamina. The esophagus opening is anterior to the bottom of the branchial sac, which is expanded into a small pouch.

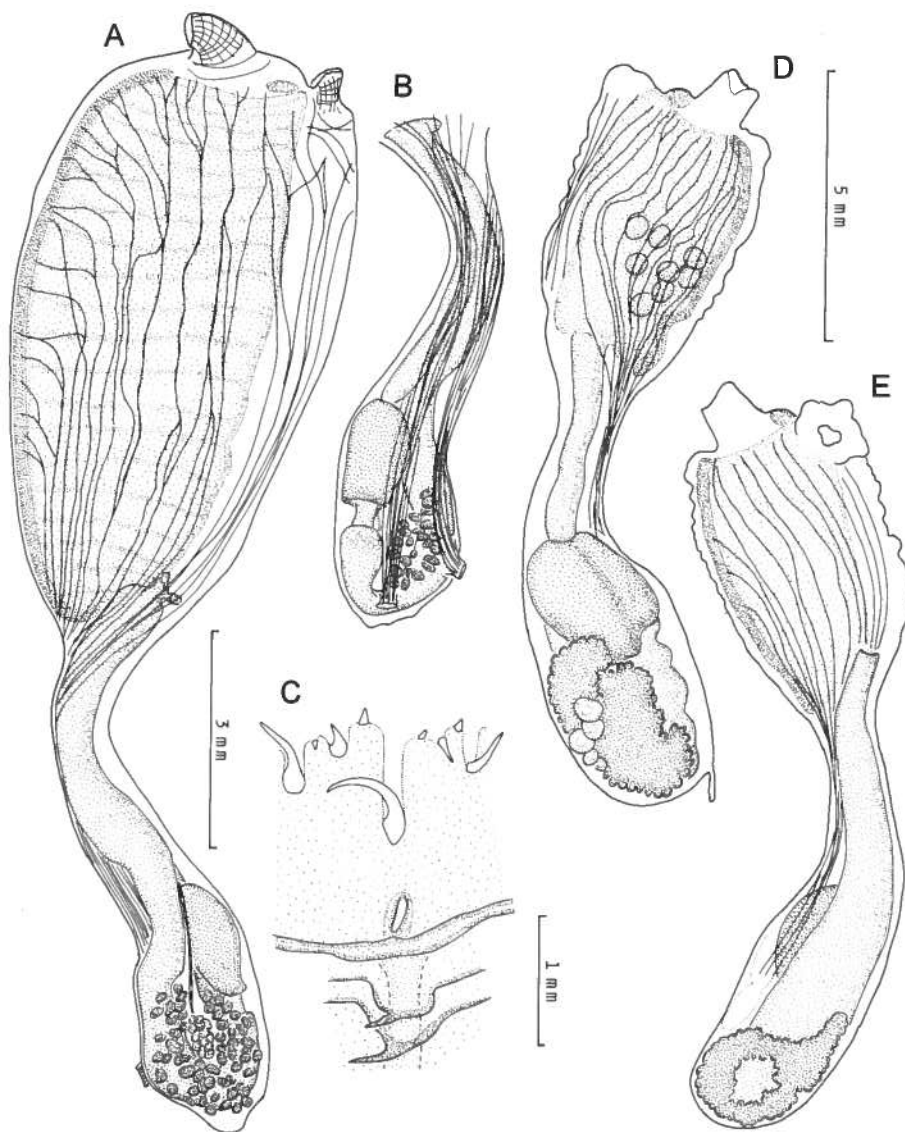


Figure 37. *Clavelina robusta* Kott, 1990: A, zooid; B, abdominal muscles; C, dorsal area. *Clavelina* sp.: D, E, both sides of a zooid.

The stomach (Figs. 37A, B), a little posterior to the middle of the abdomen, has no folds. The post-stomach is present. The proximal end of the rectum is expanded and surrounded by tubules of the pyloric gland. The intestine ends at the bottom of the cloacal cavity in an anus with two scalloped lobes. The massive ovary is on the left side just posterior to the stomach. The testes (Figs. 37A, B) are scattered over the whole left side and overlap slightly onto the right. The

incubation of the larvae begins in the distal part of the oviduct. In the specimens of this collection, the larvae are not fully developed and none are in the cloacal cavity.

Remarks: This sample corresponds well to the description of Tokioka (1967) for *Clavelina moluccensis*, specimens from Palau, whose color was slightly different "body dark blue and anterior portion of zooid surrounding branchial and atrial apertures a very bright yellow". Kott (1990a) noted that specimens from Philippines were black with fluorescent green rings around the siphons.

Geographical Distribution: The geographical distribution of *C. robusta* includes Japan, Northern and Western Australia, Palau, Philippines and Indonesia.

*Clavelina* sp.

Figs. 37D, E, Pl. 6F

Material examined: MNHN: A3 Cla 66—Palau, Rock Islands, Ngerkuul Pass, 7°19.13'N; 134°29.87'E, 3 m.

The colony is a cluster of erect zooids slightly linked to a small common base, but sometimes some individuals arise from the tunic of a zooid of the preceding generation. No extensions of the adult zooids penetrate this base. When living, the zooids were steel blue and opaque, the pigment being located in the body wall. Each siphon has a golden ring, wider on the oral siphon (Pl. 6F). The cloacal siphon is smaller, more posterior. The gold-yellow color is absent above the neural ganglion. After fixation the yellow color disappears and the body wall becomes brown-purple and opaque anteriorly.

Contracted the zooids reach at most 15 mm in length, with 6 to 7 mm for the thorax and 9 mm for the abdomen. At the base of the colony, the tunic has swellings filled with vascular ampullae. There are about 20 longitudinal muscles on each side, more crowded ventrally. The muscles formula established according to the terminology of Tokioka & Nishikawa (1976) is 4 E.6 to 10B.10D = 20. It does not seem identical on both sides of the body wall. The thoracic contraction makes a distinction between branchial and dorsal muscles difficult. Thoracic muscles extend onto the abdomen (Figs. 37D, E). The anterior part of the body was too contracted to accurately determine the oral tentacles and neural area. About 30 rows of stigmata are separated by transverse thick and high crests. The rapheal languets are blunt and short. The esophagus is long (half of the abdomen length) and has no pre-stomach. Only the typhlosome is visible on the globular stomach. The anus opens at the bottom of the cloacal cavity. The gonads are mostly located on the dorsal side of the body, and some on the right side of the gut loop (Fig. 37D). They consist of a slightly protruding ovary surrounded by a thin layer of testis follicles extending over the intestine and a part of the stomach. The voluminous heart is ventral. Some eggs are incubated in the right side of the cloacal cavity. The larvae were not yet developed.

Remarks: These specimens resemble the Japanese *Clavelina* described by Tokioka & Nishikawa (1975, 1976), and Nishikawa & Tokioka (1976), and particularly *C. elegans* (Oka, 1927a) and *C. cyclos* Tokioka & Nishikawa, 1975. These

species have in common the shape of the colony (except that the zooids for *C. elegans* have common stalks) and the same general distribution of the muscles (more numerous in the Palau species: 20 instead of 10 to 13 in *C. elegans* and 15 in *C. cyclus*). The number of rows of stigmata is also larger in the present specimens (30) than in *C. cyclus* (maximum 22) or in *C. elegans* (16 to 30). *C. cyclus* incubates its larvae in the terminal part of the oviduct or at the bottom of the cloacal cavity. It always has a striated stomach, that of *C. elegans* is more irregular. The appearance of the living *C. cyclus* is clearly different from the Palau species (see Nishikawa & Tokioka 1976, pl. 1) translucent with a narrow yellow ring at the base of the oral siphon, and not on its rim. *C. elegans* is quite transparent and cobalt blue, and becomes purplish in the fixative.

We do not have enough material of the present species to be able to name it.

#### Family Holozoidae

##### *Stomozoa roseola* (Millar, 1955)

*Clavelina roseola* Millar, 1955: 139, South Africa.

*Stomozoa murrayi* Kott, 1957b: 131 fig. 2–8, Red Sea.

*Stomozoa roseola*: Kott, 1990a: 157 and synonymy.

Material Examined: MNHN: A3 Sto 4—Indonesia, north Sulawesi, west of Manado, 1°23.74'N; 124°32.41'E, 20 m.

The colonies consist of several conical lobes, joined at their base, measuring from 4 to 5 cm in height and 1 to 2 cm for the diameter in the upper part. The translucent test has a dark purple color, the same as for zooids. This stain fades in alcohol, but many dark purple cells persist in the test, fewer in discolored zooids. Orange pigment cells are also present at the base of the oral lobes and in the branchial tissue in preserved specimens. In the superficial layer of the test, on the sides of the lobes, discoid crystals are scattered. They are not easily soluble in acetic acid, polarize the light and may be made of calcium oxalate.

The zooids apertures, at the colony surface, are seen as 2 fringed holes at the top of small protrusions. The bodies are perpendicular to the colony surface and measures 15 mm at least. The siphons have an indentated margin. Strong muscular bundles originate from the oral siphon on each side; some join the muscular ribbon along the endostyle. Other muscular fibers start from the cloacal siphon. All muscles are gathered in a longitudinal ribbon along the abdomen. The oral tentacles are on a line. The branchial sac comprises 24 to 25 rows of about 50 stigmata on each side. The transverse sinuses possess high membranes. The abdomen is longer than the thorax. The stomach is posterior, olive-shaped, with longitudinal folds probably due to contraction. The male gonads were absent in the studied colony, the ovary is located at the bottom of the gut loop. An immature embryo is incubated in the posterior part of the thorax in each zooid. The most differentiated we have found has 3 triradially arranged adhesive papillae. The trunk size is 1 mm, but contracted.

Remarks: The characters of the present specimens correspond well to those previously described for the species, except for the color of the colony, very dark

here. The siphons, muscles and number of rows of stigmata are the same. The species is cosmopolitan, so its presence in Indonesia is not surprising. The known distribution comprises Brazil, Guyana, Red Sea, South Africa, Indonesia, and New Caledonia.

*Sigillina signifera* (Sluiter, 1909)

Pl. 6G

*Polycitor signiferus* Sluiter, 1909: 5

*Sigillina signifera*: Kott, 1990a: 100, fig.34, pl.8c-d and synonymy.

Material Examined: MNHN: A3 Sig 2, 4 and 5—Palau, Koror State, Ngerkuul Pass, 7°19.13'N; 134°29.87'E, 7 m; Stone Reef, 7°11'N; 134°22.3'E, 5 m;—Federated States of Micronesia, Chuuk lagoon, S. Moen Island, sand flat, 7°24.60'N; 151°50.50'E, intertidal.

The colonies are dark green or dark blue (Pl. 6G) with a transparent tunic and the dark color of the zooids remains in fixatives. All characters are in agreement with the previous descriptions (see Kott 1990a). The long post-abdominal prolongation is well muscularized. Larvae being incubated in a thoracic brood pouch are not fully developed in the Palau colony.

Geographic Distribution: The species was already known from Palau Islands, Indonesia, Philippines and the tropical eastern and western coasts of Australia.

*Sigillina* sp.

Fig. 38A, Pl. 6H

Material Examined: MNHN: A3 Sig 1—Indonesia, north Sulawesi, west of Talisei Island, 1°51.52'N; 125°03.84'E, 18 m.

The colonies are stalked (Pl. 6H). According to the collector, the heads of the different colonies had diverse colors: white, blue, purple, orange and peach. Their size is from 4 to 12 cm in height. The zooids are in the head while the long vascular appendages extend into the stalk. No systems were observed in the zooid distribution. The oral siphons are more posterior than the cloacal ones.

The zooids are all immature in the colony observed. Both apertures are similar with 6 lobes. The thorax (Fig. 38A) is wider than high and the first stigmata row is slightly curved dorsally. About 50 stigmata were counted in a half row (Fig. 38A), they are not cut by parastigmatic sinuses. The transverse sinuses are raised in high membranes. The abdomen is narrower than the thorax. It is short with a narrow digestive loop. The stomach has a smooth wall. Gonads were not observed. Some zooid buds were growing in the colony head, close to the stalk.

Without gonads and larvae it is not possible to identify animals having so varied shapes and colors. Nevertheless it is interesting to note that another *Sigillina* species was collected in Indonesia as most species of this genus inhabit colder waters.

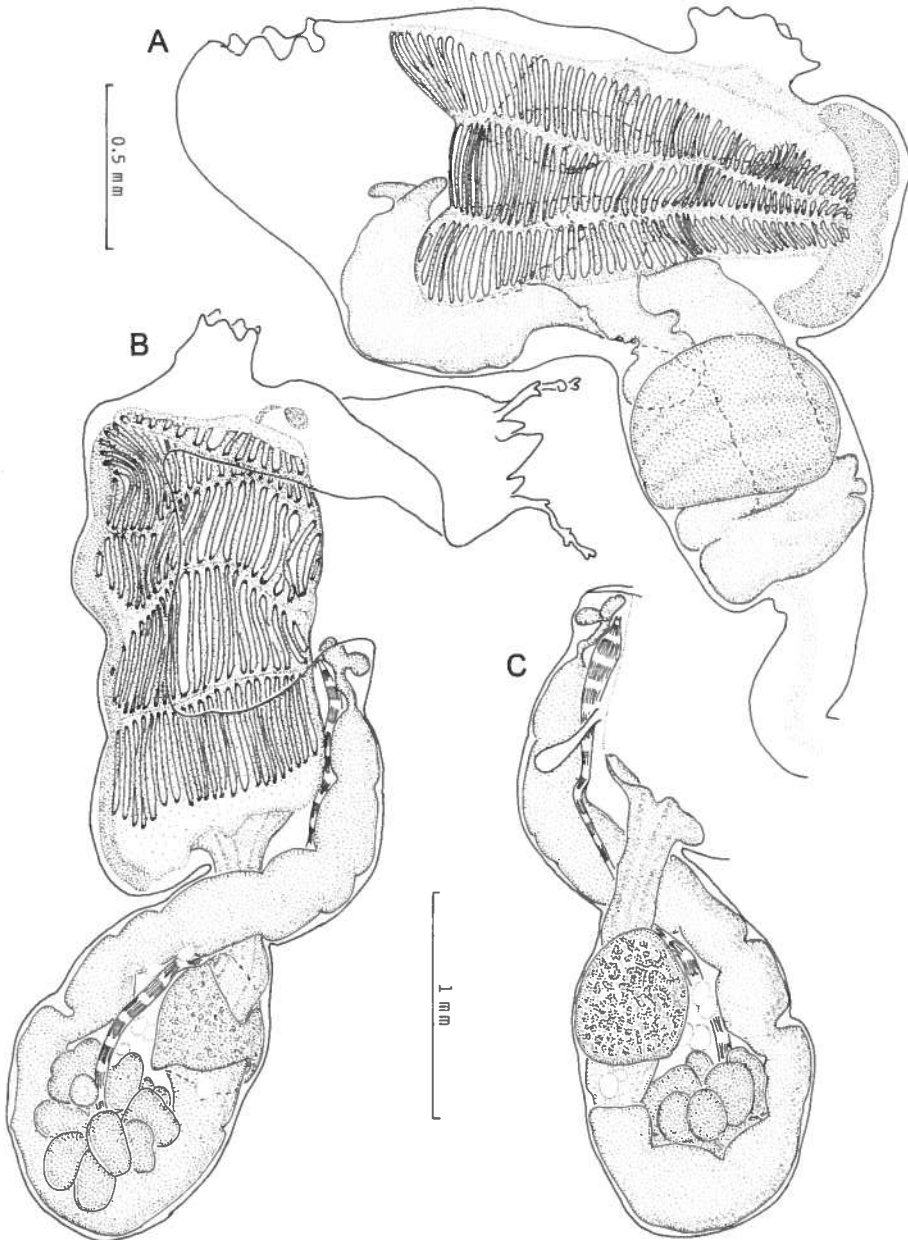


Figure 38. *Sigillina* sp.: A, zooid. *Distaplia regina* Kott, 1990: B, zooid; C, detail of the gut.

*Distaplia regina* ? Kott, 1990  
Figs. 38B, C, Pl. 7A

*Distaplia regina* Kott, 1990a: 125, fig. 44e, Queensland, Australia.

Material Examined: MNHN: A3 Dis 66—Palau, Rock Islands, 7°20.28'N; 134°26.71'E, 33 m.

The colonies are large, and encrust coral branches. They reach 9 cm in length and about 1 cm in thickness. They are very soft, gelatinous, transparent with yellow zooids (Pl. 7A). The zooids are arranged in circular systems around a slightly protruding cloacal opening. Some silt adheres to the colony surface. Larvae are not present.

The zooids measure 4 mm in length. The oral siphon has 6 low lobes. The upper rim of the cloacal siphon is produced in a wide languet (Fig. 38B) of variable shape which contains transverse muscle fibers. There are 12 oral tentacles on a ring of two alternating orders. The branchial sac has 4 rows of 20 to 25 long stigmata on each side, but no parastigmatic vessels (Fig. 38B). The rapheal languets are narrow and progressively displaced to the left side.

The digestive tract forms a round loop in which the gonads are located (Figs. 38B, C). The stomach is rather small, asymmetrical; its wall is areolated. After a short narrow segment, the intestine remains cylindrical with successive constrictions which seem due more to the gut content than to well-marked anatomical compartments. There are about 10 testis follicles in the center of the gut loop. The ovary is not well developed in the center of the male gonad. The sperm duct opens near the anus at the level of the second transverse sinus. In some zooids a brood pouch begins to protrude on the right side of the bottom of the thorax (Fig. 38C). No larvae were present.

Remarks: The number of stigmata and the stomach wall correspond well to the description of *Distaplia regina* Kott, 1990. However these pale colonies are different from the dark purple Australian specimens. Otherwise, all anatomical characters seems very similar. No larvae are known in any of the samples. They would be useful in confirming the identification.

Previously the species was known only from the Great Barrier Reef.

Order Phlebobranchia  
Family Diazonidae

The genus *Diazona* Savigny, 1816 (*Syndiazona* Oka, 1926)

The best known and most abundant species from the Indo-Pacific Ocean is *Diazona grandis* (Oka, 1926) from Japan and eastern China Sea. A second species was described from the eastern part of the China Sea by Tokioka (1955) with the name of *Syndiazona chinensis* from an immature colony. Six other colonies were studied by Millar (1975) from the Philippines and Indonesia (Kei Islands) and described as *S. chinensis* or *S.? chinensis*. In our opinion, 3 species were confused in Millar's collection. Three other colonies from the Philippines were attributed to this species by Monniot & Monniot (1989). One specimen was described by



Nishikawa (1991) from the Japan Sea. A third species, *Diazona textura* C. Monniot, 1987a was described from several New Caledonian colonies.

There are 6 species in this collection, five of them are new. All available specimens of the genus were reexamined for this present work. The species are easily distinguished by the following features:

—The colony structure. *D. angulata*, *D. carnosa*, and *D. chinensis* have massive colonies with the thorax entirely included in the tunic mass. In *D. labyrinthea* the thoraces are also included but the colony surface is raised in a network of lamellae. *D. formosa* and *D. tenera* have thoraces entirely free.

—The muscle distribution. In *D. angulata*, *D. carnosa*, and *D. chinensis*, the thoracic muscles are mostly longitudinal, whereas they are mostly transverse in *D. labyrinthea*. In *D. formosa* and *D. tenera* the muscles have a special design, shown in the figures. The abdominal muscles end aside from the vascular process in *D. formosa*, *D. tenera* and *D. labyrinthea* but are prolonged in it in *D. angulata*, *D. carnosa*, and *D. chinensis*.

—The esophago-rectal narrowing is very short in *D. chinensis*, but elongated in other species, variable to long in *D. formosa*, and especially long in *D. labyrinthea* and *D. tenera*.

#### *Diazona angulata* new species

Figs. 39A, D, Pl. 7B

Holotype: MNHN: P1 Dia 18—Philippines, Siguijor Island, Tambison point, 18 m and Apo Island, 16 m (N. Lindquist collection).

Description: The largest colony was 30 x 10 cm and 10 cm thick. The animals overhanged in colorless translucent balls (Pl. 7B). In formalin they become yellowish. Zooids project slightly from the upper surface of the colony.

The musculature consists of about 18 longitudinal ribbons issued from the siphons (Figs. 39A, B). Those from the oral siphon extend obliquely toward the endostyle where they branch before joining a strong longitudinal muscle. The bands from the cloacal siphon extend down to the bottom of the branchial sac where they join the ventral bands to form the abdominal ribbons. The muscles either extend onto a vascular process starting from the right side of the abdomen or stop abruptly at its proximal end (Fig. 39D). The endostyle projects posteriorly in a short appendix (Fig. 39B). This shape of the thorax is described in the species name. About 10 long and curled tentacles are inserted on a single ring but in two orders of size. The prepharyngeal groove is a flat wide ribbon, with a dorsal indentation. The flat dorsal tubercle has a slightly elongated opening. The rapheal languets are sharp and long, located on the left side of an unperforated area. The branchial sac has 38 rows of stigmata and 24 longitudinal vessels on each side. Most of the sinuses are entire. There is about 2 long stigmata in a mesh. The esophago-rectal peduncle is rather long, often narrow (Fig. 39A) but sometimes the same diameter as the stomach region. The stomach is long with straight or curved stripes according to the individuals. The intestinal regions are well defined

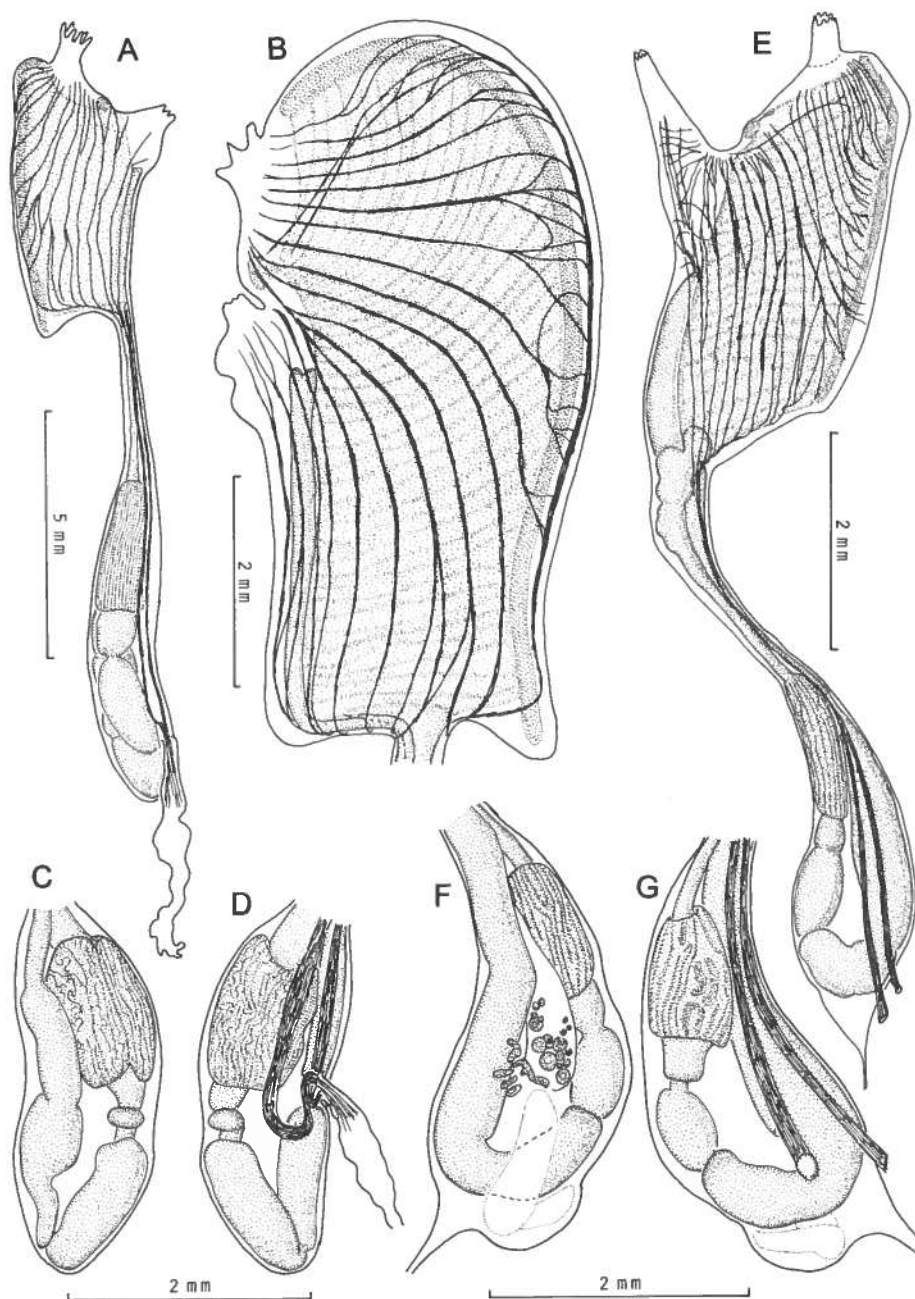


Figure 39. *Diazona angulata* n. sp.: A, zooid; B, thoracic muscles; C, D, abdomens. *Diazona carnosa* n. sp.: E, zooid; F, G, both sides of the abdomen.

