

# Stolidobranch ascidians from the tropical western Indian Ocean

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Coastal ascidians collected over two centuries from Suez to Mozambique have been successively deposited in the MNHN and are now described and figured. Some of them were already known from the Indian Ocean, others are common to the Pacific, and some others are new species. Even though the present taxonomic work notably increases our knowledge of the tropical eastern African coast, it comprises so many miscellaneous collections from such distant points that it can only begin to suggest the diversity of ascidians there. © 2002 The Linnean Society of London. *Zoological Journal of the Linnean Society*, 2002, 135, 65–120.

ADDITIONAL KEY WORDS: Ascidiacea – taxonomy – tropical – western Indian Ocean – new species.

## INTRODUCTION

The ascidian fauna of the tropical Indian Ocean remains poorly known. Our records are essentially from the African coast. The first author who described ascidians from the Red Sea was Savigny (1816) from an expedition in Egypt. A century later, Sluiter (1905) studied the material that Ch. Gravier collected along the coast of Somalia. In 1919, Michaelsen began the publication of descriptions of ascidians collected by the 'Pola' Expedition in the Red Sea. Van Name (1952) described a few species from the Gulf of Aqaba, and finally Monniot F. & Monniot C. (1997) reported on Bahrain ascidians. Some other records concern more southern areas: particularly Mozambique and Madagascar by Millar (1956, 1988), Vasseur (1967, 1969), Monniot C. & Monniot F. (1976), and Monniot F. & Monniot C. (1999). Overall, so few stations have been investigated and for such short periods of collection that the ascidian fauna remains very poorly known. A large part of the older data comes from animals collected on foot along the shore or by dredging, methods that are not very thorough for ascidians. Often only one or a few specimens of a species are available, foreclosing any estimation of intraspecific or geographical anatomical variations. For the same

reasons, it is difficult to estimate the distribution of each species. But at least a comparison between the Red Sea and more southern, but still tropical, African areas indicates that these regions share many common species. They are quite different from the temperate South African coast (Monniot *et al.*, 2001).

The material reported on here comprises 47 species, 11 of them new.

## MATERIAL AND METHODS

All the material described is registered in the MNHN (Muséum national d'Histoire naturelle) and is stored either in vials or on microscope slides. For comparison, specimens from different museums were borrowed and studied. The ascidians examined have very different origins. They were either collected rather recently by Scuba diving or have been stored in the MNHN for years. I collected a large part of the material during three successive expeditions with the Ardoukoba Association in Mozambique, Djibouti and Socotra. Other specimens collected by Scuba are those of P. Laboute and R. Plante in Madagascar, and those of the US Coral Reef Research Foundation (CRRF) in the Maldives Islands and Mauritius. A few species were collected by the Israel South Red Sea Expeditions (ISRSE) of the Tel Aviv University, and on a cruise of the 'Meteor' vessel.

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In addition, miscellaneous specimens have been brought back by naturalists who collected all kinds of invertebrates during their travels. Some specimens in alcohol date from more than a century ago and are not well preserved. The more recent ones were fixed in 4% formaldehyde in sea water.

All descriptions are the result of dissection, staining with haemalum, and drawings with a camera lucida. Some small specimens, or parts of specimens, have been included in a plastic medium and mounted on microscopic slides. Photographs of spicules and spinules were made with a Jeol JSM 840 scanning electron microscope.

#### FAMILY STYELIDAE SLUITER (1895)

##### *BOTRYLLUS GREGALIS* (SLUITER, 1898)

*Botrylloides gregalis* Sluiter, 1898: 46, pl. 2, figs 6–9 – Mozambique.

*Botryllus gregalis*: Monniot C. & Monniot F., 1997: 1623–1643, fig. 5, pl. 1C–D – Gulf of Arabia (Bahrain); Monniot F. & Monniot C., 1999: 1–35, pl. 3E – Tanzania; Monniot C. *et al.*, 2001: 74, figs 4A, 37 – South Africa, and synonymy.

##### *Material*

Madagascar: Nosy-Be, Baie de l'Entrée, coll. P. Laboute, 1992.