(Figs. 39C, D). The bilabiated anus opens at the level of the 16th row of stigmata. No zooids had gonads.

Remarks: This species seems closely related to *Diazona chinensis*. The species differs by the thoracic muscles more numerous and less anastomosed than in *D. angulata*; the position of the vascular stolon and the presence of an esophago-rectal waist. The prolongation of the endostyle in the postero-ventral corner of the thorax has never been observed in *D. chinensis*. The aspect and color of the colonies are different, in *D. angulata* the zooids make obvious swellings at the colony surface.

*Diazona carnosa* new species

Figs. 39E, G, Pl. 7C

Holotype: MNHN: P1 Dia 26—Philippines, Cebu, south east Mactan Island, wall, 10°15.62'N; 123°59.11'E, 53 m.

Description: The colonies form large masses of 10 cm and more in diameter and 2 cm in thickness. In life the color is pink (Pl. 7C) and it disappeared in formalin. The zooids are completely included in the common tunic. The siphons open independantly at the colony surface without order; they are not, or only slightly protruding.

The zooids are less than 1cm in length, but the vascular appendage may be longer than the zooid. The thoracic musculature (Fig. 39E) has about 25 longitudinal bands. Half of them ends against the endostyle while the most dorsal ones reach the base of the branchial sac and make the abdominal muscular bundles. The transverse musculature is only slightly developed on the cloacal siphon and is anastomosed with the longitudinal fibers. There is a single transverse muscle in the upper part of the thorax. Both muscular abdominal bundles protrude at the base of the body and they are prolonged by elastic fibers in the common tunic. So, the body appears to have 3 processes: one vascular and two fibrous.

The siphons are well apart. They have 6 lobes with a pigment spot between the lobes. The 12 oral tentacles, in two orders, are on a protruding crest half way down the siphon. The prepharyngeal band has 2 parallel blades without dorsal curve. The olive-shaped neural ganglion is closer to the cloacal siphon than to the oral siphon. The neural gland is on the ventral side of the neural ganglion and opens in an urn-shaped tubercle. For a branchial sac with 24 rows of stigmata, the dorsal lamina has 19 languets. The first one appears at the level of the second parastigmatic vessel. The branchial sac has generally 24 rows of stigmata, but we observed, above the first and last rows, a parastigmatic vessel and figures of stigmata divisions. There are 21 to 25 longitudinal vessels which are sometimes incomplete as in the two on each side of the dorsal lamina and the one on each side of the endostyle. In a mesh, there are 2 not very long stigmata.

The abdomen is longer than the thorax and expanded posteriorly. The elongate stomach has a few well marked longitudinal folds (no more than 9 on each side with some irregularities) (Fig. 39G). The post-stomach is present. The rectum opens by a plain margin of the anus, at the level of the tenth or eleventh row of

stigmata. The gonads were not fully developed in the colony. In the figured abdomen (Fig. 39F) there are only oocytes circled by thecal cells. In another zooid, the oviduct was full of globules as "pseudo-oocytes", up to its extremity against the anus. The heart is voluminous and reaches the post-stomach anteriorly on the right side. The vascular process is always thin and long.

*Diazona chinensis* (Tokioaka, 1955)

Fig. 40, Pl. 7D

Material Examined: MNHN: P1 Dia 21 and 23,—Indonesia, north Sulawesi, west of Manado, 1°23.52'N; 124°32.57'E, 43 m and north tip of Sulawesi, mouth of Teluk Korakora Inlet, 1°43.97'N; 124°58.03'E, 33 m.—Philippines, east of the central part of Luzon Island, 13°15.3'N; 122°45.9'E, 166–172 m

The Indonesian colonies (Figs. 40A, B, C) are massive, globular and cartilaginous. The zooids are completely embedded in the test. Both siphons, with 6 lobes, open independently at the colony surface and only make small swellings. In life, one colony was white the other purplish-brown (Pl. 7D). In formalin both colonies are whitish with brown zooids. In one colony, the zooids had a red spot on each oral lobe. The musculature has a characteristic design which is the same whatever the thorax contraction (Figs. 40A, C). The two abdominal bundles lie on the left side and extend very far along the post abdominal vascular appendage (Fig. 40A). Sixteen tentacles in 3 sizes were counted along 3 concentric circles in the oral siphon. Their bases are not joined. The prepharyngeal groove lies between two equal rims. There is a deep dorsal V. In one colony, parasitic ciliates are fixed on the prepharyngeal ring. The dorsal tubercle is urn-shaped, with a circular opening. The neural complex is located behind the dorsal tubercle. On the dorsal line 22 to 30 long and thin languets are located on an unperforated area and are more developed on the right side. The branchial sac has 25 to 36 stigmata rows with about 25 stigmata on each side. The longitudinal vessels are thin, supported by large flat papillae. There are 2 to 3 stigmata in a mesh. Some rows of stigmata were seen to be dividing. The abdomen begins with a pronounced narrowing and rapidly widens posteriorly. The esophagus is short, with a length twice the height. The stomach has many irregular plications (Fig. 40B). The successive segments of the intestine are well defined. The anus opens approximately at the level of the 10th row of stigmata. A large part of the right side of the abdomen is occupied by a mass of globules reminiscent of oocytes, sometimes extended as far as the anus. The true oocytes, recognizable with their refringent thecal cells, are located in the posterior part of the abdomen (Fig. 40B). The testes are scattered around the intestine and the heart, the latter posterior on the left side of the abdomen.

The Philippines colonies (Figs. 40D–G) were damaged during the collection with a trawl. The colonies seem massive with zooids embedded in the common test. All zooids were broken at the level of the esophago-rectal peduncle. There was also a break between the abdomen and the vascular appendage. The test was translucent and soft. The very long and thin tentacles often outburst through the oral siphon. In zooids of the same colony, the number of tentacles varies; they

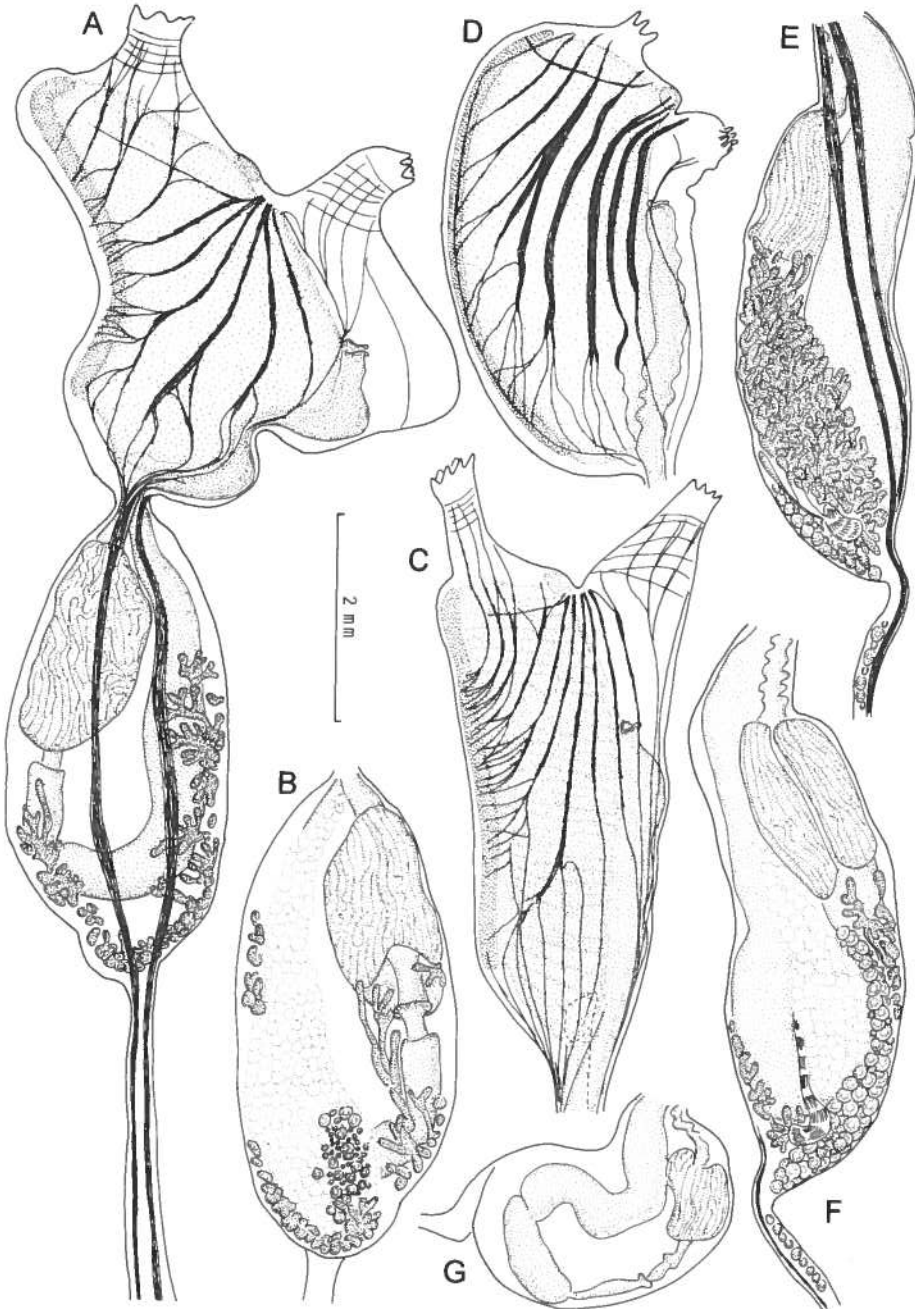


Figure 40. *Diazona chinensis* (Tokioka, 1955): A, B, C, Indonesian specimens: A, zooid with a contracted thorax; B, other side of the abdomen; C, another thorax; D to G, Philippines specimens: D, thorax; E, F, both sides of an abdomen; G, abdomen of an immature zooid.

are located in two circles: a posterior ring with 12 large tentacles alternating in two orders and an anterior ring of at least 12 small ones. The dorsal languets may be very long and sharp, reaching the double of the stigmata height. The branchial sac has 30 to 32 rows of stigmata with about 22 longitudinal vessels on each side. In a single colony, some zooids have almost entire sinuses, when other zooids only have T-shaped papillae, sometimes linked two by two. There is about 2 stigmata in a mesh. The gonads are well developed (Figs. 40E, F). Some oocytes were found inside the vascular appendage. Nishikawa (1991), in a specimen from southern Japan, also noted the presence of oocytes in the vascular appendage. The globules, as "pseudo-oocytes", are very numerous in Philippines specimens and their voluminous mass can extend up to the anus level.

Remarks: We have reexamined zooids from the type colony of *Syndiazona chinensis* Tokioka, 1955 from the Seto Marine Biological Laboratory collection. The musculature shown by Tokioka (1955, p. 11, fig. B) is confirmed, although he overlooked the transverse muscle at the base of the oral siphon. The large transverse sinuses (Tokioka's pl. 11, fig. B) were not detected either in the type specimen, in our study, nor by Nishikawa (1991).

We have reexamined all specimens described by Millar (1975). They correspond to 3 distinct species. The specimens from Kei Islands, Nohoc Roa, 35 m and Doe Roa, 30 m, and a specimen from Doe Roa, 25 m not studied by Millar, belong to the species *Diazona chinensis*. They correspond to Millar's figures 42 A, D, F, E. We have not found specimens corresponding to the figures 42 B and C showing muscles abruptly interrupted on the side of the abdomen. The latter structure was observed by us on some broken specimens from Philippines. Millar's figures 42B and C may correspond to a specimen collected at Doe Roa, 30 m which is totally dehydrated and cannot be studied. The specimen from Mindanao, identified as *Syndiazona chinensis*, and the specimen from st. 54, 85 m, identified as *Syndiazona ? chinensis*, are damaged but appear to belong to another species, with a different musculature (large bundles perpendicular to the endostyle). The specimen identified as *Syndiazona ? chinensis* from st. 34, 25 m (Millar's fig. 4) is dehydrated and cannot be used; however it clearly belongs to another species, perhaps to *Diazona carnosa* n. sp.

Geographic Distribution: Previously known from eastern China Sea, Philippines, and Japan Sea.

### *Diazona formosa* new species

Fig. 41, Pl. 7E

Holotype: MNHN: P1 Dia 24—Indonesia, north Sulawesi, west of Manado, 1°23.50'N; 124°44.60'E, 20 m.

Description: The colony (Pl. 7E) is branched and massive. From a basal mass large lobes about 2 cm in diameter irregularly divide into terminal lobes containing 2 to 10 zooids (Fig. 41A). The thoraces are partially or completely isolated. The basal test is thick, hard, yellowish, somewhat translucent. The thoracic test is thin,

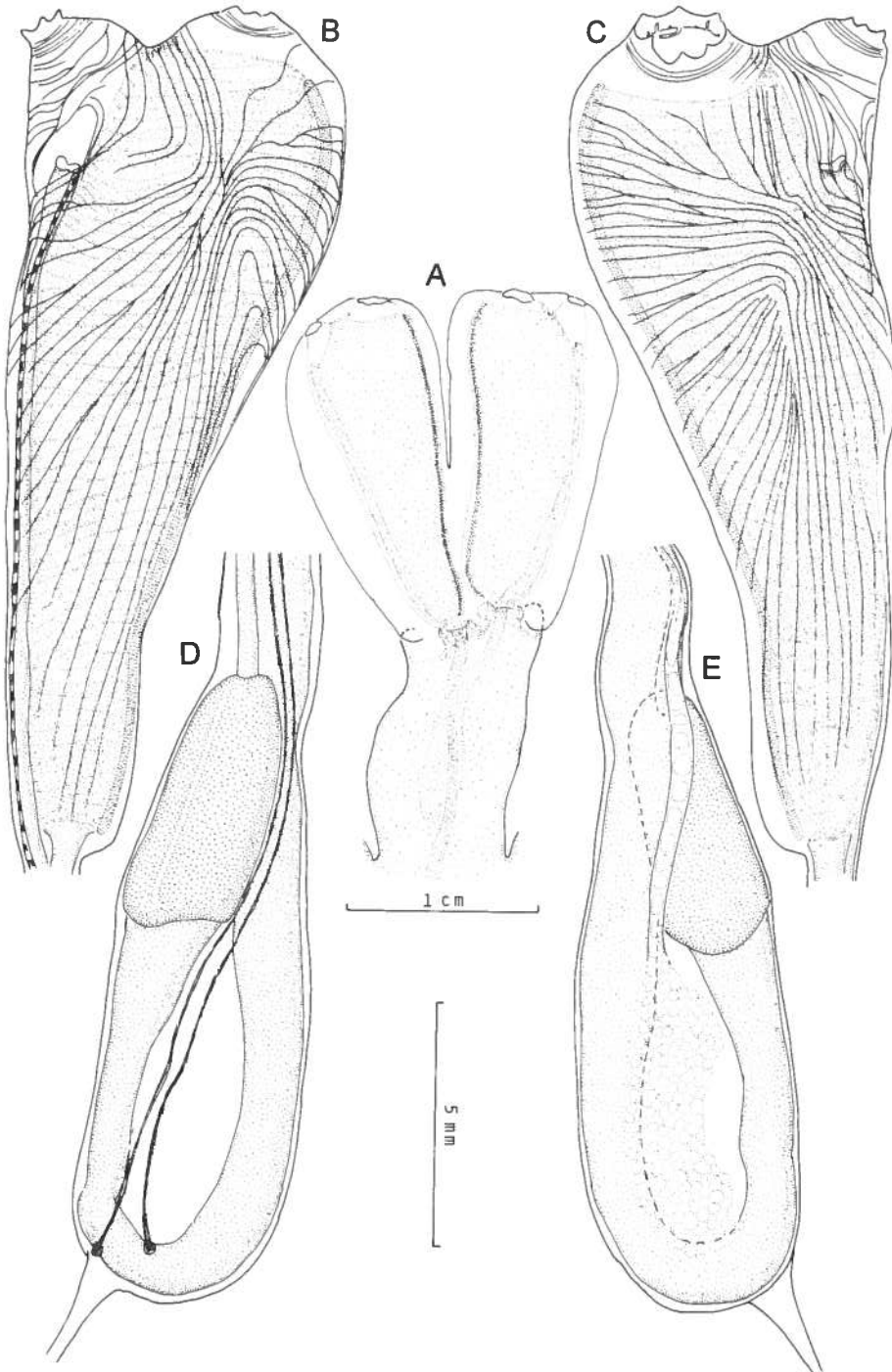


Figure 41. *Diazona formosa* n. sp.: A, two zooids; B, C, both sides of a thorax; D, E, both sides of an abdomen.

soft, and perfectly transparent. In life, the thoraces are colorless with white spots and lines.

Both siphons have 6 sharp lobes. A white spot is at the top of each lobe. There is one spot between the lobes. The neural ganglion and the endostyle are pigmented and clearly visible. The thorax is also circled with white transverse lines which correspond to large transverse sinuses and to the trabeculae which link them to the body wall. White rings are also present close to the siphons. The white pigment completely disappears after fixation. The abdomens remain yellowish. Between the thorax and the abdomen, a hard ring of test contains dark cells (Fig. 41A). The thoracic musculature forms a complex pattern which is not exactly the same on both sides (Figs. 41B, C). The muscles are interrupted over the dorsal lamina and the endostyle. The fibers become weak in the posterior part of the thorax, and extend along the abdomen in two thin bundles, that do not penetrate onto the vascular stolon.

The tentacles are located in a line on a crest in the anterior part of the oral siphon. There are about 10 large and curved ones in 2 or 3 orders of size, and smaller ones between them. The prepharyngeal band forms a high blade, very slightly indented dorsally. The dorsal tubercle is large and protruding with a longitudinal slit. The neural ganglion is globular, located below the dorsal tubercle. Long and thin rapheal languets, corresponding to the transverse vessels, extend along the whole thoracic dorsal line. The branchial sac has more than 50 rows of stigmata. Two or 3 additional rows occur in the vicinity of the dorsal tubercle area. Anteriorly about 35 longitudinal vessels were counted on each side in the anterior area, and only 20 are present posteriorly. The vessels which disappear, terminate against the endostyle. Posteriorly, the longitudinal vessels sometimes are interrupted. There are 3 or 4 elongate stigmata in a mesh.

The abdomens are often 2/3 to nearly twice the length of the thorax. The gut loop is inflated posteriorly (Figs. 41D, E). The long stomach is smooth; it narrows gradually to the intestine posteriorly. The rectum is long and extend alongside the pharynx to the bilabiate anus at the base of the cloacal siphon.

The gonads are not developed. A protruding pad of gonadal globules occurs on the left side of the intestinal loop (Fig. 41E). The testis is diffuse above the intestine. Some zooids have full sperm ducts even when the testes are not developed.

The voluminous heart is U-shaped in the posterior part of the abdomen. The body is extended by a long vascular appendage.

### *Diazona labyrinthea* new species

Figs. 42A–C, Pl. 7F

Holotype: MNHN: P1 Dia 20—Indonesia, north Sulawesi, west of Manado, 1°23.52'N; 124°32.64'E, 33 m.

Description: The colony is a firm mass 2 cm thick, with a raised network of thick lamellae arranged irregularly around deep cavities (species name) (Pl. 7F). The apertures, in double rows, open independently at the top of the lamellae.



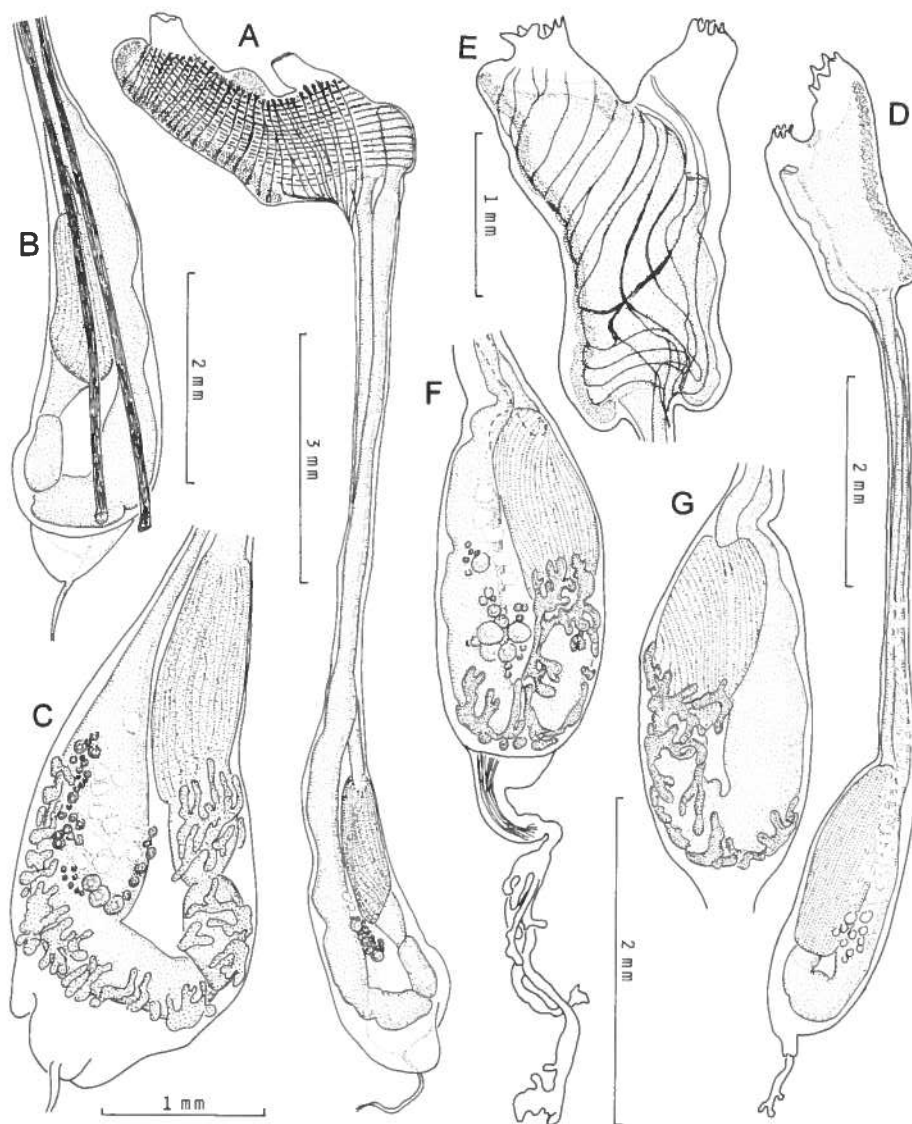


Figure 42. *Diazona labyrinthea* n. sp.: A, zooid; B, abdomen of the same zooid; C, another abdomen. *Diazona tenera* n. sp.: D, zooid; E, thoracic muscles; F, G, both sides of an abdomen.

Thoraces lie parallel to the colony surface while the abdomens are perpendicular to it. In life, the test was colorless and translucent; after fixation an opaque network of blood sinuses appear at the surface.

The musculature is very characteristic (Fig. 42A) with a regular square crossing of the transverse and longitudinal fibers on the thorax. The two abdominal bundles are only made of the fibers posterior to the neural ganglion. They stop

abruptly behind the stomach, and so, do not extend in the posterior vascular process (Fig. 42B).

The wide apart siphons have no defined lobes. About 20 tentacles in two orders of size were counted; the largest arise more posteriorly but may come out of the siphon. A high undulated crest connects all the tentacles. The prepharyngeal groove has only one undulated margin. It makes a deep dorsal V. The dorsal tubercle has a circular opening, it is located far anterior to the neural ganglion, protruding between the siphons. About 20 dorsal languets are inserted on the transverse vessels; they are short anteriorly and longer posteriorly. The first transverse sinuses do not reach the dorsal line. There is a dorsal unperforated area on the right side. The branchial sac is distorted; the rapheal part extends from the neural ganglion to the esophagous aperture, but the endostyle stops far from the esophagus (Fig. 42A). There are about 25 rows of stigmata and 30 longitudinal vessels on each side. The papillae which support the vessels are short and stout and do not have a dorsal branch. On each side of the dorsal line, the first row of stigmata has T-shaped papillae. The transverse vessels are protruding internally; the meshes contain short stigmata.

The esophago-rectal waist is long. The elongate stomach has thin regular grooves (Figs. 42B, C). The anus with a plain edge opens close to the cloacal siphon. The gonads were not fully developed in the colony (Fig. 42C). The ovary with few oocytes is posterior to the stomach. The pad of globules is poorly developed also. The testis follicles were empty lying over the pole of the intestinal loop. The voluminous heart is at the bottom of the abdomen.

*Diazona tenera* new species

Figs. 42D–G, Pl. 7G

Holotype: MNHN: P1 Dia 22—Indonesia, north Sulawesi, west of Manado, 1°23.50'N; 124° 44.60'E, 12 m.

Description: The colony, hanging from a rock, forms a delicate (= *tenera*) gelatinous mass with a colorless transparent test (Pl. 7G). Only the thoraces protrude from the common test. White patches are seen on and between the lobes of both siphons, one above the neural ganglion, and two white lines, along the endostyle and the dorsal lamina. After fixation, the pigment disappears except for a yellowish patch at the base of the endostyle. Both siphons are close to each other, the oral one with 8 lobes, the cloacal one with 6. All thoraces were contracted anteriorly. The arrangement of muscles (Fig. 42E) is characteristic. The abdominal bundles terminate in the proximal part of the vascular process (Fig. 42F).

About 20 tentacles are located anteriorly inside the oral siphon; they are short, curved and stout. Their size is variable and not regularly arranged. The prepharyngeal groove has only one rim. The dorsal tubercle has a large round opening. The globular neural ganglion is posterior to the dorsal tubercle. There is a rather large unperforated area anterior to the first row of stigmata. The 27 sharp rapheal languets are curved to the right side, increasing in size toward the

bottom of the branchial sac. On the right of the dorsal line is a wide unperforated area with raised crests which correspond to the transverse vessels and their rapheal languets. The branchial sac has 28 rows of stigmata on the left and 29 to 30 on the right side. There are 20 longitudinal vessels on each side. The 3 longitudinal vessels on each side of the dorsal line, and the 2 close to the endostyle have T-shaped papillae more or less joined. These papillae, single or joined, have a protrusion directed toward the dorsal line but which does not exceed the sinus level. The vessels are close to each other and limit long meshes containing 1 to 3 stigmata. The rows of stigmata do not show any division but a few small stigmata are intercalated in a row.

The esophago-rectal waist is long (Fig. 42D). The long stomach has thin regular plications. The intestine is not subdivided. The simple anal opening is facing the eighth row of stigmata. It is accompanied by the sperm duct and the oviduct. The gonads (Figs. 42F, G) are diffuse, the ovary on the right side and a bunch of testes encircle the pyloric end of the stomach and the posterior end of the gut loop. The "pseudo-ovarian" globules are not well developed; they form polyhedral masses; according to the zooids, they extend from the middle of the ovary to the esophago-rectal waist.

Family Perophoridae  
*Ecteinascidia diaphanis* Sluiter, 1885  
Fig. 43

*Ecteinascidia diaphanis* Sluiter, 1885: 168, Indonesia; Kott, 1985: 90, Australia, and synonymy.

Material Examined: MNHN: P2 Ect 64—Federated States of Micronesia, Chuuk lagoon, reef south of Dublon Island, 7°20.92'N; 151°52.70'E, 13 m.

The zooids 1.6 cm in length are grouped in a cluster. Their siphons are terminal and close to each other. The zooids are linked to a stolonical network by a short stalk. The test carries only some polychete tubes. In formalin, the zooids are transparent, colorless and without patches of blood cells.

The siphons are retracted into the tunic and have 8 short lobes, without pigment spots. Their musculature is poorly developed. The lateral thoracic muscles (Fig. 43A) consist of two sets of parallel fibers, slightly branched, posterior to the cloacal siphon. Anteriorly, down to the anus, the fibers are continuous on both sides of the body; posteriorly, the muscles do not extend beyond the level of the 12th row of stigmata (Fig. 43A). A short but wide velum is located anteriorly in both siphons. About 50 tentacles are regularly intercalated in 4 orders, on a crest. The tentacles of fourth order have a variable development and may be missing in some parts of the ring. A beginning of a fifth order is indicated by small buds on the tentacular crest. The prepharyngeal groove does not have a dorsal indentation and is made of a high anterior blade and a wide flat posterior ribbon. A triangular sheet joins it to the dorsal lamina (Fig. 43B). The dorsal tubercle is protruding, urn-shaped with a circular opening (Fig. 43B). The neural ganglion is slightly elongated and the globular neural gland is located externally

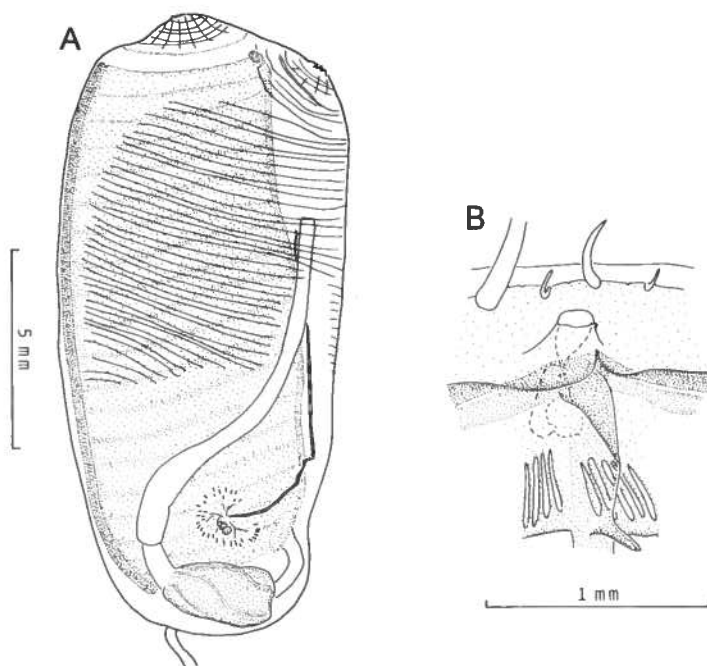


Figure 43. *Ecteinascidia diaphanis* Sluiter, 1885: A, zooid; B, neural area.

and slightly on the left of the ganglion. The dorsal lamina has numerous languets linked at mid length by a thin membrane. There are no papillae at the level of the first transverse vessel. The branchial sac is made of 20 rows of stigmata; the most posterior does not reach the dorsal line. For one specimen, we counted 18 complete longitudinal vessels, 2 longitudinal series of flat papillae on each side of the dorsal lamina and one series on each side of the endostyle. There are few neoformations of stigmata and none of transverse vessels. The meshes are long with 6 to 8 regular stigmata.

The oval stomach has clear spiral ridges. The post-stomach is well differentiated. The intestine begins by a widening. The anus opens with a plain margin at the level of the seventh row of stigmata. The rectum is not very curved and forms an angle with the transverse vessels (Fig. 43A). The gonads are not fully developed. The testis follicles are arranged in a crown around the ovary located above the stomach. The common sperm duct begins anteriorly to the ovary; it runs along the dorsal lamina and ends in a small papilla posterior to the anus. The oviduct lies in the right side of the body.

Remarks: Although the gonads are not fully developed, these specimens well correspond to the description of *E. diaphanis* by Kott (1985), with very small differences: 20 rows of stigmata instead of 16 to 19 and a largest number of stigmata in a mesh, 6 to 8 instead of 2 to 3. Kott's fig. 35, shows the anus opening closer to the cloacal siphon than in our specimens, but the exact level with regard

to the branchial sac is not indicated, and a larger interval separates the musculature of the cloacal siphon and the transverse thoracic muscles.

Kott (1985) synonymized *E. hataii* Tokioka, 1950 from Palau with *E. diaphanis*, a decision with which we agree. Our samples, except for a larger size (16 mm instead of 10 mm), and more stigmata rows, correspond well to Tokioka's description. We are unable to consider the largest size of the siphons of *E. hataii*, as this author always represents the ascidians with the condition that they may have when relaxed.

Kott (1992b) synonymized the New Caledonian species *E. koumai* C. Monniot, 1987a and *E. ndoue* C. Monniot, 1991a with *E. diaphanis*. We cannot accept this synonymy as unlike the present species, *E. koumaki* has transverse muscles anterior to the cloacal siphon and a sperm duct opening at the anus level. This species is close, though, to *E. diaphanis* for the remaining structure. In *E. ndoue* the shape of the gut, with a pronounced secondary loop, is very different from *E. diaphanis*.

*Ecteinascidia styeloides* (Traustedt, 1882)

Fig. 44

*Phallusia styeloides* Traustedt, 1882: 277, pl. 4, fig. 5, pl. 5, fig. 16, West Indies.

*Ascidia styeloides*: Herdman, 1891a: 593.

*Ascidiella styeloides*: Van Name, 1930: 470, fig. 42, West Indies.

*Ecteinascidia styeloides*: C. Monniot, 1983a: 59, fig. 3, Puerto Rico and Guadeloupe; Monniot & Monniot, 1987b: 128, Mediterranean Sea (Corsica).

*Ecteinascidia garstangi* Sluiter, 1897: 10, pl. 1, fig. 1, pl. 3, fig. 1–4, Mozambique; Sluiter, 1900: 5, Hawaii; Sluiter, 1904: 10, Indonesia (in part); Vasseur, 1969: 922, fig. 14–16, Madagascar; Renganathan, 1984: 54, fig. 1, South India; Nishikawa, 1986: 35, fig. 2., Micronesia.

*Ecteinascidia diligens* Sluiter, 1900: 3, pl. 2, fig. 1–3, Hawaii.

*Ecteinascidia tokaraensis* Tokioka, 1954b: 255, pl. 30, fig. 1–5, South of Japan.

*Ecteinascidia conklini*: Goodbody, 1984: 33, West Indies.

*Ecteinascidia imperfecta*: Nishikawa, 1984: 155 (in part), Micronesia.

? *Ecteinascida rubricollis*: Kott, 1964: 146, Queensland.

Material Examined: MNHN: P2 Ect 63—Palau, Koror State, Rock Islands, 7°20.28'N; 134°26.71'E, 30 m.

About 10 zooids were found united by stolons as epibionts on a group of *Polycarpa contexta*. The largest zooids are 12 mm long. The tunic is thin and transparent, and has some hydrozoans and algae. The siphons are short, close together in erect specimens but the cloacal siphon may lengthen to 4 mm in a zooid inserted between 2 *Polycarpa*. The tunic is covered with small hairy protrusions above all the surface in contact with *Polycarpa*. The siphons are edged in about 10 triangular lobes. Inside the oral siphon are 4 cup-shaped protrusions. The lateral musculature (Fig. 44) is made of transverse fibers extending from the level of the second row of stigmata to the top of the intestinal loop (second type after the terminology of Nishikawa 1986). The fibers issued from both sides are

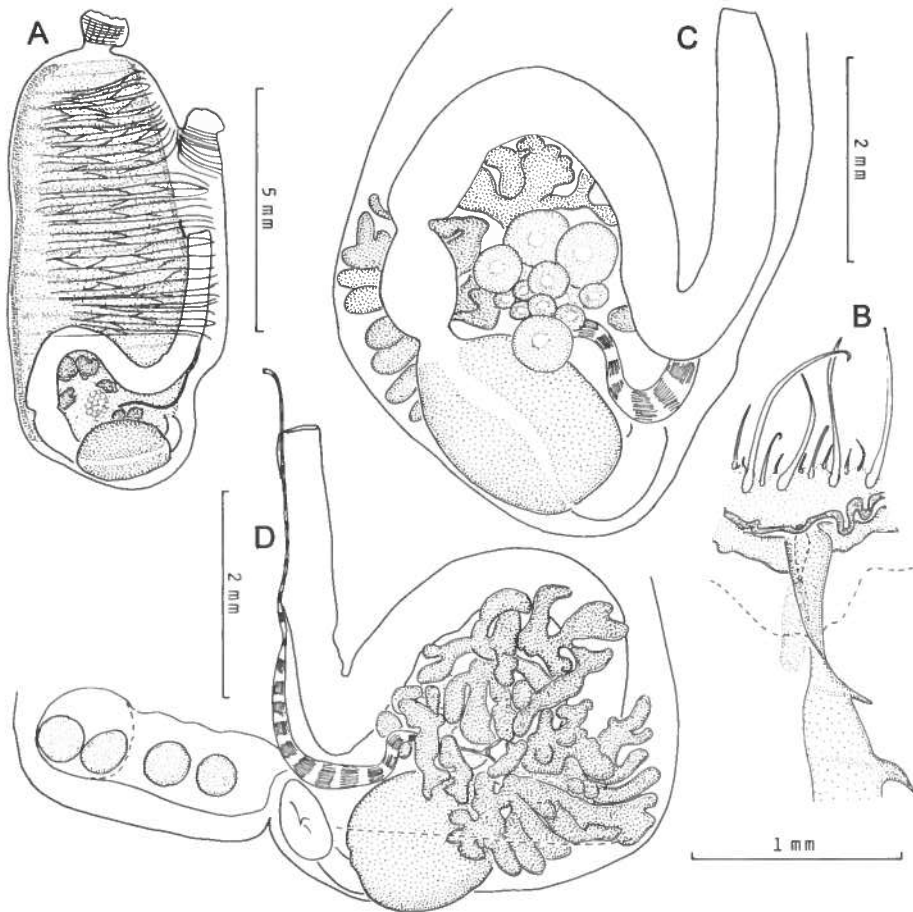


Figure 44. *Ecteinascidia stylويدes* (Traustedt, 1882): A, muscles; B, neural area; C, D, external and internal sides of the gut and gonads.

connected along the dorsal axis of the body. The transverse fibers are linked together by numerous branches. The lateral muscles are independent from the siphonal musculature. About 35 long and thin oral tentacles in 3 orders are placed on concentric close circles. The prepharyngeal groove has unequal rims; the most anterior makes a protruding rod, the posterior one is a flat and larger ring. There is no dorsal indentation. The dorsal tubercle, urn-shaped, inserted into the body wall, opens by a simple hole. A V-shaped structure (Fig. 44B) is anterior to 15 protruding rapheal languets united at their base by a high sheet. The first languet corresponds to the second transverse branchial sinus, the others to the successive transverse sinuses. The branchial sac has 19 rows of stigmata on each side. There are 19 longitudinal vessels on the right side and 20 on the left. Only the first sinus on the right and those against the endostyle are incomplete. There are 2 to 3

stigmata in a mesh. There are few interrupted sinuses and few intercalated stigmata. The growth seems to be achieved in those individuals.

The gut forms a double curve (Figs. 44A, C). The esophagus opens at the level of the 16th row of stigmata. The stomach is globular, without ridges. The intestine has a pronounced constriction. The top of the primary curve reaches the 13th stigmata row, whereas the bottom of the secondary curve is at the level of the 16th stigmata row. The rectum is long, attached to the dorsal lamina, and opens with a smooth-edged anus between the 10th and 11th rows of stigmata. The globular ovary is placed on the external side of the testis, in the center of the gut loop (Fig. 44C). The testis lobes extend on the internal side of the stomach and the intestine, even in individuals with poorly developed gonads. In incubating specimens (Fig. 44D) the testis lobes cover the whole intestinal loop and protrude externally. The sperm duct follows the rectum and ends in a papilla extending beyond the rectum (Fig. 44D) at a length equal to that of one stigmata row. The oviduct is prolonged toward the bottom of the right side. Some of the larvae are incubated inside the oviduct, and the most part in the right side of the cloacal cavity. The colony only contained young non-differentiated larvae.

Remarks: Nishikawa (1986) in his revision of *E. garstangi* suggests the synonymy of *E. garstangi* and *E. styeloides*. We reexamined samples of *E. styeloides* collected in the mangroves of Puerto Rico and Guadeloupe and Mediterranean samples from Corsica. Only insignificant differences were found in the Pacific samples of the Palau collection. The West Atlantic and Mediterranean specimens have, in life, a characteristic aspect with long siphons with a red-brown pigmentation darker than that of the body. This color disappears in fixatives. Nishikawa (1986) noted a red color of the Solomon Islands specimens. Most anatomical characters are identical: the musculature, the prepharyngeal groove, the large height of the membrane uniting the dorsal languets, the gut shape and the sperm duct extending farther than the anus. The only difference observed is, in *E. styeloides* a more regular distribution of the testis follicles than in described samples of *E. garstangi* from the Indo-Pacific region. This minor distinction does not seem to justify separate species. The name *E. styeloides* has priority and is used according to the rules of nomenclature.

Geographic Distribution: West Indies, Mediterranean Sea (Corsica), Mozambique, Madagascar, southern India, Hawai'i, Micronesia, southern Japan, Queensland.

Family Ascidiidae  
*Ascidia azurea* new species  
Fig. 45, Pl. 7H

Holotype: MNHN: P5 Asc A 262—Indonesia, north Sulawesi, west of Manado, 1°23.74'N; 124°32.41'E, 30 m.

Description: One sample only was examined, it was 4 × 2.1 × 1.3 cm, erect and fixed on the rock by 1/3 of the left posterior side. The test is perfectly smooth, without epibionts, of an opaque blue (Pl. 7H), at the origin of the species name.

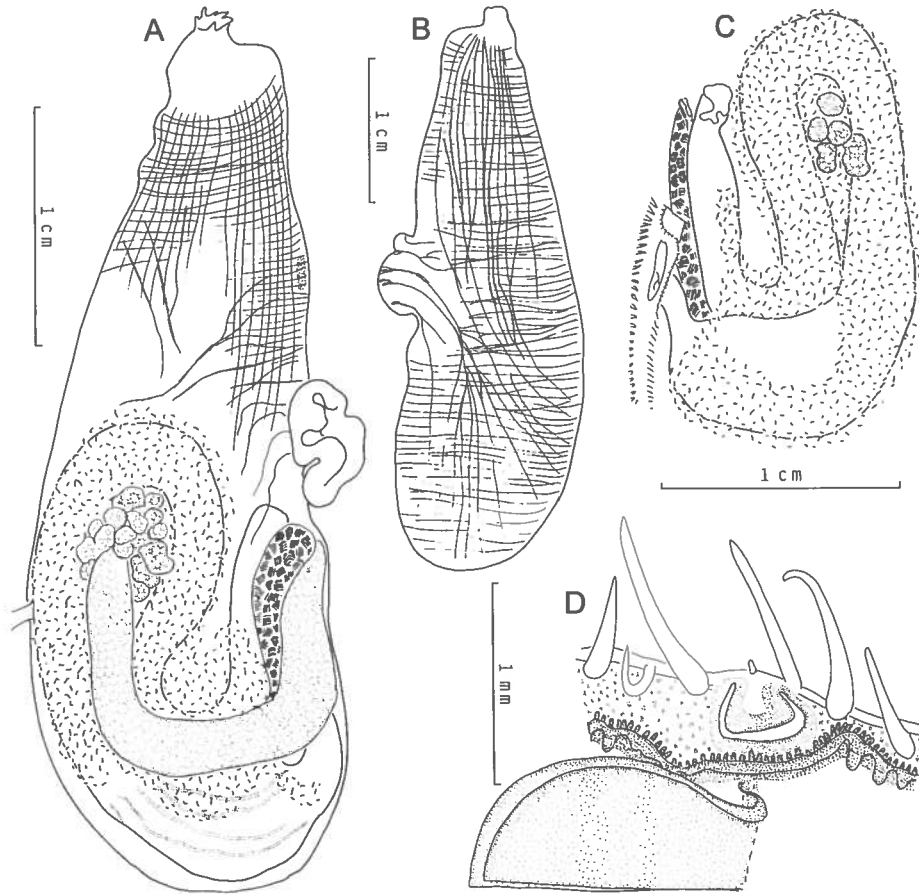


Figure 45. *Ascidia azurea* n. sp.: A, left side; B, muscles on the right side; C, internal side of the gut; D, neural area.

In formalin it turned whitish. No vessels or blood ampullae are seen in the firm and thick test (1 mm thick on the left and 2 mm thick on the right side). The oral aperture is lined by about 10 undulations, without basal pigment spots. The cloacal siphon may lengthen and extend posteriorly when alive; contracted it has no lobes but is irregularly swollen. The musculature is strong (Figs. 45A, B) and forms an irregular network in the middle of each side. Forty tentacles are regularly arranged in 4 orders of size. They are not very long and their bases are well separated. The prepharyngeal groove has a particular structure. The anterior rim is covered with digitiform papillae. The posterior rim is high and smooth (Fig. 45D). The prepharyngeal groove is closer to the tentacles on the left side than on the right side. There is no dorsal indentation. The prepharyngeal area is covered with papillae. The dorsal tubercle is U-shaped. The neural ganglion is far from the dorsal tubercle. The dorsal lamina rapidly increases in height anteriorly. It



forms 2 blades from its origin to the level of the neural ganglion. Posteriorly, there is only one high sheet; its height abruptly diminishes before the esophagus opening, and there, it is replaced by papillae, united by a low membrane. In the centre of the branchial sac, the transverse vessels extend onto the left side of the dorsal lamina ending in papillae. At the esophagus entrance, on the right side, the transverse vessels end in a line of papillae, shorter posteriorly. At the level of the gut entrance on the right side, in the branchial sac, we counted 62 longitudinal vessels and 45 on the left side. The branchial papillae are high, flat, without lateral processes. The branchial meshes are longer than wide. Minute plications are accentuated in the median part of the branchial sac; they form pouches made of two successive meshes with a depth the double height of a papilla. There are no parastigmatic vessels and no intermediate papillae. All the external side of the branchial tissue is covered with small papillae.