Mozambique: Ibo, intertidal, sea grass beds, mangroves and barrier reef, coll. C. Monniot, 1995.

Djibouti: coll. C. Monniot, 1996.

##### *Remarks and distribution*

*Botryllus gregalis* is the commonest *Botryllus* species along the west coast of the Indian Ocean. Its distribution extends from the Red Sea and Arabian Gulf down to South Africa. The colonies are very polymorphic and of varied colours. In Mozambique the prevailing colour is brown (from beige to black), but there are also green, orange, or black and orange colonies. The species is abundant in the intertidal zone and in sea grass beds. Some rare samples from mangrove roots were red. On the external slope of the coral reef, small colonies were settled on *Halimeda*. A single, uniformly orange, colony was collected at Madagascar at 20 m depth on a sedimentary bottom. Until now *Botryllus niger* (Herdman, 1886) has been the only *Botryllus* species recorded in Madagascar, from Tulear. I have described colonies from Bahrain, Djibouti and Tanzania in which zooids are gathered in patches separated by wide channels constituting spacious, meandering common cloacal cavities. The zooids are joined by their ventral side, the cloacal siphons opening outward into channels surrounding the group

of zooids. This pattern is the reverse of that in many other species, such as *B. schlosseri* (Pallas, 1774) and *B. leachi* Savigny (1816) where the zooids are arranged in systems each having a central common cloacal cavity. The arrangement of groups of zooids separated by meandering channels is most often encountered in colonies growing on marine phanerogams, in this case ones 2 cm in width. The colonies living on more fragmented substrates have several common cloacal openings in less developed systems that are often circular. This is the case with the type specimen.

##### *BOTRYLLUS MAEANDRIUS* MONNIOT C. *ET AL.*, 2001 (Fig. 1)

*Botryllus maeandrius* Monniot C. *et al.*, 2001: 75, figs 4B, 38 – South Africa.

##### *Material*

Mozambique: Ibo Island, coral reef, 15 m, on *Halimeda*, coll. C. Monniot, 1995.