The gut (Fig. 45C) describes a double loop reaching the level of the cloacal siphon. The voluminous stomach has few glandular grooves visible on the external side. The cylindrical intestine ends with an anus having a plain but undulated margin. The ovary is a mass of tubules in the primary intestinal loop and is more developed on the external side (Figs. 45A, C). The testis follicles are scattered over the whole gut loop. The gonoducts, full of oocytes and spermatozooids, open together at the anus level. The accumulation vesicles are small, not gathered in a defined outline. All the internal side of the body wall is covered with small papillae.

Remarks: This species has characters similar to four other *Ascidia*: *A. empheres* Sluiter, 1895, *A. gemmata* Sluiter, 1895, *A. glabra* Hartmeyer, 1921, and *A. melanostoma* Sluiter, 1885. All have in common the same body shape, a smooth and thick test, the same musculature pattern, a neural ganglion at mid-distance from the base of the siphons, the same shape of the gut with a cylindrical intestine and a prepharyngeal area covered with papillae. However, all these species were observed when living and none had a blue color. Additionally all these species have a female gonad more developed on the internal side of the digestive tract with tubules overlapping the limbs of the gut loop and becoming visible from the external side. It is not the case in *A. azurea* whose ovary is strictly enclosed in the primary intestinal loop. *A. melanostoma* as *A. azurea* possesses papillae on the anterior side of the prepharyngeal groove.

*Phallusia arabica* Savigny, 1816

Fig. 46, Pl. 8A

*Phallusia arabica* Savigny, 1816: 164; Kott, 1985: 61, fig. 24a-d, pl. 1e, not synonymy.

Material Examined: MNHN: P5 Pha 73—Indonesia, north Sulawesi, west of Manado, 1°26.57'N; 124°44.48'E, 20 m.

The studied sample measures 51 x 55 x 18 mm, it was attached on the rock by half of the posterior left side. In life the animal was of a uniform pale blue color. It had protruding siphons with 12 lobes with white spots, better marked on

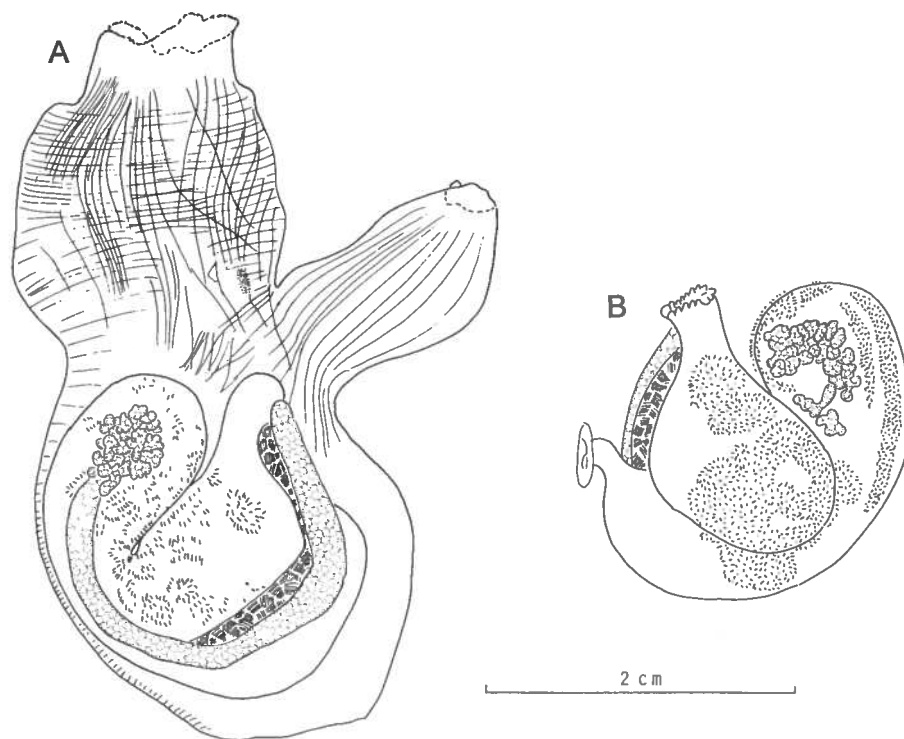


Figure 46. *Phallusia arabica* Savigny, 1816: A, left side; B, internal side of the gut.

the cloacal siphon (Pl. 8A). All colors disappear in formalin and the animal is yellowish in a translucent tunic.

After fixation, the siphons are contracted and not so protruding. The firm and thick test is 1 to 3 mm in thickness and has a granular surface. It contains numerous blood star-shaped diverticula, which are colorless. Internally lies a network of large blood sinuses originating from a vessel leaving the body at the top of the gut loop. The test is slightly depressed interiorly against the digestive tract. The body wall is thin. The siphonal lobes are not well marked and their edge is dentate. The musculature is strong on the right side and on the anterior part of the left side (Fig. 46A). It has no striking characters. About 60 short and well spaced tentacles, in 4 or 5 orders of size, are inserted above a muscle. The prepharyngeal groove, with two laminae, is close to the tentacle ring (closer on the left side); the area between them is covered with papillae. There is no dorsal indentation. A dorsal tubercle was not found in the studied specimen. The neural ganglion is, at the base of the cloacal siphon. The accessory openings of the neural gland are placed in a cluster, near the neural ganglion, they are more isolated and less numerous anteriorly, and disappear at  $\frac{2}{3}$  of the distance between the ganglion and the prepharyngeal groove. The dorsal lamina is doubled anteriorly. Posterior to the neural ganglion, it is a single sheet of medium height. On the left side, the

transverse sinuses extend onto the dorsal lamina in a small papilla. On the right side, the dorsal lamina is covered by digitiform papillae. It curves around the esophageal opening and then diminishes in height. On the right side, close to the esophageal opening, the transverse sinuses form a low plain lamina; posteriorly they only form decreasing papillae. The branchial tissue is neatly pleated. It has about 70 longitudinal sinuses on the right side and 60 on the left. The main papillae are not high and have small lateral extensions. Many intermediate papillae like small buttons become visible only after staining. The square meshes contain at least 10 stigmata. Parastigmatic vessels only exist when a row of stigmata is dividing.

The gut forms a closed loop (Figs. 46A, B). The rectum is dilated. The anus is attached to the body wall, it has low lobes. The ovary is in the primary gut loop, spread over the internal side (Fig. 46B). The testes are in small dense masses over the digestive tract. The gonoducts open together under the anus. The accumulation vesicles are small and contain brown grains.

Geographic Distribution: The species is recorded from the Red Sea, Madagascar, Sri Lanka, Philippines, and north eastern Australia.

*Phallusia julinea* Sluiter, 1919

Pl. 8B

*Phallusia julinea* Sluiter, 1919: 7; Kott, 1985: 65, fig.25, pl.1f, and synonymy.

Materiel Examined: MNHN: P5 Pha 74—Papua New Guinea, North coast, Nagada Harbor, 5°09.35'N; 145°48.00'E, 1 m.

This species is very distinctive (Pl. 8B) and recorded from the north coast of Australia, Indonesia, Palau Islands, and New Caledonia.

Family Plurellidae

*Plurella kottae* new species

Fig. 47, Pl. 8E

Holotype: MNHN: P7 Plu 1—Philippines, Cebu, Mactan Island, Buyong, 10°17.19'N 124°00.15'E, 27 m.

Description: This species forms masses of aggregated zooids 3 cm thick (Pl. 8E). The siphons emerge from this mass without peculiar disposition. The siphons are almost equal, some of them a little shorter or lower, are the cloacal apertures. The individuals are included for  $\frac{2}{3}$  in a common mass. It is not possible to isolate the individual tunics. The appearance of this species is similar to that of the aggregated *Polycarpa tokiokai*. The tunic is entirely encrusted with sand and has a reddish color in life. The siphons have internal chalk-white strips separated by red or brown lines (Pl. 8E).

There are 16 to 20 lobes at each siphon, slightly protruding. In formalin, the colors disappear. The tunic is divided in two layers, the external one contains much sediment, the internal is thin, without inclusions and easy to separate from the external one in the branchial region. It is thicker at the level of the gonads

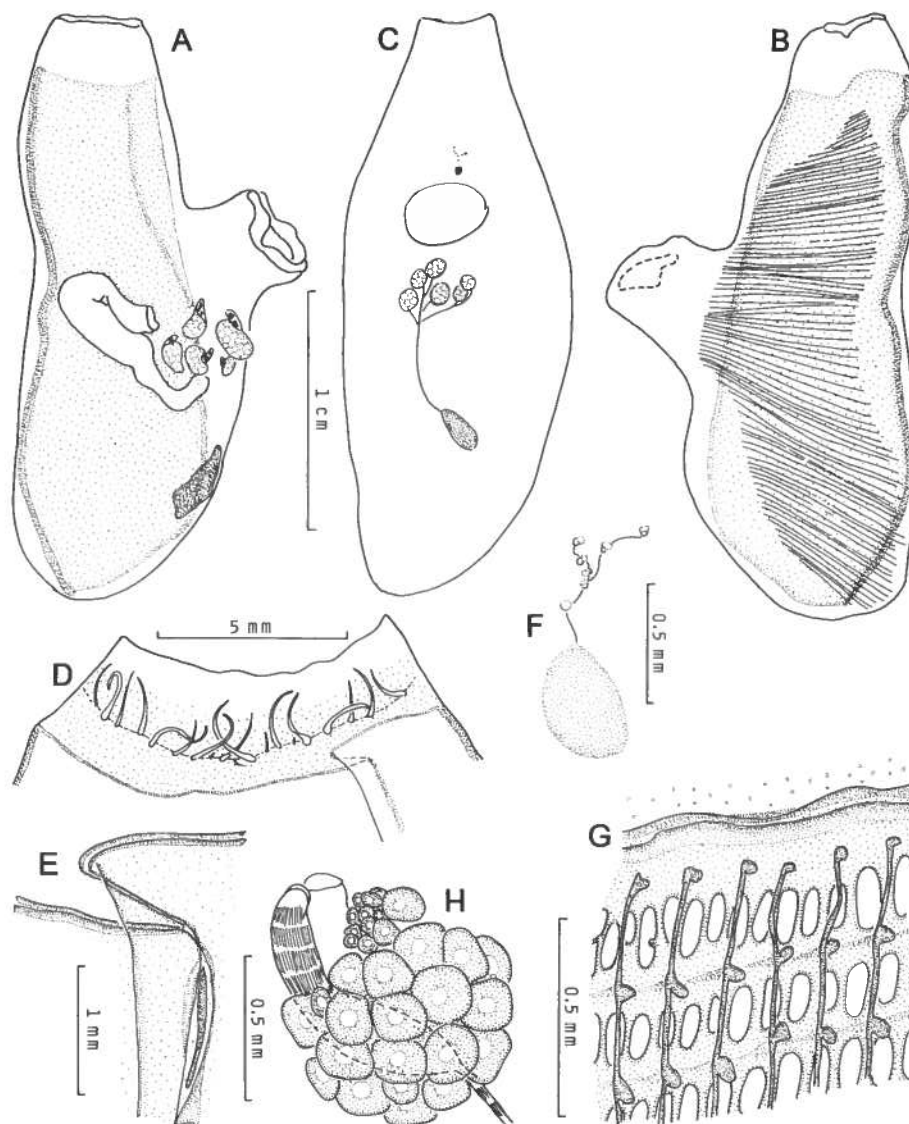


Figure 47. *Plurella kottae* n. sp.: A, B, both sides of a specimen; C, ventral side of another specimen; D, opened oral siphon; E, branchial fold above the rapheal groove; F, neural ganglion and accessory openings of the neural gland; G, detail of the branchial sac; H, internal side of the ovary.

which are embedded in it. The siphonal musculature is reduced to some circular and longitudinal fibers. In the oral siphon, the musculature fades in front of the tentacle ring. On the right side of the body is an area of thin crowded muscles (Fig. 47B). This area does not cover the whole width of the right side. There is a considerable assymetry of the two sides of the body. The body wall is extremely

thin and is difficult to separate from the internal layer of the tunic. At the level of the siphons, the right side may be three times wider than the left side (Fig. 47D). Sixteen large, long and thin tentacles are evenly spaced along a crest, sometimes alternating with smaller ones. Small papillae cover the area anterior to the tentacle ring. The prepharyngeal groove has two equal low crests. On the left, it makes a fold characteristic of the family, which is linked to the dorsal lamina. Anteriorly, the dorsal lamina is a double membrane. In the bottom of the furrow is an elongate hollow (Fig. 47E) linked with cells which stain more than the dorsal lamina. In its half way down, the dorsal lamina is a single sheet with a plain margin and thickenings on its left side. The dorsal lamina is interrupted at the esophagus opening. Posteriorly it is replaced by two parallel high blades which represent the retropharyngeal groove. The neural ganglion (Figs. 47C, F) is 1 mm above the base of the cloacal siphon, inside the internal tunic, but also projecting into the external tunic in an area where the two layers are tightly united. The neural gland is anteriorly prolonged by a thin channel, branched and ended in a small number of urn-shaped ciliated openings at the surface of the internal tunic layer (Fig. 47F). No communication was seen between the neural ganglion and the anterior groove of the dorsal lamina.

The branchial sac is flat, extending along the whole body, overlying the gut and the gonads. It has a fold on the left side along its whole length, corresponding to the indentation of the prepharyngeal groove. Anteriorly this fold covers the dorsal lamina, but posteriorly it separates from it. On the right side the branchial wall is flat. There are more than 110 longitudinal vessels on the left and less than 50 on the right, without the 10 to 25 crowded vessels making the fold. The vessels are thin with protruding papillae. In opposition to all other families in the Phlebobranchia, the first row of stigmata is overlapped by the longitudinal vessels as in the Stolidbranchia (Fig. 47G). There are 1 or 2 stigmata in a branchial mesh, rounded or elongate, according to the branchial area.

The gut is not included in the tunic as in *Microgastra granosa* (Sluiter, 1904). It is only linked to the branchial sac by the esophagus and seems independant from the body wall. It forms an open loop (Fig. 47A). Its shape is distorted by its content and no differentiations can be seen. The anus is slightly bilabiated. The gonads are typical of members of the Plurellidae, embedded in the internal layer of the tunic. The single testis is enclosed in a pouch at half way between the cloacal siphon and the posterior end of the body. The single sperm duct branches close to the group of ovaries at the base of the cloacal siphon. The ovaries are variable in number and are not arranged in lines but grouped in clusters (Fig. 47A). Each ovary associated with a branch of the sperm duct dilated in an ampulla, generally full of sperm (Fig. 47H). This ampulla is present even empty.

Remarks: This species is perhaps the same as the species mentioned by Kott (1985) but not named and only partly described. It differs from *Plurella elongata* Kott, 1973 by numerous characters: the location of the cloacal siphon close to the oral siphon, a loop of the gut, and ovaries in clusters and not in lines. Kott (1973, 1985) estimated that the *Plurella* species were colonial. At this stage the budding mechanism is not known. She only said that the largest zooids were placed in the

center of the colony and that the vascular ampullae of the tunic should play a part in the budding. We have not observed any indication of budding, and the colonial structure of the *Plurella* species remains to be demonstrated.

Order Stolidobranchia  
Family Styelidae  
*Botryllus firmus* new species  
Fig. 48, Pl. 8C, D

Holotype: MNHN: S1 Bot B 108—Papua New Guinea, Port Moresby, Basilisk passage, 9°32.32'S; 147°08.04'E, 28 m. MNHN: S1 Bot B 109—Indonesia, north Sulawesi, west of Manado, 1°27.08'N; 124°44.59'E, 20 m.

Description: In life, the two colonies had a very different aspect. The type colony was uniformly gold yellow and opaque (Pl. 8C) encrusting a dead gorgonian. The other colony was black with a gold yellow meandriform design (Pl. 8D). The pattern corresponds to the common cloacal channels. After fixation, the two colonies became a little translucent and pale brown.

The colony structure is characteristic. The holotype forms a thick hard pad (7 mm) giving the species name. The long zooids (up to 4 mm) are arranged perpendicularly to the surface and regularly spaced on each side of the common cloacal channels of the colony. In some places of the meandriform network, the cavity is enlarged and opens by a protruding round common cloacal opening (Fig. 48A). The roof of the channels is supported by the atrial languets of each zooid. They are short when the zooids are facing in two parallel rows; they are longer at the level of the common cloacal openings, as they extend up to its rim. These languets only are gold-yellow in the colony S1 Bot B 109. The common test is hard, full of blood vesicles. Its surface is smooth and shining. In formalin, the zooids turn pale ochre with two brown patches at the upper part of the endostyle and above the neural ganglion. These patches of pigment are not visible on living zooids. The zooid cloacal siphon is very large and reaches the level of the esophagus opening (Figs. 48B, C, D). The body wall is thick, in two sheets forming an angle along the endostyle. There are no dermato-branchial trabeculae. The buds, which are not regularly alternated are completely embedded in the common test.

The oral siphon is not lobed. 12 tentacles in 3 orders regularly alternate. The branchial sac has 16 to 18 rows of 18 to 20 long stigmata. The 3 longitudinal vessels are close to each other, separated by only 2 or 3 stigmata, and far from the endostyle and dorsal lamina. We did not find, as in many *Botryllus* species, a second row of stigmata which does not reach the dorsal lamina, nor oval transverse stigmata in the posterior part.

The digestive tract (Fig. 48C, D) is posterior and describes a well pronounced double loop. The stomach has about 12 protruding folds in the anterior part. On the right side the folds are elongate and progressively disappear in the pyloric region; but on the left side, against the intestine, they are short and well delimited. The caecum is small, stalked, difficult to see and may be confused (without staining) with the heart forming a large vesicle somewhat posterior to the caecum. The

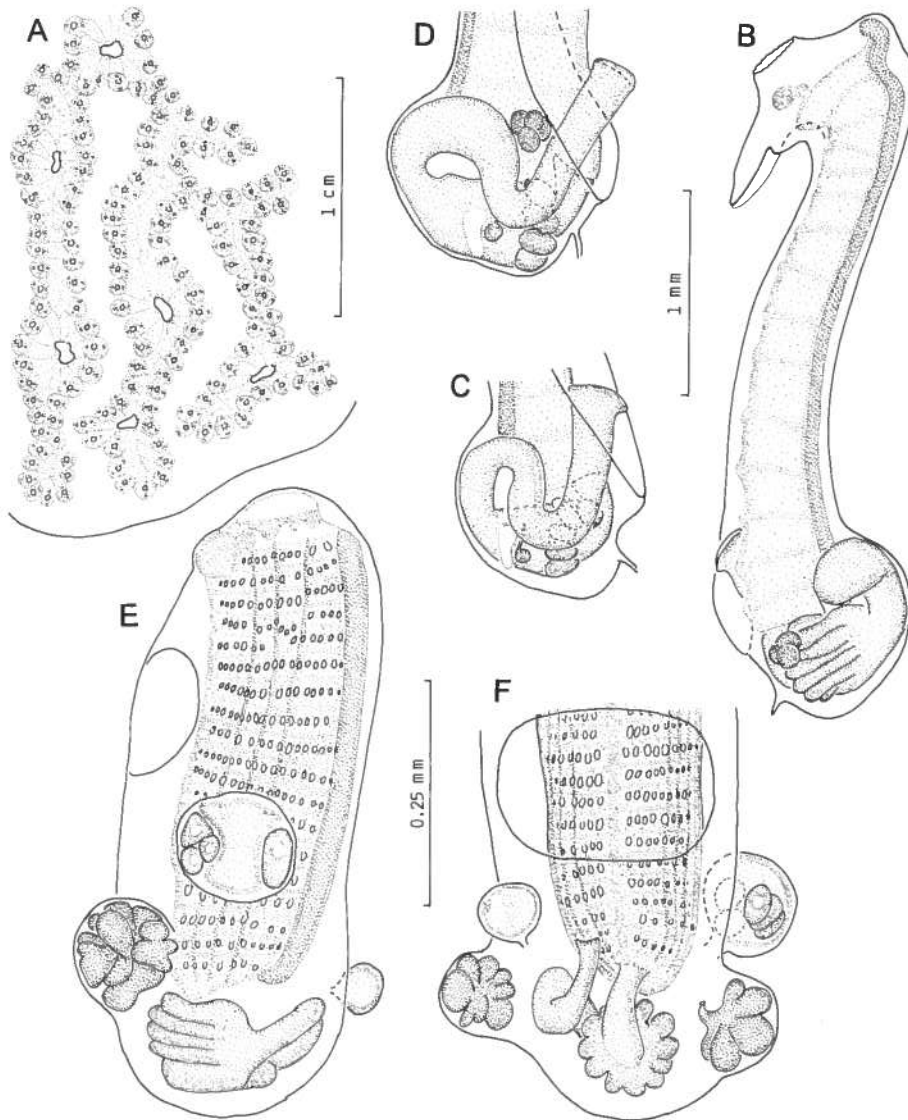


Figure 48. *Botryllus firmus* n. sp.: A, part of the colony; B, right side of a zooid; C, D, left side of the gut in two zooids; E, F, right and dorsal sides of a first order bud.

intestine describes a closed loop, its top at the level of second last stigmata row, the base at the stomach level. The anus is wide, with a plain rim, located in front of the third last row of stigmata. The feeding zooids only have very posterior testes at the level of the intestinal loop. One regularly is on the right side, close to the stomach (Fig. 48B) and sometimes another is on the left, in the gut loop. The buds of the first generation, whose siphons are not yet open, have 1 or 2 well-

developed testes, protruding exteriorly, and 2 buds of second generation (Figs. 48E, F). The latter, on the right side, have on each side a group of oocytes before the beginning of the branchial differentiation. The left bud, smaller, does not seem to contain oocytes. The studied colonies did not contain ripe oocytes nor tadpoles.

Remarks: The knowledge about the Indo-Pacific species of the genus *Botryllus* is incomplete. Saito *et al.* (1981a, b) and Saito & Watanabe (1985) have demonstrated that the biological cycles, and particularly the period of oocyte development, could help to isolate 5 Japanese species from *Botrylloides violaceus* (Oka, 1927b). This species name is not valid and was changed to *Botryllus aurantius* (Oka, 1927b) (see C. Monniot 1988: 169). In many *Botryllus* species, colonies with ovaries are rare but almost all samples have testes. The reverse sometimes occurs (the testes of *Botryllus tuberatus* Ritter & Forsyth, 1917 were seen only twice). The species identification requires the presence of gonads: for example *Botryllus firmus* n. sp. is characterized by the oocytes located in the buds of the second generation.

*Botryllus firmus* n. sp. differs from the 5 Japanese species included in *Botrylloides violaceus*, considered by Tokioka (1953) as the commonest Japanese species. All these species have in common the appearance of the female gonad in the bud of first order, a postero-dorsal ovary, an antero-ventral testis and the second stigmata row not reaching the dorsal lamina. According to the species, the cloacal aperture may be large or reduced and the secondary gut loop more or less curved, but always present. The specimens identified as *Botrylloides violaceus* by Kott, 1985 have the intestine without a neat secondary loop, and the anus opening at the middle of the branchial sac. Although the gonads are unknown, it cannot belong to *B. aurantius*.

*Botrylloides violaceus marginatus* Tokioka, 1967 from Palau has an external aspect very similar to *Botryllus firmus* n. sp., but the zooids are smaller, have a large cloacal aperture and a second stigmata row which does not reach the dorsal lamina, rudimentary stigmata in the posterior part of the branchial sac. The gonad of the type specimen is not known, but in another sample Tokioka noted very posterior gonads and figured a young gonad which seems hermaphrodite, a very uncommon condition for a *Botryllus*.

*Botryllus anceps* (Herdman 1891) (*Botrylloides magnicaecum* sensu Kott, 1985) also has a large cloacal aperture, an oval stomach with a large caecum, the intestine without a second loop, an ovary anterior to the testis and occurring in feeding zooids.

By its external aspect, *Botryllus firmus* n. sp. looks like some Australian specimens that Kott, 1985 grouped under the name *Botrylloides perspicuum* Herdman, 1886. Her description, however, includes at least 5 specimens showing important differences from *B. firmus* in the colony and zooid structure. The specimens described by Herdman (1886) (*B. perspicuum* and *B. perspicuum rubicundum*) from the Philippines have a secondary intestinal loop little pronounced. No indications are given concerning the cloacal aperture and gonads.



*Amphicarpa agnata* (Kott, 1985)

Fig. 49A

*Stolonica agnata* Kott, 1985: 232, fig. 110, Queensland, West Australia.*Amphicarpa agnata*: C. Monniot, 1988: 182, fig. 8, New Caledonia.

Material Examined: MNHN: S1 Amp 14—Federated States of Micronesia, Chuuk Atoll lagoon, patch reef north of Fefan Island, 30 m.

The samples from Micronesia were attached on flakes of calcareous *Halimeda* sediment or on shell debris at 30 m depth. The colony studied consists in numerous zooids united by stolons. The tunic is slightly covered with sand. The color in formalin is light brown. Some zooids shelter in their tunic bivalve molluscs whose size sometimes reaches that of the ascidian host (7 mm). The presence of the bivalve does not affect the ascidian development.

Some small differences can be noticed with previous descriptions. In the Chuuk specimens, the branchial sac may have 17 rows of stigmata (13 in Australia, 12 in New Caledonia). The second branchial fold on the left side is replaced by a single sinus higher than the others. Kott (1985) found 1 to 3 sinuses on this fold. In our material, in the anterior part of the branchial sac, on the sides of the higher sinus the two lateral sinuses are closer, but do not make a fold. The shape of the stomach is slightly different. Here (Fig. 49A) the stomach is larger in its pyloric region and has 13 plications. Kott describes "a cylindrical rather a pyriform stomach", with 12 folds. In New Caledonia the stomach has only 6 folds. The pyloric caecum is more developed in the Chuuk colony. The structure, number and disposition of the gonads are everywhere identical.

Geographic Distribution: Queensland, New Caledonia.

*Eusynstyela latericius* s. str. (Sluiter, 1904)

Fig. 49B–D, 50, Pl. 8F

*Gynandrocarpa latericius* Sluiter, 1904: 94, pl. 15, fig. 8–11.*Eusynstyela latericius*, C. Monniot, 1991b: 14, fig. 4 A–C.

Material Examined: MNHN: S1 Eus 13 and 15—Indonesia, north Sulawesi, west of Manado, 1°23.50'N; 124°44.60'E, 12 m.

The colony forms a sheet about 10 cm across. The zooids have  $\frac{2}{3}$  of their body included in the common test. They are purple-red with a large white strip between the siphons (Pl. 8F). Fixed they become brownish, the white strip remains as a paler mark. The test is naked and thin. The zooids are horizontal, the largest reaches 8 mm. The siphons are well apart, separated by 4 to 5 mm.

The thin body wall is linked to the test with some elastic fibers around the siphons. The muscles are diffuse. About 12 tentacles of variable size, not regularly alternating, are inserted along a high crest. The prepharyngeal groove has only one crest and outlines a dorsal V. The dorsal tubercle is low with a longitudinal slit. The dorsal lamina has a plain edge, its height progressively increases from the dorsal tubercle to the esophagus opening. The endostyle is not directly attached to the body wall but joined to it by a thin membrane.

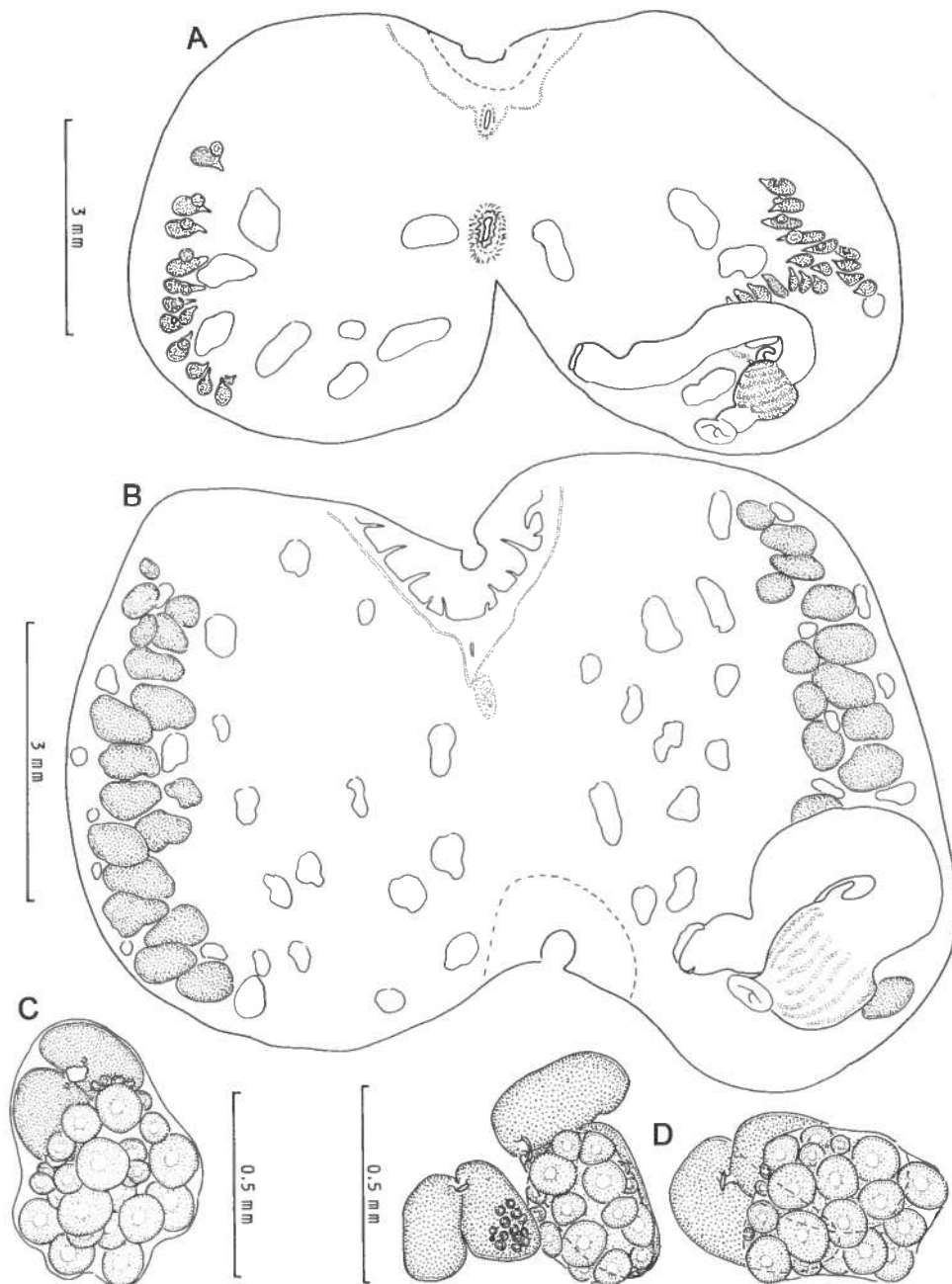


Figure 49. *Amphicarpa agnata* (Kott, 1985): A, specimen opened along the ventral side. *Eusynstyela latericius* (Sluiter, 1904): B, zooid opened along the ventral side; C, detail of a polycarp; D, different stages of the polycarps of the Figure 50 zooid.

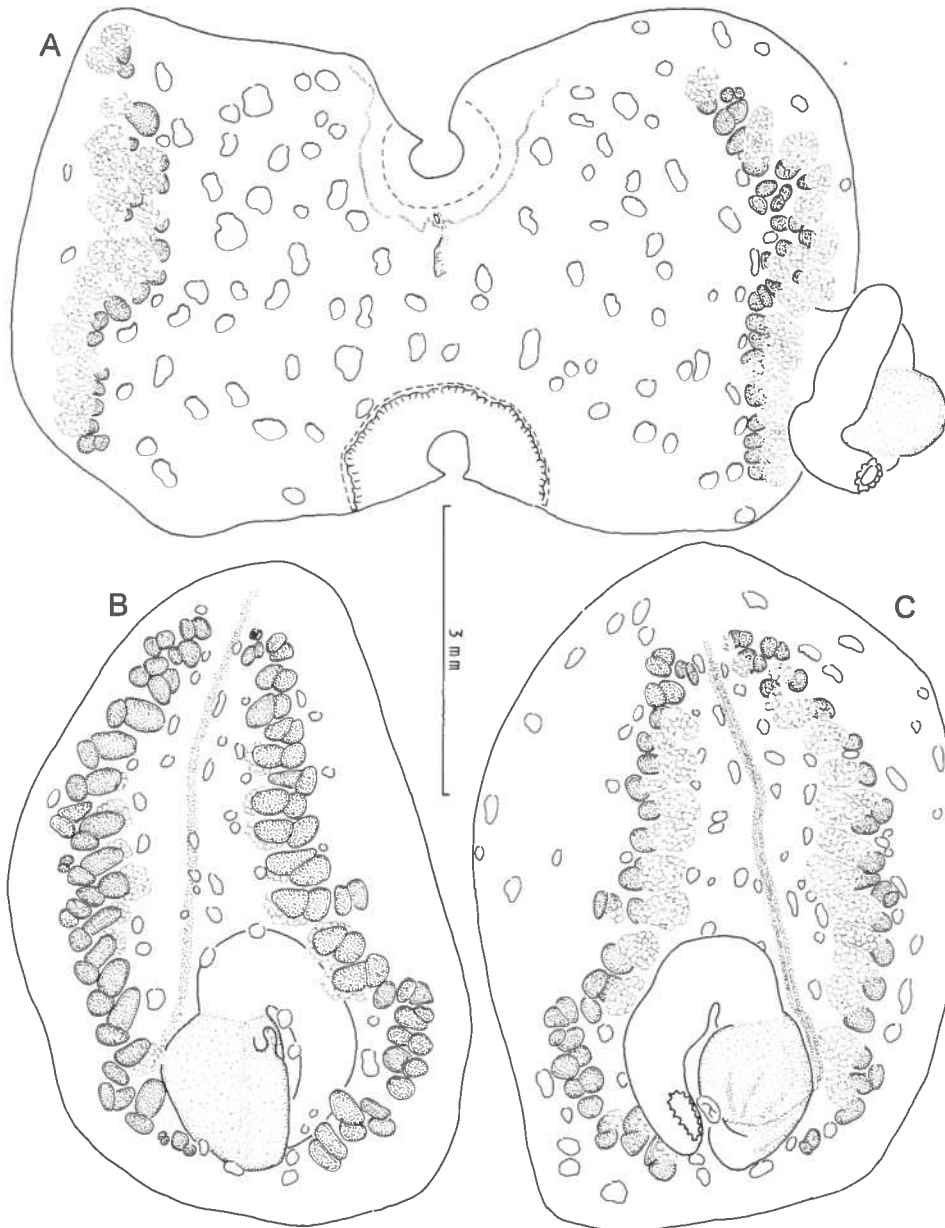


Figure 50. *Eusynstyela latericius* (Sluiter, 1904): A, specimen opened along the ventral side; B, C, external and internal views of the ventral side.

The branchial formula is:

R.E. 2 6 5 12 5 (5) 5 8 2 R. 1 10 5 (5) 5 12 4 8 2 EL

In the anterior part of the branchial sac there is an indication of 4 folds. Folds 1, 3, and 4 are obvious, the second on each side is reduced to 5 grouped sinuses which are not protruding. In the posterior part of the branchial sac, folds 2 and 4 on the right and fold 2 on the left disappear. This is not the result of a flattening but in the median part of the branchial sac the sinuses interrupt. The first longitudinal vessel on the right of the dorsal lamina posteriorly moves aside from it (the interval being of 7 or 8 stigmata anteriorly up to 20 posteriorly). On the left side, the first longitudinal vessel is almost parallel to the dorsal lamina (interval of 8 stigmata anteriorly and 5 posteriorly). Between the folds the meshes are longer than wide, with 3 to 5 stigmata. On the folds the meshes contain 1 to 2 stigmata. Even where the rows of stigmata sometimes double, there are no parastigmatic vessels.

The gut makes a small closed loop (Fig. 49B). The globular stomach has 12 folds. The caecum is straight and short. The intestine only forms a short loop and the bilabiated anus opens close to the cloacal siphon. The gonads are arranged in two irregular lines on each side of the endostyle. Each polycarp is made of an oval ovary and 2 testis follicles placed externally and anteriorly from it. The oviduct opens above the testis by a flat aperture. No sperm ducts were observed but the testis follicles seem to open by a slit on each side of the female papilla. On the left side of the body, the most posterior polycarps are overlaid by the intestine. The endocarps are scattered over the body wall. No cloacal tentacles were observed (Fig. 49B).

In another colony we noted some differences. In formalin the common test is yellowish and the zooids are pale pink with a yellow spot between the siphons. The rim of the siphons is a thin red line. There are only few elastic fibers uniting the tunic and the body wall. The branchial sac has fewer longitudinal vessels, with higher folds number 2, almost disappearing in the posterior part. The branchial formula is:

R.E. 1 7 4 9 2 7 3 9 1 R. 1 9 2 6 3 9 3 6 1 E.L.

The stomach (Fig. 50) is globular and only has some incomplete ridges on the ventral side. Its pyloric limit is clearly seen. The caecum is small, curved, half hidden in a stomach depression. The anus is largely opened with a folded and undulated rim. The gonads are distributed in 2 lines on each side of the endostyle. The left one turns around the gut (Figs. 50B, C). The polycarps are not all at the same developmental stage. The youngest are encountered at the anterior and posterior extremities of the lines and also ventrally. They are initially formed of 2 testes with short sperm ducts joined in a common papillae. Then, on the most ventral testis, develops a cluster of small oocytes. At last, the ovary extends and covers the ventral testis. It can extend ventrally on the body wall and partially cover the dorsal testis (Figs. 49C, D) but never totally. We have not seen the oviducts. The cloacal aperture is surrounded by a short velum with small tentacles.

Remarks: Kott (1985) proposed only one species of *Eusynstyela* for the Indo-Pacific region; *E. latericius*. In New Caledonia C. Monniot (1991b) recognized 3

species; *E. misakiensis* Watanabe & Tokioka, 1972; *E. aliena* and *E. phiala* C. Monniot, 1991b, closely allied with, but distinct from, *E. latericius* (Sluiter 1904). The type colony was partially figured in 1991 but not completely described. The present colonies conform with the type having an irregular distribution of gonads with round testes placed dorsally to the ovary, short gonoducts, and a short gastric caecum which is not, or only slightly, curved. Sluiter's drawings (pl. XV, figs 9, 11) are wrong.

Geographic Distribution: *E. latericius* is widely distributed in western Australia, Queensland, Arafua Sea, Indonesia, Viet Nam, Gulf of Siam, Philippines, Japan, Sri Lanka and Mauritius.

***Stolonica limbata* new species**

Fig. 51, Pl. 8G

Holotype: MNHN: S1 Sto 19—Palau, Koror State, Rock Islands, 7°20.28'N; 134°26.71'E, 30 m.

Description: The colony is made of a group of erect zooids, connected by stolons and covered with some sand. When living the color was red (Pl. 8G). The siphons are slightly protruding, the oral one larger, both with eight white spots. In formalin the color turned brownish. The tunic is thin.

The organs can be seen through the thin body wall. The musculature is fine and regular. About 30 oral tentacles, in 3 orders, regularly alternate. The size of the tentacles of the third order is variable. The prepharyngeal groove has two rims with a slight dorsal indentation. The neural gland opens on the dorsal tubercle in a transverse slit. The neural ganglion is close to the dorsal tubercle. The dorsal lamina is low anteriorly and high posteriorly. The branchial sac has 3 rod-like, low folds on each side corresponding to the folds 1, 3 and 4. In the anterior part the formula is:

D.E. 2 5 5 9 11 10 2 R. 3 9 9 8 5 5 2 E.I.

The space between the two first folds is wider and in some zooids, a slight dorsal convergence of 2 to 3 sinuses indicates the remains of the second fold. Between the first fold and the dorsal lamina are 3 sinuses anteriorly and 9 posteriorly. The extra sinuses form either against the dorsal lamina or in the middle of the space between 2 consecutive sinuses. Between the folds the meshes are long and contain 2 or 3 stigmata crossed by a parastigmatic vessel. On the folds there is no more than 1 sinus in a mesh.

The gut (Figs. 51 A, C, D) is located posteriorly with a large stomach in the shape of a trapezium, marked with about 40 grooves; those on the posterior side complete, the anterior ones very short. There is a large curved caecum embedded in a conjunctive tissue. The anus is smooth, slightly curled. The gonads are limited to the posterior part of the body. There are 2 male gonads on the left side and 8 to 10 hermaphrodite gonads on a single line, on the right (Figs. 51A, B, C). Sometimes the first or the last of the latter are only male. The sperm ducts of the hermaphrodite gonads lengthen according to the maturity stage of the ovaries (Figs. 51E, F, G) and finally cross the branchial tissue to open inside the branchial

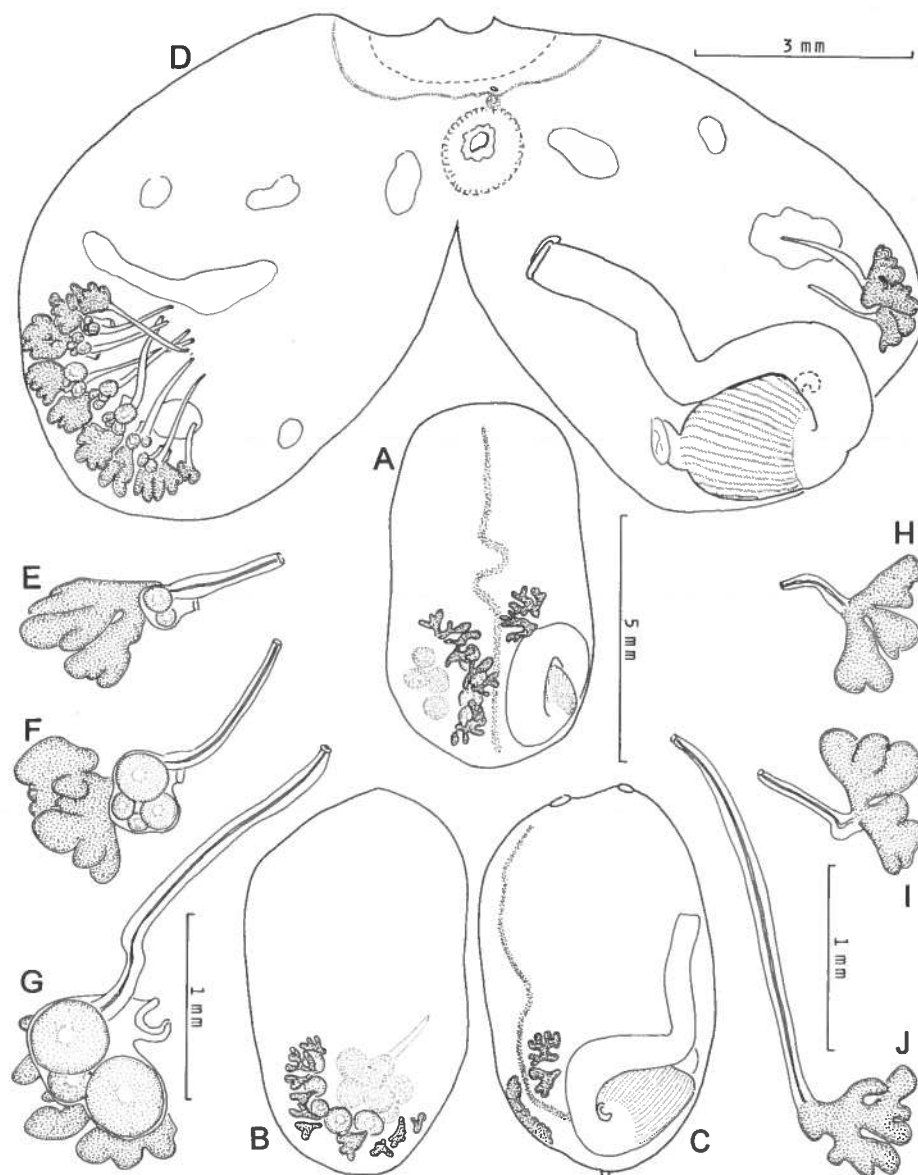


Figure 51. *Stolonica limbata* n. sp.: A, B, C, ventral, right and left sides of a specimen; D, same specimen ventrally opened; E, F, G, successive development stages of the right side hermaphroditic gonad; H, I, J, left side testes at the same stages.

cavity. In contrast to the situation in most *Stolonica* species, the sperm ducts of the left side gonads also lengthen (Figs. 51H, I, J). Larvae are incubated on the right, in the space limited by the gonads and a large transverse endocarp. The

characteristic location of the large endocarp which limits the extension of the larvae justifies the species name *S. limbata* (*limbatus* = edged). Other endocarps are present; they do not show the characteristic symmetrical disposition. The cloacal siphon has a row of small tentacles (Fig. 51D).

Remarks: The genus *Stolonica sensu stricto*, is homogeneous, characterized by 1 line of gonads on each side, male on the left and male and hermaphroditic on the right. We do not follow Kott (1985, 1990b), who successively mixed species of the genera *Stolonica* and *Amphicarpa*. *Stolonica aluta* Kott, 1985 which has on the right side "sac-like ovaries crowded in amongst male follicles" (p. 233) instead of hermaphroditic gonads, is not a *Stolonica* but an *Amphicarpa*.

The tropical species of *Stolonica* have the following characters:

*S. inhacae* (Millar, 1956) has only one branchial fold and a spherical stomach.

*S. reducta* (Sluiter, 1904) has 3 branchial folds, an long stomach, and always short sperm ducts.

*S. sabulosa* Monniot, 1972, from Brazil and Bermuda, is close to the Palau species. It has 3 branchial folds, the same kind of stomach and gonads. But its gonads are located in the middle of the ventral side instead of the posterior part, and there is no endocarp limiting the brooding of the larvae.

*S. truncata* Kott, 1972 has 3 branchial folds, a short stomach, and very elongate male gonads with short sperm ducts.