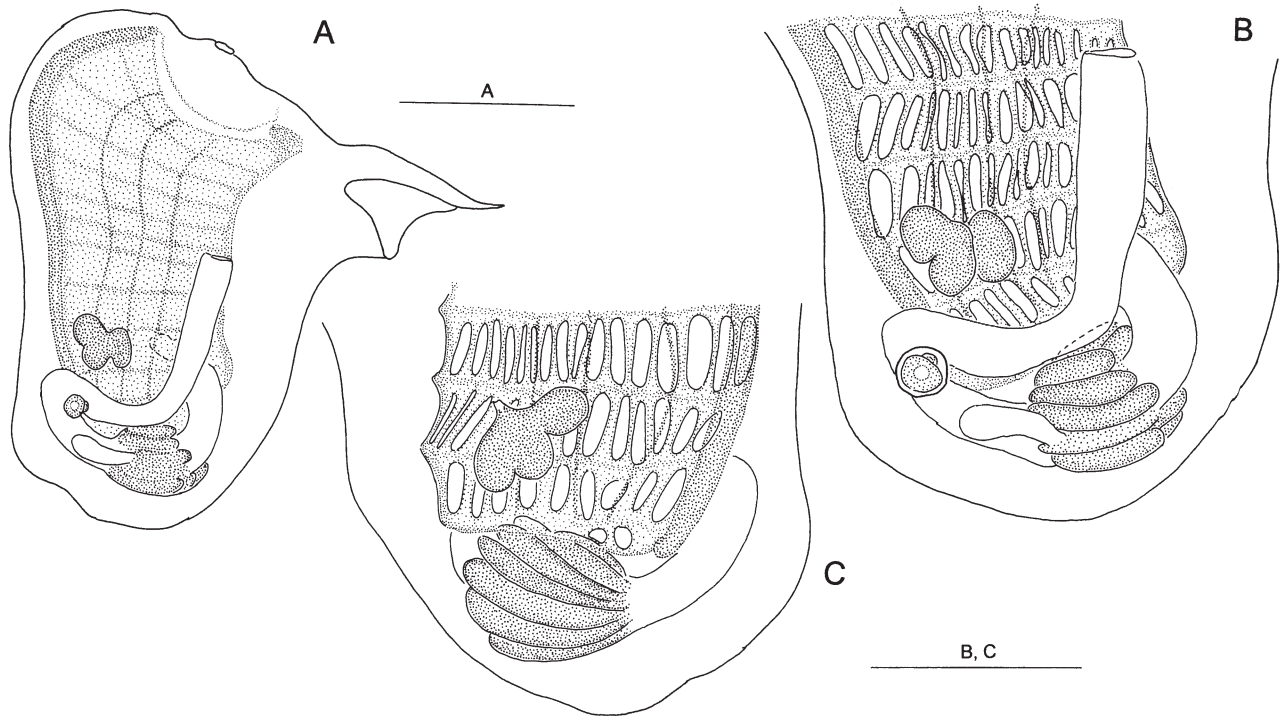
##### *Description*

The tunic is filled with sand. The colony is more than 1 cm thick, made of two circular systems around a slightly depressed centre. The zooids are 1.5–2 cm long lying perpendicular to the colony surface. The cloacal siphon has an elongated languet (Fig. 1A) which keeps a reddish tint in formalin. The cloacal opening may be widely open or reduced to a tube (Fig. 1A).

There are 12 rows of stigmata. The second row is incomplete and only ventral, interrupted at the level of the second longitudinal vessel. At the posterior end, the last row has only a few, round stigmata. We counted 16 stigmata in a half-row in the middle part of the branchial sac.

The gut forms a loop placed mainly under the branchial sac (Figs 1B,C). The oval stomach has 10–11 folds, its anterior part makes a crown of protrusions around the oesophagus. The folds are well individualized along their whole length and have rounded pyloric ends. There is a large, finger-like caecum, slightly widened at its tip, and parallel to the intestine (Fig. 1A). The top of the gut loop does not exceed the level of the last, incomplete stigmata row. The long rectum ends in a smooth anus between the seventh and eighth stigmata rows. The pyloric gland is made of small scarcely visible ampullae and does not narrow the intestine.

The male gonads lie at the same level on the left and right sides of the body (Figs 1B,C). A young ovary with two oocytes is located on the left side, posteriorly and ventrally to the testis (Fig. 1B), and bulges out from the external side of the body wall. The colony does not contain buds.



**Figure 1.** *Botryllus meandrius*: A, left side of a zooid. B, gut and gonads seen from the left side. C, gonad on the right side. Scale bars: A = 0.5 mm, B, C = 0.25 mm.

#### Remarks

*Botryllus maeandrius* has only been recorded from South Africa (Monniot *et al.*, 2001). Its occurrence in Mozambique considerably extends its distribution. It remains the only sandy *Botryllus* species of the east coast of Africa. Three other sandy species are known from other parts of the world: *B. okai* Monniot C., 1988 (a changed name for *Psammobotrus purpureus* Oka, 1932:Monniot C., 1988: 172) from Japan and southern and western Australia; *B. arenaceus* Monniot C., 1988 from New Caledonia. These three species have several oocytes anterior to the testis.

#### *BOTRYLLUS TUBERATUS* RITTER & FORSYTH, 1917

*Botryllus tuberatus* Ritter & Forsyth, 1917: 461 – California.

Synonymy: see Monniot, 1988: 170, fig. 2D – New Caledonia; Monniot F. & Monniot C., 2001: 313 – Philippines.

#### Material

Mozambique: Ibo Island, coll. C. Monniot, 1995.

#### Remarks

This inconspicuous species has only been found on the barrier reef. The small flat colonies have one or a few circular systems less than 1 cm in diameter, with dark

green zooids visible through a transparent colourless tunic. This species is frequent on *Halimeda*.

*B. tuberatus* occurs in different forms. Ritter & Forsyth (1917) described erect colonies with several lobes, each having a common cloacal cavity. This is this shape that Oka (1927a) described for this species under the name *B. communis*.

Oka (1928) and Tokioka (1953) described *B. primigenus* with a lobed form in which some zooids are isolated in the tunic without common cloacal openings.

Kott (1985) and Monniot C *et al.* (1991, photo p. 206) described flat, deeply coloured colonies.