*S. variata* C. Monniot, 1988 is reminiscent of the Palau species, but the stomach is more elongate with a maximum of 25 grooves, the male gonads are more numerous on the left side (5 at least) with always a short sperm duct, whereas the sperm ducts of the right gonads are always long.

*S. vesicularis* Van Name, 1918, as described by Kott (1985), is characterized by 3 branchial folds on the right side and 2 on the left, a triangular stomach with 14 very short grooves. The 3 male gonads on the left and 9 gonads on the right (the number of hermaphrodite ones among them being not precised) have a long sperm duct. Kott's description is rather different from the original one by Van Name (1918) and from that by Millar (1975). The latter authors reported the species has a short oval stomach with about 30 complete grooves. The left gonads are more numerous than the right ones and are in a V along the endostyle and intestine. No true hermaphrodite gonads were described. This species probably belongs to the genus *Amphicarpa*. Actually, the species described by Kott (1985) cannot be *Stolonica vesicularis*.

### *Polycarpa argentata* (Sluiter, 1890)

Fig. 52, Pl. 8H

*Styela argentata* Sluiter, 1890: 340

*Polycarpa argentata*: Kott, 1985: 148 fig. 66, and synonymy ; C. Monniot, 1987b: 277 fig. 1 A,B, New Caledonia.

Material Examined: MNHN: S1 Pol B 307, 308, 309—Palau, Mutremdiu, Barrier Reef, 7°16.51'N; 134°31.55'E, 5 m.—Papua New Guinea, Madang, Nagada Harbor, 5°09.35'S; 145°48.00'E, 1 m.

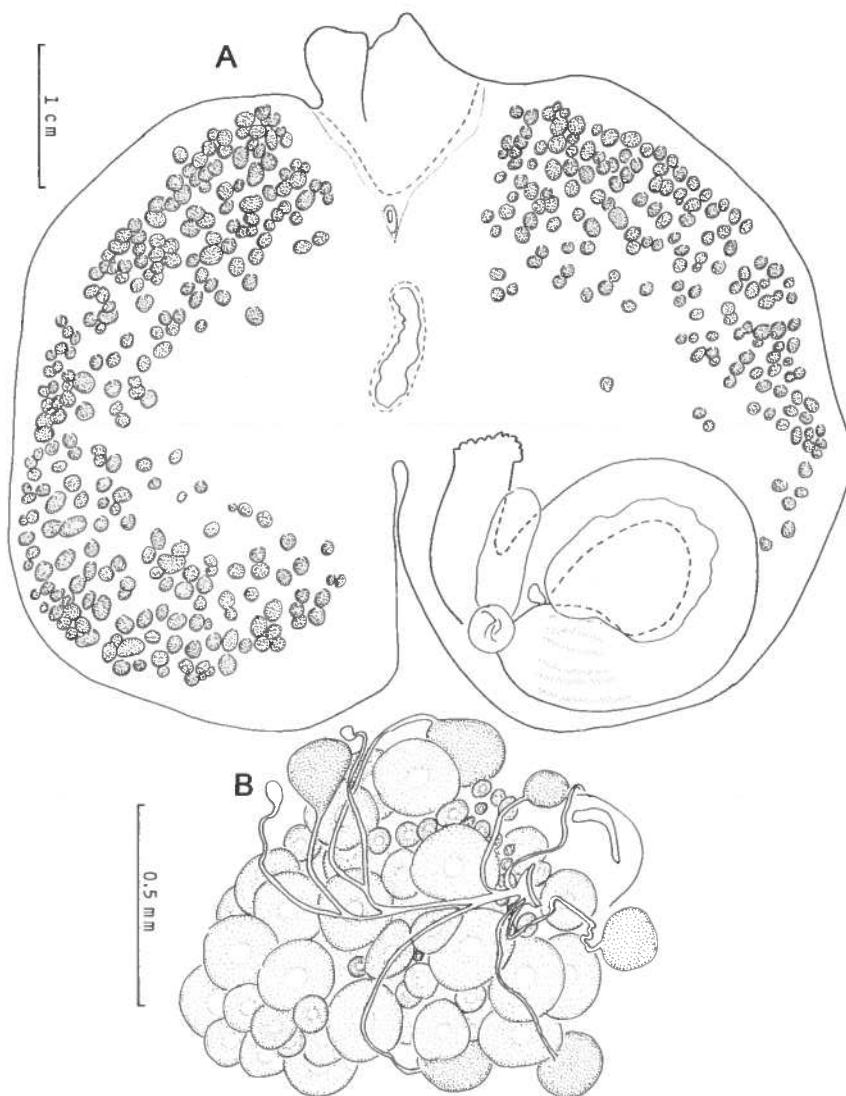


Figure 52. *Polycarpa argentata* (Sluiter, 1990): A, specimen opened along the ventral side; B, gonad.

The specimens were erect, brownish red and covered with epibionts in life (Pl. 8H). The siphons are long, with a circular opening and internally 8 white stripes and greenish-white spots. In formalin, the test is wrinkled and silver colored. The tunic lining is pink, without ornamentations. The body tunic is tough exteriorly, greyish and softer interiorly.

The body wall is not thick and slightly translucent. The muscular fibers are brownish-red. The gonads that are included in the body wall thickness can be



seen in transparency. There are 16 tentacles in 3 orders (2 orders of large ones and small ones intercalated). The prepharyngeal groove has only one high crest; it draws a deep dorsal V. The dorsal tubercle is slightly protruding, its opening is a simple hole. The low dorsal lamina encircles the esophagus entrance. The endostyle is high, attached to the body wall by a thin membrane. The branchial sac has 4 low, widely separated folds. We counted:

R.E. 6 12 6 12 7 11 6 13 or (10 1 3) O.R. 3 10 4 12 7 12 6 13 5 E.L.

In the posterior half the first folds lower and become only a group of sinuses. On the right side the 3 first sinuses are more brought together than the others. The first sinus on the right parts aside from the dorsal lamina (8 stigmata anteriorly and more than 40 in the medium part). The branchial folds join the esophagus opening progressively lowering. Between the folds there are about 10 stigmata in a mesh, and 1 to 2 on the folds. There are no parastigmatic vessels.

The gut (Fig. 52A) has a translucent wall. The short esophagus opens into an olive-shaped stomach with few and not well defined internal grooves. The isodiametric intestine forms a regular curve. The rectum opens in a scalloped anus. The gonads (Fig. 52B) are included in the body wall and are only slightly protruding in the cloacal cavity. The gonoducts do not protrude. The gonads are very numerous, up to 250 on the right and 150 on the left. Some eggs, without visible segmentation, were found in the cloacal cavity.

Remarks: This specimen well corresponds to the descriptions of Australian and New Caledonian samples and to that of *P. iwayamae* Tokioka, 1950 from the Palau Islands. The present specimen and those described from Palau are larger than specimens recorded elsewhere, which do not exceed 3 cm. The number of gonads is also greater than in other regions. The branchial folds of the present specimen are low but in New Caledonia and Australia they are higher and slightly cover each other. The sinus number is the same but the space between the folds grows in larger specimens.

Geographic Distribution: Previously known from Palau, Gilbert Islands, Marshall Islands, Western Australia, Queensland, New Caledonia.

*Polycarpa aurata* (Quoy & Gaimard, 1834)

Synonymy: see Kott, 1985: 149, fig. 67, pl. 3c.

Material Examined: MNHN: S1 Pol B 303—Chuuk lagoon, 7°22.63'N; 151°50.70'E, 22 m.

This species is recorded from the north coasts of Australia, Indonesia, New Guinea, Philippines, Chuuk and Palau Islands.

*Polycarpa captiosa* (Sluiter, 1885)

Fig. 53, Pl. 9A

*Styela captiosa* Sluiter, 1885: 202, pl. 9, fig. 4–7, Indonesia, Billiton Island; 1904: 60, Indonesia, Saleyer, Timor, and Ambon Islands.

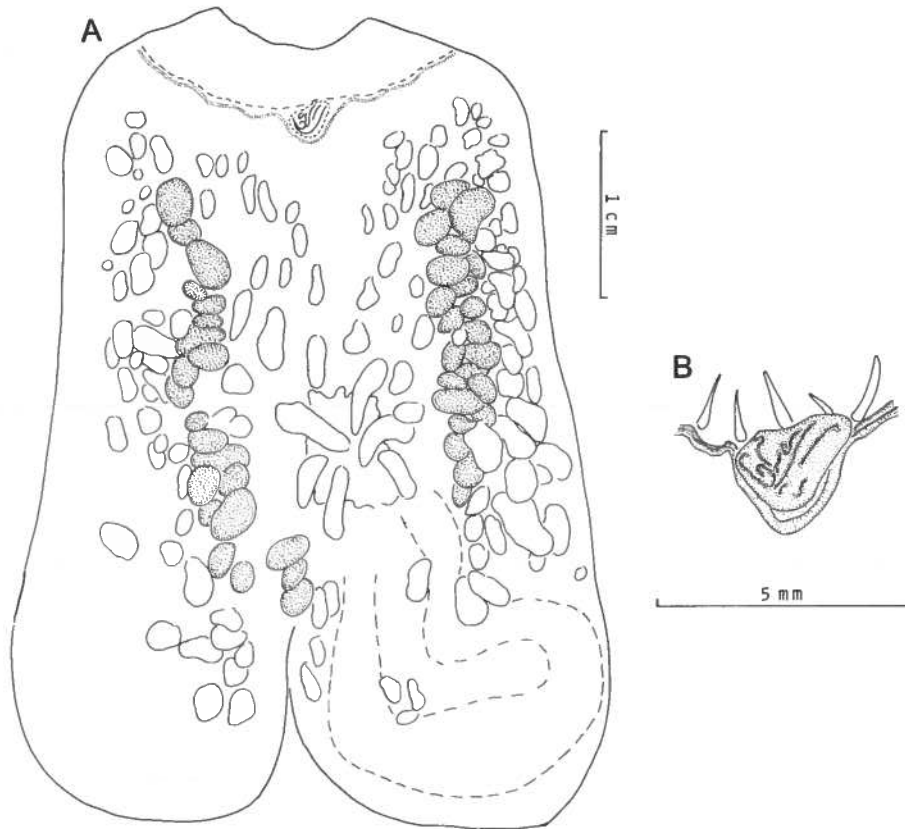


Figure 53. *Polycarpa captiosa* (Sluiter, 1885): A, internal side of the body wall; B, dorsal tubercle.

*Polycarpa captiosa*: Tokioka, 1950: 136, fig. 14, pl. 10, fig. 1, Palau Islands; 1967: 171, fig. 70, Palau and Mariana Islands.

*Polycarpa papillata*: Kott, 1985? part: 184, Australia.

Material Examined: MNHN: S1 Pol B 299—Palau, Rock Islands, Marine Lake, 1 m.

The specimen of 8 cm in length was attached by the posterior half of the ventral side, the upper part of the body was erect. When living, the siphons are long and well separated, the deep red test is tuberculated, with some epibionts (Pl. 9 A). The siphons are 4 lobed, with gold yellow patches, 4 on the oral siphon and 2 on the cloacal siphon, and uniformly red inside. In formalin the siphons turned black-brown, the tunic yellowish.

The tunic is about 2 mm thick. The body wall is opaque, 1 mm thick and yellow. The musculature cannot be seen. Internally the body wall, full of gold granules, is wrinkled with polygonal areas. Gonads and endocarps contrast on the body wall as they remain pale, devoid of pigment granules. The oral tentacles

are short, not pigmented, about 20 in 3 orders of size. The prepharyngeal groove has 2 high equal rims against the tentacle ring and the branchial sac. The dorsal V is filled with a protruding dorsal tubercle with multiple openings (Fig. 53B). The dorsal lamina, branchial sac and gut have been eviscerated. A part of the branchial sac remaining attached to the prepharyngeal groove, allows determination that the branchial folds were high and not pigmented. On the left side of the body remains the shape of the gut with a double curve, a well marked secondary bend (Fig. 53A). There, the body wall lacks the polygonal pattern present elsewhere. The endocarps which were close to the gut stayed in place. The gonads (Fig. 53A) are grouped in an irregular row on each side. They are protruding into the cloacal cavity. The testis follicles and oocytes are poorly developed. The endocarps are numerous and upright, those which are close to the cloacal siphon are long tending to penetrate into it.

Remarks: Several authors, including Tokioka (1952) and Millar (1975), describing *P. captiosa* had emphasized the similarities of this species with *P. papillata*, but separated the two species. Kott (1985) considered them as synonyms and thought that specimens attributed to *P. captiosa* were particularly large specimens of *P. papillata* in which the "concave shape" and widely spaced siphons corresponded to animals that "lie horizontally". The examination of the type specimen of *P. captiosa* has shown it to be identical to the Palau sample examined here. Sluiter's (1885) description has numerous errors. Sluiter (1885 pl. IX fig. 6) misinterpreted the narrow groove located between the prepharyngeal groove and the dorsal tubercle as the dorsal tubercle. The latter is actually very large, with several openings in transverse slits. The anus is not constricted, but widely opened and without lobes.

*P. captiosa* and *P. papillata* differ in gonad distribution, properties of the test, the body wall (thin, translucent and brittle in *P. papillata*; thick, opaque, muscular with a pigmented internal layer, in *P. captiosa*), the gut loop and stomach shape, and the anal border (deeply lobed in *P. papillata*, smooth in *P. captiosa*).

Geographic Distribution: Indonesia, Palau, Mariana Islands, and perhaps present in Australia.

*Polycarpa cryptocarpa* (Sluiter, 1885)

Pl. 9C

Material Examined: MNHN: S1 Pol B 298—Palau, Rock Islands, Topkukau, 7°21.03'N; 134°27.01'E, 7 m.

The sample in this collection conforms to the description of specimens of this species by Tokioka, 1950. The living specimens have a dark brown tunic with wide siphons (Pl. 9C). The siphonal rim is underlined with white dots. This aspect is somewhat different from that observed in New Caledonia, where the internal tunic of the siphons was uniformly white.

Geographic Distribution: Japan, Philippines, Indonesia, Indies, Palau, Solomon Is., Gilbert Is., Marshall Is., Queensland, New Caledonia.

*Polycarpa papillata* (Sluiter, 1885)

Pl. 9D

*Styela (Polycarpa) papillata* Sluiter, 1885: 192.*Polycarpa papillata*: Kott, 1985: 184, fig. 85–86 and synonymy except references concerning *Styela* and *Polycarpa captiosa*.

Material Examined: MNHN: S1 Pol B 304—Papua New Guinea, North coast, Barrier reef of Madang, 5°10.21'S; 145°50.37'E, 10 m.

This species has been recorded in New Caledonia, Australia, Indonesia, Philippines, Palau Islands, Sri Lanka, and Madagascar.

*Polycarpa pigmentata* (Herdman, 1906)

Figs. 54A, B, Pl. 9E

*Styela pigmentata*: Herdman, 1906: 318.*Polycarpa pigmentata*: Kott, 1985: 192, fig. 89; C. Monniot, 1987b: 283, fig. 3.

Material Examined: MNHN: S1 Pol B 317—Papua New Guinea, New Ireland, Kavieng, west of Albatross Channel, 2°45.06'S; 150°42.84'E, 10 m.

The large specimen is entirely black except the pure white internal side of the siphons and their ochre margin (Pl. 9E). When fixed the reflex tunic becomes black. The siphons obvious on the living animals are 4 cm apart in the retracted animal. The tunic remains soft and black in its whole thickness. Some epibionts are present, mostly encrusting bryozoans.

The body wall is black, opaque, 1 to 2 mm thick. The muscles do not form a thin layer but are distributed in the whole thickness, especially in the most internal part. The body wall contains large translucent vesicles of 0.5 to 0.6 mm diameter, sometimes with hollow whitish fragile concretions and patches of dark pigments. The oral tentacles are short, colored ochre in life. They are about 10 only, irregularly alternated and more numerous dorsally. The prepharyngeal groove has only one crest and forms a deep V prolonged by a small groove. The flat dorsal tubercle occupies all the V and has multiple openings (Fig. 54A). The dorsal lamina is long, smooth, low and only slightly increases in height posteriorly. The endostyle is attached to the body wall. The branchial sac contains black cells. It has 5 folds on the right side and 4 on the left. The longitudinal vessels are arranged as follows:

R. E. 6 22 8 20 8 22 10 13 4 8 0 R. 3 15 9 20 9 22 9 20 6 E. L.

The ventral folds are relatively high but do not cover each other; they are less protruding dorsally. The additional fold on the right is complete. The first sinus on the right is anteriorly closer to the dorsal lamina, then it runs apart from it, separated by about 20 stigmata, before coming back close to it, near the esophagus. The disc-shape tissue, circling the esophagus opening, is very thick; the folds join it without lowering. There are 7 to 10 stigmata in a mesh between the folds, 2 or 3 on the folds. There are no parastigmatic vessels.

The gut (Fig. 54B) is very posterior. It is partly encircled by a deep hollow of the body wall. When the intestine is lifted up, its trace is clearly visible on the body wall. The short esophagus gives in a slightly enlarged stomach with internal

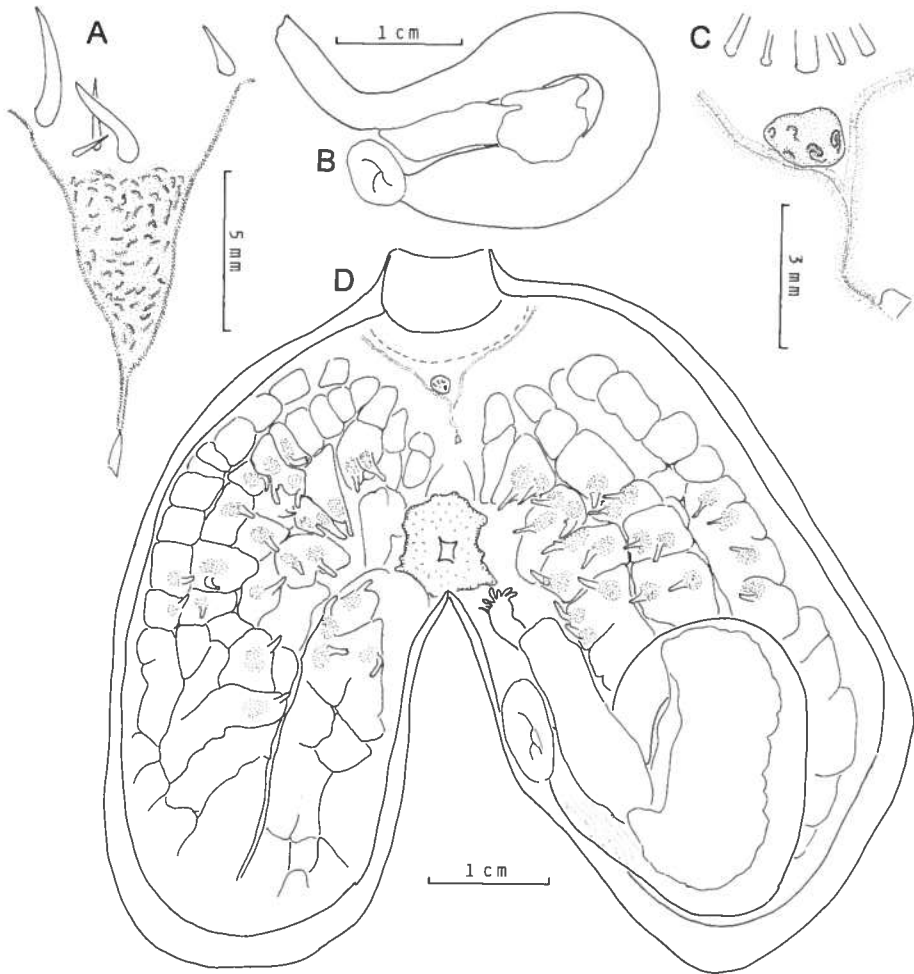


Figure 54. *Polycarpa pigmentata* (Herdman, 1906): A, dorsal tubercle; B, gut. *Polycarpa rima* n. sp.: C, dorsal area; D, specimen opened ventrally.

grooves that are not visible exteriorly. There is no caecum. The rectum is not linked to the dorsal lamina but to the body wall. The anus is slightly lobed. The gut is only attached to the body wall at the level of the endocarp and rectum. The gonads are not functional in this specimen; they are completely included in the body wall and the ducts are not protruding. The gonads are not numerous, no more than 10 on each side, developed enough to be seen in the body wall, but many more if some of the pigment masses represent very young gonads. The testis follicles are lobed. There are 2 large foliated endocarps in the gut loop. The cloacal siphon possess a thick crest bordered with small tentacles.

Remarks: This specimen better correspond to Kott's (1985) description of *P. pigmentata* than to that of C. Monniot (1987b). It differs from the New Cal-

edonia specimens by many small details. In New Caledonia the shape is more massive and quadrangular, there is a stiff external and soft internal tunic. The body wall has the same structure but is less pigmented. The tentacles are more numerous, the dorsal tubercle more protruding, the dorsal lamina shorter (this perhaps related to the body shape). The branchial sac is more resistant and the sinuses contain white fibers. The gut forms a larger loop with a smooth rimmed anus. The present specimen is intermediate for the shape of the anus and digestive tract between the Australian and New Caledonian samples.

**Geographic Distribution:** Except for Sri Lanka, the type location, and Western Australia, the geographic distribution of this species remains in the Pacific: Japan, Philippines, Indonesia, Palau, Solomon Is., Marshall Is., Chuuk, Fiji, New Caledonia.

*Polycarpa rima* new species

Figs. 54C, D, Pl. 9F

**Holotype:** MNHN: S1 Pol B 318—Papua New Guinea, Eastern Fields Atoll (Coral Sea), 140 km southwest of Port Moresby, 30 m.

**Description:** The specimens were erect, 8 x 3 cm, attached by a small part of the posterior left side with strong hairs. The oral aperture is terminal, the cloacal siphon is 3 cm from the oral siphon; when alive (Pl. 9F) the siphons are bare, externally golden and white internally, but in formalin the whole tunic turns dark brown in its total thickness and is soft.

The body wall is opaque. The muscles bands are dark brown and they form a dense network. The body wall is 1 to 2 mm in thickness, with two parts: one external containing the musculature, the internal one of a light brown is fibrous and contains numerous blood lacunae, the gonads and large clear vesicles. In the cloacal surface of the body wall are scattered rare black granules which are more numerous on the endostyle, the branchial tissue, the endocarps and the digestive tract. This surface layer is divided by deep furrows in more or less quadrangular fields, as suggested by the species name (*rima* = crack).

About 40 tentacles are distributed in 3 or 4 orders on a single circle. The prepharyngeal groove is made of two low equal crests. It has a dorsal V extended posteriorly into a groove 2 to 3 mm long in front of the dorsal lamina (Fig. 54C). The dorsal tubercle is large and protruding with a small number of independent openings. The dorsal lamina is long, low with a plain margin. The branchial sac is thick and tough. On the external side the transverse sinuses are large and muscularized. Each dermato-branchial trabeculum has a muscles. The branchial formula is:

R.E. 4 17 4 21 3 21 2 (22+7) 0 R. 0 25 3 21 3 21 4 18 4 E.L.

The first sinus on the left side is close to the dorsal lamina but the first fold is doubled soon in the anterior part of the branchial sac. Posteriorly, all the sinuses constituting the first fold part but remain in two distinct groups. The branchial folds are not high with sinuses very close to each other. The sinuses between the

folds correspond to the most ventral sinuses of the preceeding fold. 10 stigmata are in a mesh between the folds. There are no parastigmatic sinuses.

The digestive tract (Fig. 54D) forms a double loop. The stomach is not enlarged and has few internal grooves, hardly visible. The cylindrical intestine ends in an anus with has finger-like lobes on the margin. The gonads are deeply embedded in quadrangular fields of the body wall, and each field may contain up to 3 of them. They are only visible by a light color through the body wall internal layer and by large female papillae. The male papilla, much smaller, opens on a button located at the base of the female papilla. The testis follicles are numerous and long, they encircle the ovary. There are 2 very large endocarps in the gut loop. The cloacal aperture is circled by a fleshy undulated crest having small tentacles on its margin. The tentacles are scattered inside the siphon.

Remarks: The gonad disposition, in an internal layer of the body wall divided in polygonal areas, is similar in *P. mytiligera* (Savigny, 1816) and *P. molguloides* Herdman, 1882 (see Kott, 1985, C. Monniot, 1987b). *P. rima* differs from *P. molguloides*, a species from southern Australia, by the tunic covered with hairs and sand, fewer vessels in the folds, lobed testis follicles, short genital ducts, and a simple dorsal tubercle. It differs from *P. mytiligera* which has a smooth anal rim and not protruding genital ducts. *P. rima* is essentially characterized by the length of the genital ducts.

*Polycarpa tokiokai* new species

Fig. 55, Pl. 9G

*Polyandrocarpa nigricans* non Heller, 1878, Tokioka, 1979: 91, fig. 5, Philippines.

*Polycarpa nigricans*: Monniot & Monniot, 1987: 234, fig. 5, Philippines.

? *Polycarpa pedunculata*: C. Monniot, 1987: 288, fig.6A-C, New Caledonia.

Material Examined: Holotype: MNHN: S1 Pol.B 316—Palau, Marine Lake; MNHN: S1 Pol B 301—Palau, Airai Channel, ship hull, 7°21.03'N; 134°30.95'E, 1 m; MNHN: S1 Pol.B 302, Koror State, Rock Islands, 7°18.48'N; 134°28.12'E, intertidal; MNHN: S1 Pol.B 344, Palau, Marine Lake, 7°17.7'N; 134°27.3'E; MNHN: S1 Pol.B 296—Indonesia, west of Manado, 1 km West of Murex Resort, 1°27.07'N; 124°44.59'E, 7 m.

The specimens collected on a ship hull were grouped each measuring 2 to 3 cm, their tunics fused at their base only or along almost their whole length. Out of the tunic, the individuals have the same size, no young specimens or buds were found.

The specimens collected in the intertidal area (Pl. 9G) are much smaller, 1 to 1.5 cm, with tunics fused at their base. On the adult specimens we found some very young specimens whose tunics were not fused to the supporting adult specimen.

In life, the test is orange, the rim of the siphons blackish. The siphon lining has 8 brown stripes alternating with 8 paler ones with bright yellow dots. The pigmented bands are limited to the upper part of the siphons. The surface of the

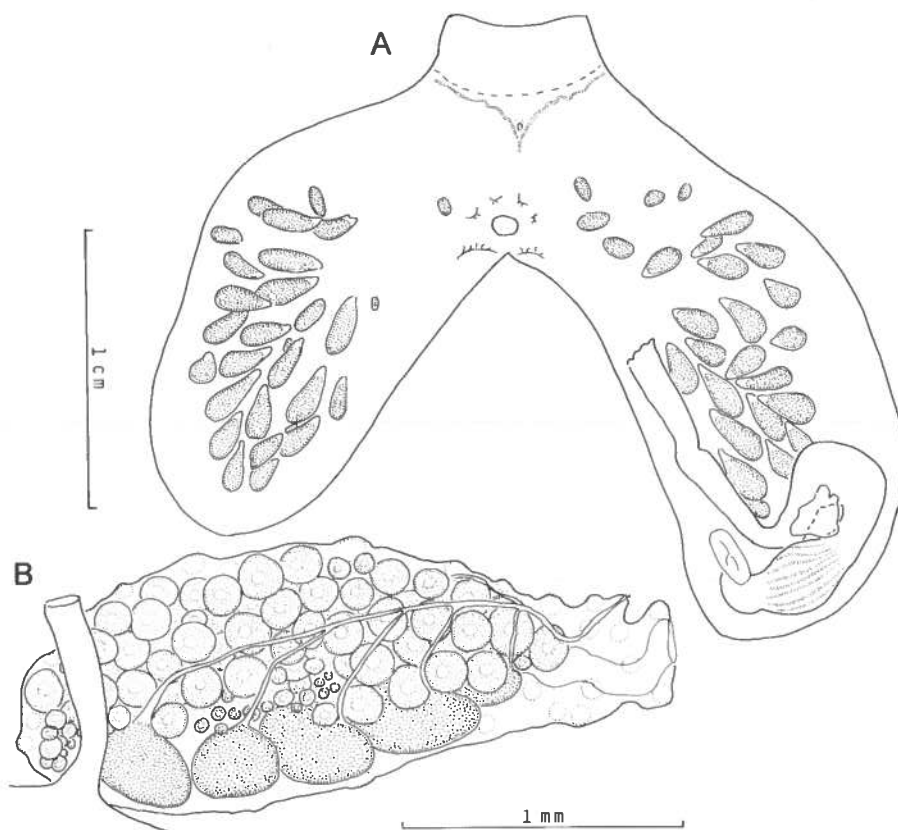


Figure 55. *Polycarpa tokiokai* n. sp.: A, holotype opened ventrally; B, detail of the gonad.

test is smooth or it has small tubercles. There are some epibionts. The test turned dark brown in alcohol. It is about 1 mm thick, soft and nacreous internally.

The thin musculature is mostly longitudinal. The internal side of the body wall contains whitish granules more abundant in the anterior part. There are 16 to 30 long and thin tentacles in 2 or 3 orders of size and, between them, some others small and irregular in size. The prepharyngeal groove has 2 equal rims and encloses a deep dorsal V. The anterior one flattens in the dorsal part, the posterior curves in a deep V. The dorsal tubercle has a large irregular opening from a wide crypt. The neural ganglion is long. The dorsal lamina is long, smooth edged and high. The branchial sac is not pigmented; it has 4 folds which do not recover each other. The branchial formula in a large specimen is:

R.E. 3 6 3 9 3 8 3 8 O D.L. 1 6 4 10 3 10 2 8 2 EL

While in a small specimen we counted:

R.E. 2 7 2 10 2 9 2 9 O D.L. 1 7 2 9 2 8 2 7 1 EL

The first sinus on the right side of the dorsal lamina is more developed than others. It moves aside from the dorsal lamina, separated from it anteriorly by 4



to 6 stigmata and by 20 to 30 stigmata at the esophagus opening. In large specimens an unperforated area may develop posteriorly, on the right side of the dorsal lamina, diminishing the number of stigmata. The branchial meshes are transversally elongated. 8 to 12 stigmata were counted in a mesh between the folds and 6 to 3 on the folds. There are no parastigmatic vessels.

The digestive tract is not voluminous (Fig. 55A). The long stomach has about 15 grooves visible from the outside; the intestine forms a closed curve; the rectum is long, attached to the body wall, ended in a widely opened anus with a smooth edge, somewhat curled or fringed with small lobes. We have not seen a caecum. A large endocarp occupies the entire intestinal loop; it is attached to the body wall, the stomach and the intestine. The gonads (Fig. 55B) are characteristic. They are linked to the body wall and a dermato-branchial sinus by their distal part. They are erect in the cloacal cavity. They are embedded in a thick tissue containing granules. They possess 2 rows of external testes and an internal ovary. The spermatozooids are collected in 2 sperm ducts joining in a single papilla, slightly protruding anteriorly to the ovary. The oviduct is wide and opens far from the male papilla. There are numerous granules in the body wall around the gonads. The number of polycarps varies from less than 10 to about 40 in adult specimens. The cloacal tentacles are thread-like on small crests scattered around the siphon.

Remarks. This two populations, correspond to the specimens of *Polyandrocarpa nigricans* described from the Philippines by Tokioka (1970b) and Monniot & Monniot (1991) as *P. nigricans*. The complete fusion of the test at the base of the individuals was the argument Tokioka's used to include this species into the genus *Polyandrocarpa*, even without any budding evidence. Since this time, Kott (1985) and C. Monniot (1987b) have systematically placed the species having zooids more or less fused by a part of their tunic into the genus *Polycarpa*, even when they were not issued from a simple egg, but budded from lysed zooids. The aspect of the gonads in specimens from Philippines, Indonesia and Palau, protruding into the cloacal cavity, does not correspond either to other descriptions of *P. nigricans* or to Heller's specimens.

We have searched for Heller's type of *P. nigricans*, it is not located among the other type species of this author and is not cited in the 1905 Michaelsen's revision of Heller's types. Hartmeyer (1905) redescribed *P. nigricans* after one of the aggregates collected at Mauritius by Dr. Möbius and used for Heller's description. Hartmeyer noted that the species was abundant in Mauritius and that numerous specimens were stored in the museums of Kiel and Berlin. The aggregated specimens observed by Hartmeyer (1905) were probably dispersed and some zooids are at the Zoological Museum of Copenhagen, in the Senckenberg Museum in Frankfurt and in the Museum of Wien. We have examined all these specimens, all labeled Hartmeyer, 1905. Kott (1985) considered the specimen in the Zoological Museum of Copenhagen as the holotype. We believe that all specimens can be considered as belonging to the type series examined by Heller (1878), and are paratypes. The species from Mauritius is different from the species described above.

Three different species have been assigned to *P. nigricans*.

(1) *Polycarpa nigricans* stricto sensu: *Polycarpa nigricans* Heller, 1878: 174, fig. 80, Mauritius; Hartmeyer, 1905: 390, pl. 13, fig. 1, 12–14, Mauritius; Vasseur, 1967: 115, pl. 5, fig. 37–40, Mauritius. This species has aggregated or solitary zooids, 2 to 3 cm high with gonads included in the body wall and only slightly protruding in the cloacal cavity with large projecting gonoducts (Hartmeyer 1905, fig. 14). Each polycarp is enclosed in a mass of clear vesicles contrasting with the dark granules of the body wall and the area around the dorsal tubercle. The testis lobes are round, small, not regularly arranged as noted by Vasseur (1967, fig. 40).

(2) *Polycarpa nigricans* non Heller, 1878: Kott, 1985: 174, fig. 80, pl. 3f, West Australia; C. Monniot, 1987: 286, fig. 5, New Caledonia. This species is solitary or aggregated, with a black tunic in life, and gonads deeply embedded in the body wall which cannot be seen on the internal surface. The gonoducts are not or only slightly protruding. The testis lobes are long on each side of the ovary. The West Australian samples have a complex dorsal tubercle. This is not the case in New Caledonian specimens.

(3) *Polycarpa tokiokai* n. sp. The polycarps are clearly protruding into the cloacal cavity. The testis follicles are long, regularly arranged around the ovary. The polycarps are encircled by whitish granules. *Polycarpa pedunculata* C. Monniot, 1987 may belong to this species.

It is not possible to insert in one of these three species the reference of *P. nigricans* from the Comoro Islands, given without description by Lafargue & Vasseur (1989: 65).

### *Polycarpa* sp. A

#### Fig. 56

Material Examined: MNHN: S1 PolB326—Indonesia, north Sulawesi, west of Manado.

A specimen measuring 85 x 40 mm, entirely black in formalin, slightly flattened laterally, was erect in life. The siphons are slightly protruding. The oral aperture is apical, the cloacal aperture 30 mm from it. The relatively soft tunic is wrinkled. Its anterior part is partially covered with epibionts, mostly calcareous encrusting algae. The tunic is somewhat translucent about 2 mm thick. The light brown body wall reveals the gonads in transmitted light. The muscles are colorless in a regular network in the external layer of the body wall. The internal layer is thicker, with large clear vesicles. The total thickness is 1 to 2 mm.

We counted 14 large tentacles in 3 orders and numerous small ones intercalated. The prepharyngeal groove has an anterior groove and a posterior crest (Fig. 56B). The deep dorsal V is prolonged by a groove to reach the dorsal lamina. The dorsal tubercle is not protruding and has 2 openings in the present sample. It is circled with non-protruding blood vesicles (Fig. 56B). The dorsal lamina is low. On its right side and posteriorly lies a large unperforated area covered with papillae. The endostyle is only attached to the body wall by a sheet of tissue. It is very long and ends against the esophagus opening. Consequently,

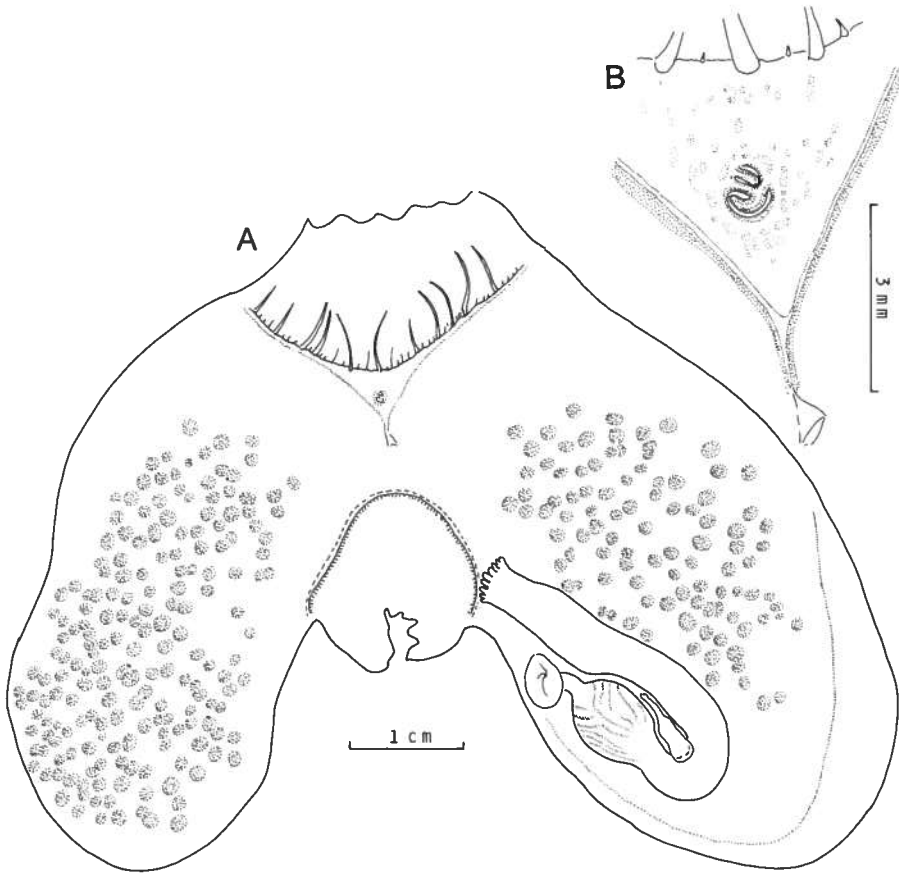


Figure 56. *Polycarpa* sp. A: A, specimen opened ventrally; B, dorsal area.

the branchial sac forms a large posterior bag. The branchial tissue is of a pale ochre. The 4 folds are low and a pseudo-fold is added on the right side. In the posterior part the formula is:

R.E. 3 14 5 16 5 17 7 (12 3 4) 0 D.L. 3 10 6 17 5 17 6 17 4 E.L.

Anteriorly, the first sinus on the right is more developed. Posteriorly, it draws near to the dorsal sinuses of the first fold and makes a protruding pseudo-fold. There is no additional sinus there and the space between the pseudo-fold and fold 1 remains constant, so the dorsal sinuses of the first fold move apart in this space. At the same level the first fold lowers. We counted about 20 stigmata between the dorsal lamina and the first sinus on the right side anteriorly, and posteriorly 20 to 30 stigmata. The meshes contain 6 to 8 stigmata between the folds, and 2 to 3 on the folds. Parastigmatic vessels are only present in the case of a division of the rows of stigmata.

The gut forms a closed loop, without a secondary curve (Fig. 56A). The stomach is distended, with some grooves seen in transparency. There is no caecum.

The lobed anus is gaping. There is one small endocarp in the intestinal loop, which does not overlie the intestine and is covered with small papillae. The gonads (184 on the right and 99 on the left in this specimen) are totally embedded in the body wall thickness, at variable depths. The ovary is central in a sphere of lobed testis follicles. The oviduct and sperm duct open separately by non-protruding papillae. In the cloacal siphon is a circular crest covered with small cloacal tentacles.

Remarks: This specimen seems close to *P. cryptocarpa* (Sluiter, 1885), but differs by a more transparent body wall, the absence of black granules in the tissues, lobed testis follicles and a simple dorsal tubercle, when, at a same size, that of *P. cryptocarpa* is always circonvoluted. There is also one single endocarp in the gut loop instead of 2 or 3.

It also looks like *P. viridis* Herdman, 1882 from the southern and eastern Australia. The shape of the dorsal tubercle, a single endocarp, a lobed testis, large clear vesicles in the body wall and the gut structure are common characters. But the gut seems to have a variable but accentuated curve. Kott (1985) said the gonads were oval, but as the gut, they can vary. Our specimen is more similar to her fig. 28j for the gonads, and to her fig. 98k for the gut. The shape of the gut of this specimen, with the rectum in continuity with the intestine is distinctive. The color in life is not known while that of *P. viridis* is clear. It is necessary to have additional specimens to fix the status of ours.

*Polycarpa* sp. B

Figs. 57A, B, Pl. 9H

Material Examined: MNHN: S1 Pol B 315—Papua New Guinea, Eastern Fields Atoll (Coral Sea), 140 km southwest of Port Moresby, 10°00.65'S; 145°39.9'E, 2 m.

The 4 cm specimens were attached to the reef by their ventral side. The reddish brown tunic is shaded by filamentous sea weeds (Pl. 9H). The quadrate extended siphons have 4 lighter patches. The reflex tunic of the siphons is milk-chocolate in color. When fixed, the tunic becomes brown, the inside of the siphons lighter and slightly nacreous. The consistency is hard, mammillated and wrinkled. The siphons are slightly protruding.

The body wall is thick and opaque with 4 distinct layers: the external one is thin and contains spherical tan to black granules. The next layer contains brown muscular fibers. The middle layer is thick, whitish and contains the gonads; while the internal layer is thin with granules. About 30 tentacles are irregularly distributed in 4 or 5 orders, they are long but not curved. The prepharyngeal groove has two equal crests. It makes a clear dorsal V prolonged in a narrow posterior slit down to the dorsal lamina (Fig. 57B). The dorsal tubercle, slightly protruding, has multiple openings (Fig. 57B). The height of the dorsal lamina progressively increases down to the level of the middle of the esophagus opening. The branchial sac is light-brown in formalin. It has 4 folds which do not recover each other. The formula is:

R.E. 3 16 6 15 6 22 6 18 4 R. 3 17 8 20 6 17 6 16 5 E.L.

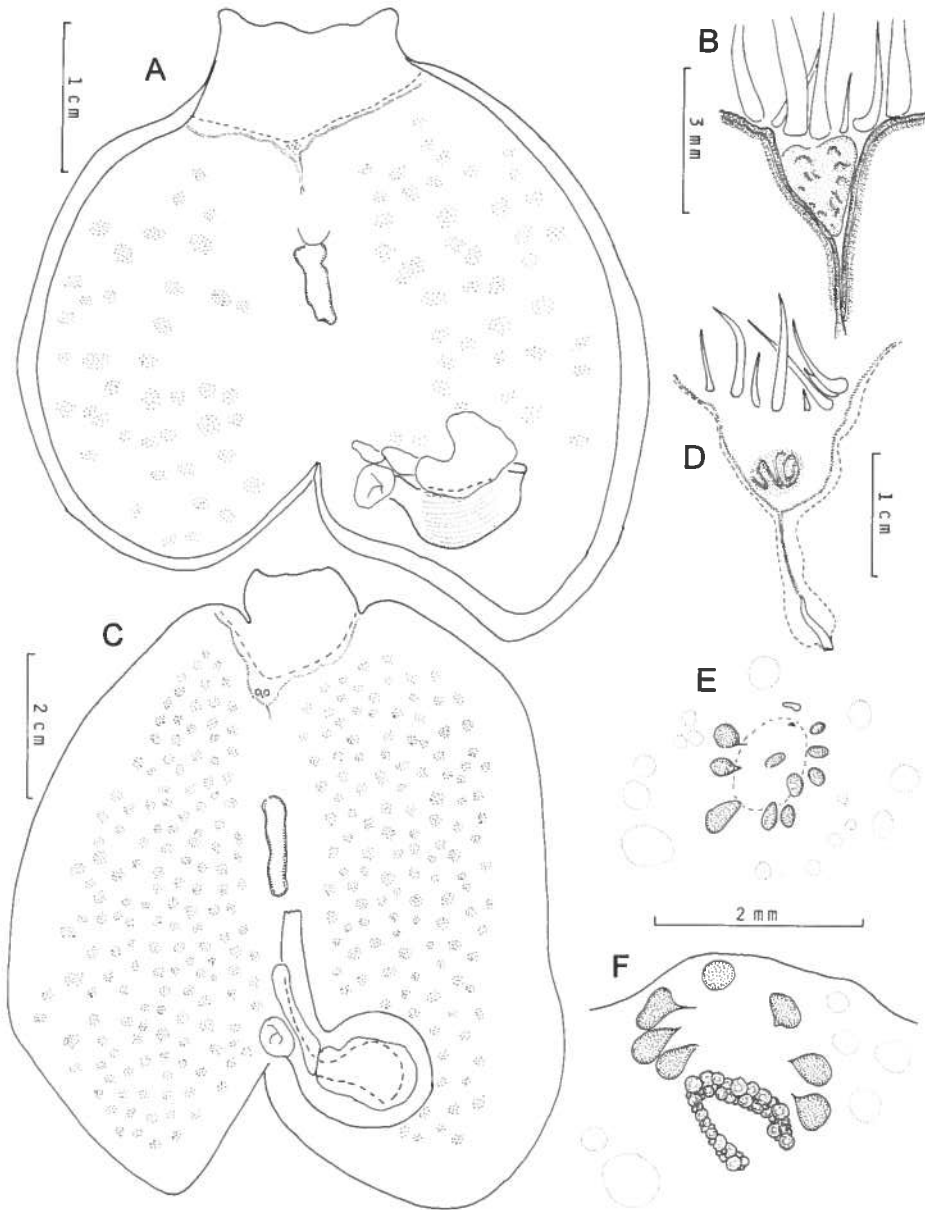


Figure 57. *Polycarpa* sp. B: A, specimen opened ventrally; B, dorsal area. *Polycarpa* sp. C: C, specimen opened ventrally; D, dorsal area; E, internal side of a polycarp; F, transverse section of a polycarp.

The first sinus on the right of the dorsal lamina is close to it in the anterior half of the body, with 5 to 7 stigmata in a mesh; afterwards it parts from it with

more than 20 stigmata in a mesh. The folds lower regularly at the esophagus opening and the vessels do not produce papillae.

The gut was totally missing in one specimen and incomplete in the other (Fig. 57A). The stomach grooves are clearly visible through the wall. There is no caecum. The gut is attached to the body wall by a large trabeculum in the pyloric region. This species is probably able to eviscerate. The gonads are totally included inside the body wall. The ducts are almost invisible superficially. In the specimen studied, the gonads are inactive. A large endocarp and two smaller ones are located in the gut loop. The cloacal aperture is circled by a thick crest with small tentacles. The body wall shows a protrusion anterior to the cloacal siphon (Fig. 57A).

This species is closely allied to *P. pigmentata* (Herdman, 1906) and *P. nigricans* Heller, 1878, sensu Kott, 1985, but does not belong to these species. It differs from *P. pigmentata* which has a light colored internal tunic in the siphons, a less massive shape, a dark body wall with light granules, and an additional branchial fold on the right side.

*P. nigricans*: Kott, 1985 has a hard, entirely black tunic, and protruding siphons even in contracted zooids. It has fewer sinuses on the folds and more sinuses between the first right fold and the dorsal lamina. *P. nigricans* Heller, 1878 is always smaller. It has a gastric caecum which is missing here.

Without a complete digestive tract a species identification cannot be given.

#### *Polycarpa* sp. C

Figs. 57C–F, Pl. 9B

Material Examined: MNHN : S1 Pol B 327—Federated States of Micronesia, Chuuk State, Mortlock Islands, Losap Atoll, oceanside reef, southwest side, 6°50.12'N; 152°40.85'E, 25 m.

This large species (12 x 4 cm; 10 cm really occupied by the body wall) is black except a thin light brown line around the apertures (Pl. 9B). The siphon lining is also black. The posterior part of the tunic is very thick and can almost be considered as a peduncle. This species externally looks like *Polycarpa pedunculata*. The body is slightly curved with siphons 4 cm apart. The tunic is longitudinally wrinkled and has some epibionts. It is tough but remains flexible. The tunic, 1.5 mm in thickness, is slightly nacreous interiorly.

The body wall is opaque black 0.5 to 2 mm thick. The black muscles form the external layer. The brown, soft middle layer contains whitish vesicles the diameter of which reaches 0.6 mm. The internal layer is thin and light. About 20 rather short tentacles in 2 or 3 orders of size are more tight dorsally than ventrally. The prepharyngeal groove has only one rounded crest. It forms a large dorsal V prolonged by a groove. The dorsal tubercle, slightly protruding, is complex and does not fill all the V surface (Fig. 57D). The dorsal lamina is long and low; an unperforated area lies on its right side. The endostyle is high, attached to the body wall. Its axis has a dark brown color.

The branchial sac is slightly pigmented, thin and brittle. It has 4 folds. Anteriorly we counted:

R E. 8 15 15 18 10 21 14 17 8 R. 3 16 10 21 10 15 15 15 10 E.L.

There is no additional fold on the right side. The first sinus on the right is close and parallel to the dorsal lamina, an uncommon location for a *Polycarpa*. The space between the first fold and the dorsal lamina on the right increases posteriorly with 11 longitudinal sinuses instead of 8 anteriorly, while on the fold 15 sinuses remain instead of 17. The folds become progressively lower to join the esophagus opening. There are 8 to 10 stigmata in a mesh between the folds and 5 to 8 on the folds. There are no parastigmatic vessels.

The gut is small (Fig. 57C). The stomach is slightly enlarged and the internal grooves are not visible from outside. A caecum was not detected. The rather long rectum has a translucent wall; it is attached to the body wall; the anus is scalloped. The gonads are embedded in the body wall. The diverse elements of the polycarps do not touch each other but are embedded in a brown tissue. Each gonad is combination of a white ovary deeply sunken into the body wall, as a hollow vesicle, circled by a half sphere of pyriform testis follicles (Figs. 57E, F). The gonads make small swellings at the body wall surface, the genital papillae are not protruding. More than 100 gonads are scattered on the whole body wall (Fig. 57C). There are 2 large endocarps, one occupying all the center of the intestinal curve, the other spread between the esophagus and the rectum and extending along the rectum (Fig. 57C). The cloacal siphon has an internal fleshy crest with a line of small tentacles on its rim.

Remarks: This large size species seems to belong to a new species closely allied to *P. cryptocarpa* (Sluiter, 1885) but differs from it by numerous characters. At the same size, *P. cryptocarpa* possesses a spongy-looking dorsal tubercle with multiple openings, a resistant branchial sac with an additional fold on the right side, a voluminous and opaque gut, gonads with protruding papillae in buttons and dark brown eggs.

This sample differs from other large black *Polycarpa* with gonads embedded in the body wall, and particularly from *P. obscura* Heller, 1878 which has white threads joining the branchial sac to the body wall, and from *P. ovata* Pizon, 1908 in which testes are branched. It would be necessary to verify on other specimens the very peculiar characters of this individual.

#### Family Pyuridae

##### *Herdmania momus* Savigny, 1816

Material Examined: MNHN: S2 Her 6—Indonesia, north Sulawesi, west of Manado, 1°23.74'N; 124°32.41'E, 10 m.

This very common species is distributed in all warm seas around the world.

##### *Pyura albanyensis* Michaelsen, 1927

Fig. 58

Synonymy: C. Monniot, 1989: 490; 492 fig.8, pl.11 A, B.

Material Examined: MNHN: S2 Pyu 350—Papua New Guinea, Madang, 5°15.47'S; 145°49.12'E, 10 m.

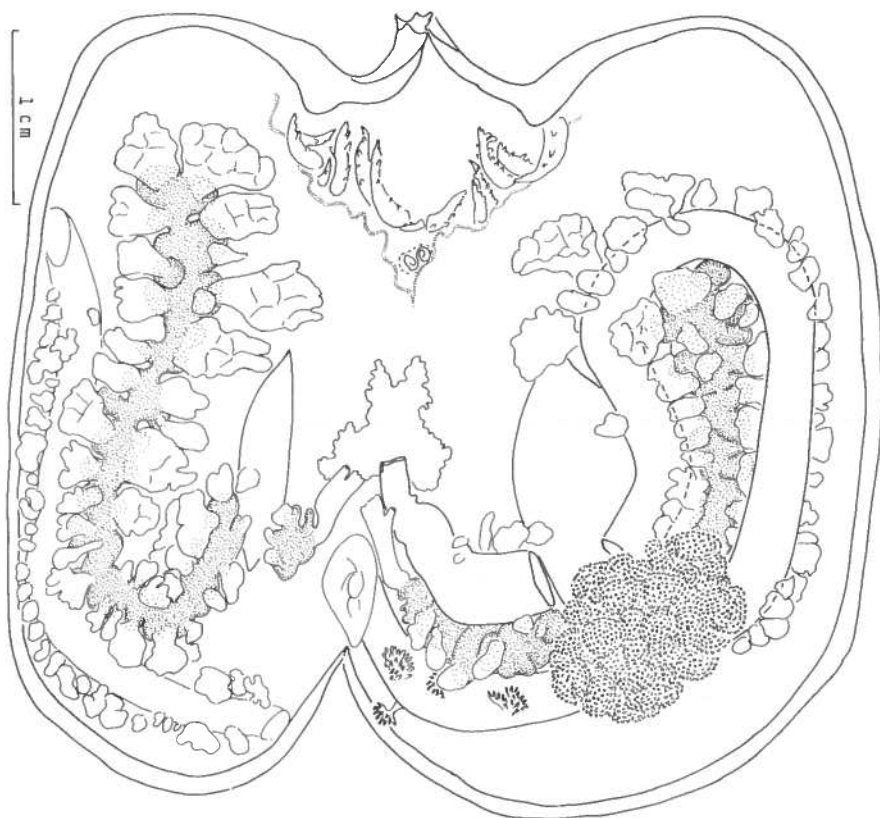


Figure 58. *Pyura albanensis* Michaelsen, 1927

The specimen 6 cm long was attached on the coral reef by its ventral side. The tunic is for the most part coated with small algae in continuity with the substrate cover. Between the epibionts, the tunic is reddish. The short siphons have 8 ochre bars separated by black bars. In formalin, the internal tunic turns uniformly purple with only large iridescent spinules on the rim of the siphons. In the retracted animal, the oral siphon cannot be seen and the cloacal siphon is hidden in the bottom of a tunic depression. The tunic is 4 to 5 mm thick, tough and rigid. It is brown in all its mass.

A whitish dense musculature makes the body wall opaque. The external layer has transverse muscular bundles joined on the dorsal and lateral sides, more spaced on the ventral side. The internal layer has close, but well separated, longitudinal bundles, regularly spaced. The muscles are so strong that the body wall has been torn on each side when fixed in formalin (Fig. 58).

The oral tentacles are not numerous (16), without order and they are only irregularly digitated. They are planted above a strong muscular ring. The prepharyngeal groove has two equal sheets. It forms irregular curves at the level of



the branchial folds and a deep dorsal V. The dorsal tubercle is protruding with its opening in two spirals turning in the same way. The short dorsal lamina is made of sharp languets of medium size, placed on the left side of an unperforated band. The thin branchial sac has 6 high folds that may cover each other. We counted on the right side:

E. 15 20 13 26 14 26 12 29 9 35 5 27 6 R.

The folds are neatly interrupted at the esophagus opening and the longitudinal vessels are prolonged by papillae. The branchial meshes are square with 6 to 8 stigmata between the folds, and 4 to 6 stigmata on the folds; they are regularly crossed by large parastigmatic vessels.

The stomach is not enlarged. The hepatic gland is made of 4 small finger-like lobes (one of them located in the right side cloacal cavity) and of a large pedunculated mass in the shape of a cauliflower (Fig. 58). The cylindrical intestine ends in a short rectum with an anus cut in a lateral slit.

There is one gonad on each side made of a central tube and lateral rather regular diverticula in the apex of the right side gonad. The left gonad occupies all the space between the two legs of the gut (Fig. 58). The sperm ducts were not seen on the gonad. The terminal gonoducts are almost as wide as the rectum and open by large papillae close to the anus. The endocarps cover the gonad lobes and a large part around the digestive tract. On the right side, they are lined on both sides of a long and voluminous heart.

Geographic Distribution: Around Australia, New Caledonia, Arafua Sea, Palau.

*Microcosmus manaarensis* ? Herdman, 1906

Fig. 59

*Microcosmus manaarensis* Herdman, 1906: 11, pl. 2, fig. 23–31, Sri Lanka; Oka, 1915: 16, pl. 1, fig. 6–7, Madras; Millar, 1975: 309, fig. 87, Java Sea and Singapore. Material Examined: MNHN: S2 Mic 131—Philippines, Cebu, south east Mactan Island, reef top, 10°15.62'N; 123°59.11'E, 10 m.

The animal was strongly attached to the rock by its ventral side. The body is 5 cm long and 3 cm high. The divergent siphons protrude in about 2 cm and their apertures are 1 cm in diameter. In life, the tunic is purple dorsally and yellow ventrally. When fixed, the color turns uniformly dark purple in its whole thickness, reaching 5 mm near the siphons. The epibionts are mostly hydrozoans.

In cutting the tunic we have been surprised to find inside it another complete tunic, with siphons which were not linked to the external siphons. Sediment was embedded in the internal ventral half of the external tunic. The internal tunic was only linked to the external one by a small part of the ventral side where are the tunic vessels. The internal tunic, 1 mm thick, is light brown with red siphons. Its surface is reticulated with small spines. The reticulated aspect is accentuated by a network of brown pigment granules, sometimes black. The internal siphons have large acicular spinules largely pointing exteriorly. We did not observe spinules on the external siphons. The inclusion of sediment inside the internal layer of the

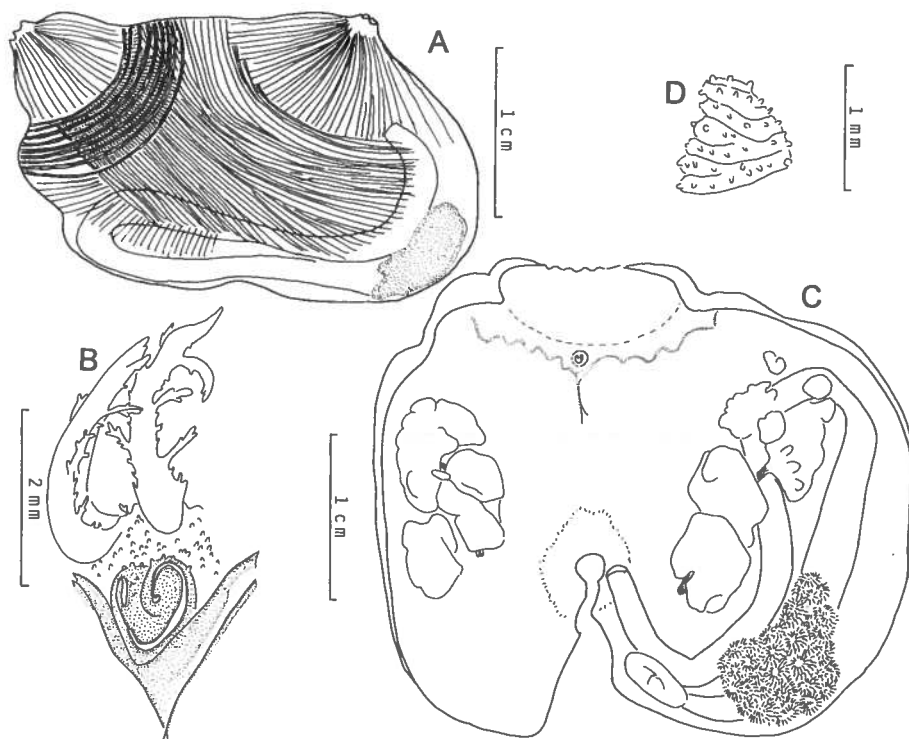


Figure 59. *Microcosmus manaarensis* Herdman, 1906: A, muscles; B, dorsal area; C, specimen opened ventrally; D detail of the liver.

external tunic proves that both tunics were separated before the collection of the animal. It is not possible to know if this phenomenon is normal or an artifact.

The musculature is very strong, with a strong retractor muscle in the oral siphon (Fig. 59A). The siphons have only radial fibers. Strong ribbons of circular fibers cover the radial fibers at the base of the oral siphon. The circular muscles starting at the base of the cloacal siphon join the radial fibers of the oral siphon to make a muscular scarf several mm thick, protruding. The radial fibers of the cloacal siphon run under this scarf and reappear on the ventral side of the body. The musculature is thick and continuous on the whole body except above the gut. The siphonal linings are red, doubled by a large velum almost closing the siphons made of a ring of non muscular body wall, resistant and divided in two lobes. 22 tentacles are arranged in 3 or 4 orders; they are more developed dorsally. The largest measure 5 to 6 mm and are slightly branched with some buttons on the primary branches (Fig. 59B). The prepharyngeal area is covered with papillae. The prepharyngeal groove has 2 well separated crests, the anterior one more developed. It is undulated around the top of the branchial folds and cut in a dorsal V. The dorsal tubercle protrudes (Fig. 57B). The dorsal lamina is a plain membrane progressively higher. It ends at the esophagus opening but does not join

any fold. The branchial tissue has 6 high overlapping folds. We counted on the right side:

E. 1 23 4 24 4 21 4 24 4 25 3 20 3 R.

Posteriorly the folds are lower and the vessels join in a single crest and fuse with the retropharyngeal groove. The longitudinal vessels are high, without papillae. There are about 8 long stigmata in a mesh between the folds and 3 to 5 on the folds. Parastigmatic vessels are present.

The gut forms a closed flat loop. The hepatic gland is voluminous, made of glandular ridges, more or less parallel, with small papillae (Figs. 59C, D). The intestine is thin, a little included in the body wall in its ascending limb, and protruding in the descending part. The anus has 2 plain lobes. The gonads were inactive. Two lobes are on the right side and 3 lobes on the left side. The gonoducts are short but distinct. On the left side, endocarps are linked to the gut and one is isolated, anterior, at the top of the gut loop (Fig. 59C). The cloacal siphon possesses a ring of small tentacles.

Remarks: Kott (1985) in the Indo-Pacific region only recognizes one *Microcosmus* species with 6 branchial folds: *M. helleri* Herdman, 1882. This species presents two very different aspects: specimens with a thin tunic including sediment and varied debris with a weak musculature, described by Herdman (1882) under the name *M. helleri* and specimens with a thick hard tunic and strong musculature described under the name *M. goanus* by Michaelsen (1918). This author estimated both species closely allied because of the similarity of the rest of their anatomy. One year later, Hartmeyer (1919) synonymized the two species

Kott (1985) said: "the condition of the surface test, with or without its coat of sand, appears to be a response to the habitat of the individual. Specimens with both conditions occur at the same location, and some individuals even have a thick sand adhering to parts of the test, while elsewhere they are naked" (p. 350). In the western Atlantic and off Senegal where the species is recorded (Monniot & Monniot 1994) the only form covered with sediment is known. After Kott (1985) the species is characterized by the presence of 4 prolongations which close the oral siphon at the tentacle level, and the absence of spinules or scales inside the siphons.

Kott (1985) synonymized *M. helleri* and *M. manaarensis* Herdman, 1906 (synonymy suggested by Van Name, 1921 as that of *M. gleba* Traustedt, 1885 from the Banda Sea) for the close similarities of the branchial sac, the gut, and the gonads. *M. manaarensis* was described three times. Herdman (1906) described the species as entirely covered by a thick layer of sediment, having two superposed tunics "so as to give the appearance of one test lying within another" (p. 312). His figure 26 represents these two layers and the siphons of the internal tunic do not seem related to the openings of the external tunic. Oka (1915) has recorded, near Madras, specimens entirely covered with sediment: "crust of sand covering the test" (p. 16). Millar (1975) also described a double tunic (fig. 87d). All descriptions mention a strong musculature. Herdman figured (pl. 2, fig. 27) a strong bilobate diaphragm closing the siphons.

It is certain that *M. helleri* and *M. manaarensis* are closely allied, distinct by the tunic structure and the shape of the lappet closing the siphons. It is possible

that the two species developed two ecological forms, one living in contact with the sediment with the tunic including varied particles, the other living in rocky areas, with a hard and naked tunic. In this hypothesis, the double tunic of the Philippines sample would not represent a monster, but a particular anatomical character. This specimen possesses large spinules absent in *M. helleri*.

Geographic Distribution: India, Sri Lanka, Singapore, and Java Sea.

### Acknowledgments

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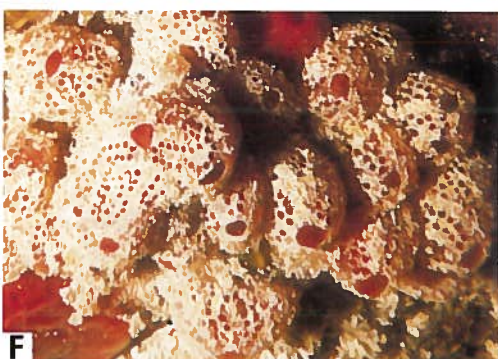
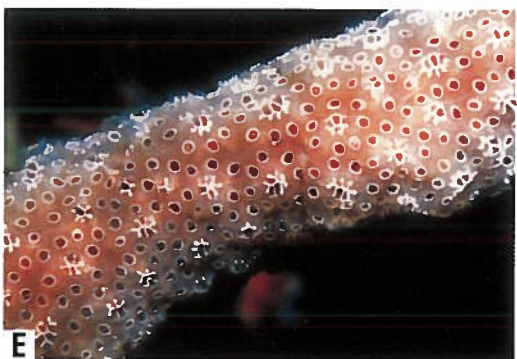
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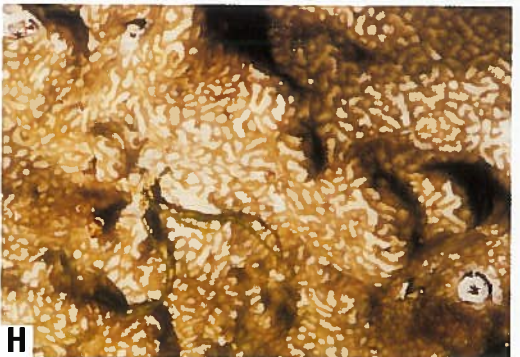
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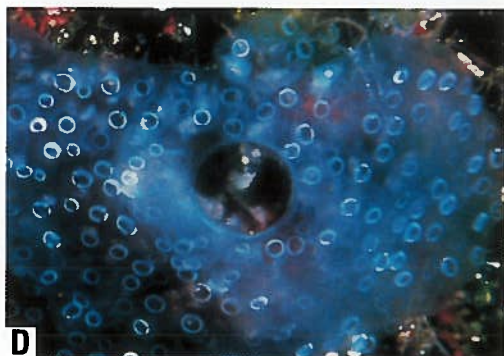
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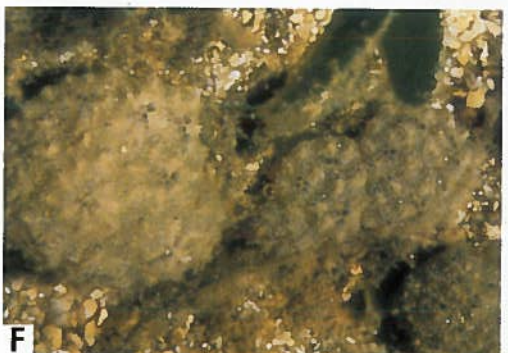
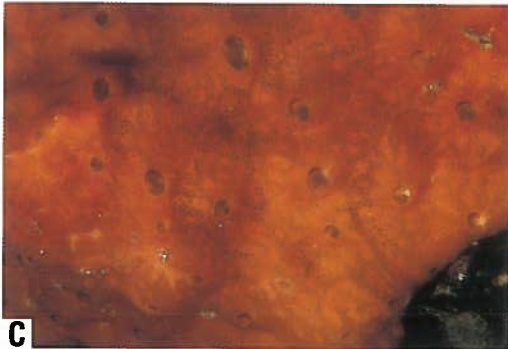




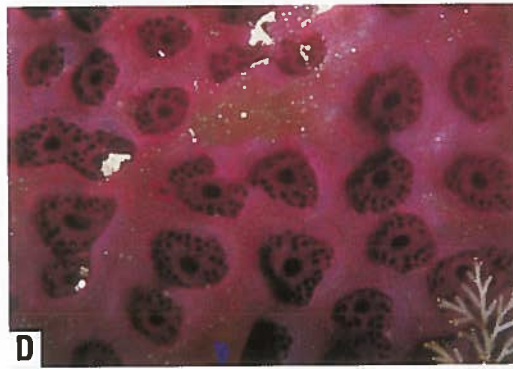
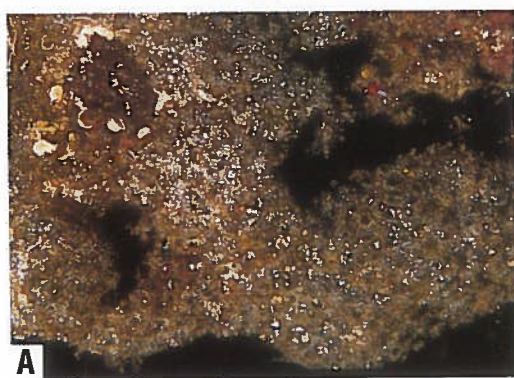




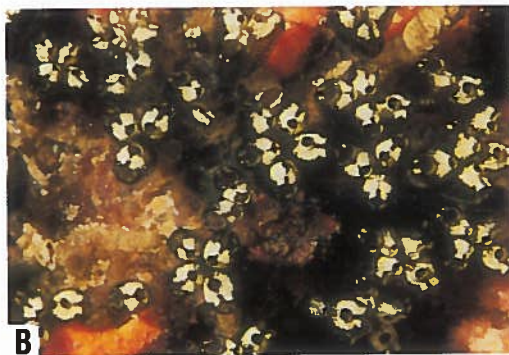














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