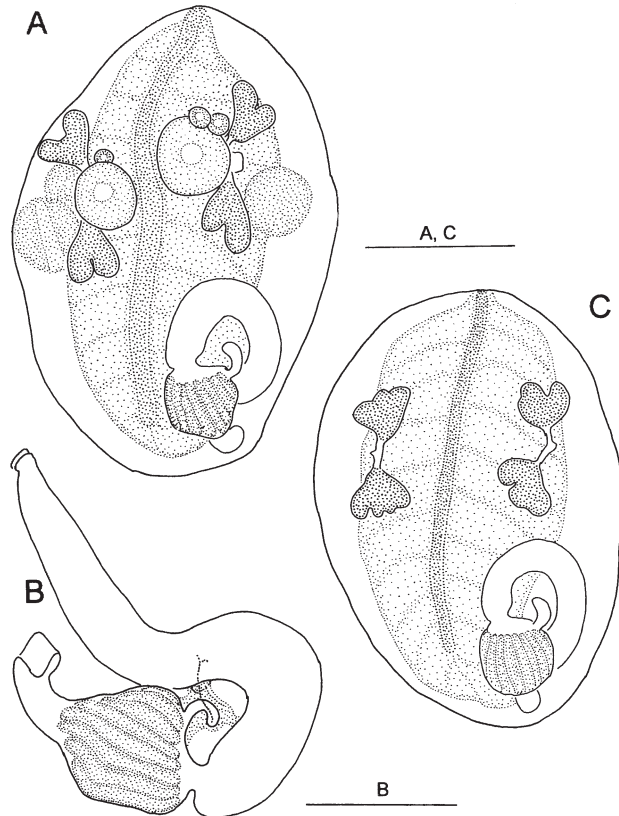
In Mozambique the flat, green colonies are sometimes assembled in large plates. The green colour has been recorded in the Antilles, Polynesia, New Caledonia, and the Philippines, and we have observed it in Galapagos samples (coll. P. Humann). The zooid anatomy and the sexual cycle are the same in all forms.

#### *SYMPLEGMA BAHRAINI* MONNIOT C. & MONNIOT F., 1997 (Fig. 2)

*Symplegma bahraini* Monniot C. & Monniot F., 1997: fig. 7D–H, pl. 1E,F – Arabian Gulf, Bahrain.

#### Material

Juan de Nova Island: east side, 20 m, external side of the reef, yellow colonies, coll. P. Laboute, 1993.



**Figure 2.** *Symplegma bahraini*: A, ventral side of a zooid having ovaries and testes well developed. B, internal side of the gut. C, ventral side of a protandric zooid with testes only. Scale bars: A,C = 1 mm, B = 0.5 mm.

Mozambique, Ibo Island, external side of the reef, coll. C. Monniot, 1995.

#### Description

The colonies were collected on *Halimeda*. They are slightly different from the type.

There are 12 oral tentacles in three orders of size, instead of 16 in the type, and four of them are clearly larger and planted a little posteriorly from the crest that carries the other tentacles. The prepharyngeal band has a simple blade, thickened dorsally, where the urn-shaped dorsal tubercle opens in a simple hole. The dorsal lamina is smooth, posteriorly clearly directed to the left and of increasing height there.

The branchial sac has 11 stigmata rows on each side and an additional transverse oval perforation on the posterior right side. The second row of stigmata does not reach the dorsal lamina. The four longitudinal vessels form an arch over the first stigmata row and are thickened where they join the dorsal lamina. On the left side, the first two longitudinal vessels join the dorsal lamina at the level of the sixth and eighth

transverse vessels. The elongated stigmata lack parastigmatic vessels. The formula on the right is:

$$E\ 6\ v\ 3\ v\ 4\ v\ 5\ v\ 8\ DL$$

The gut occupies the posterior third of the body's left side (Figs 2A,C). The top of the loop reaches the seventh row of the stigmata and the anus reaches the sixth row. The stomach has an irregular outline (Fig. 2B). It has 14–15 grooves (instead of 12–14 in the type). A large, curved caecum receives the pyloric duct at the tip (Fig. 2B). The caecum is encircled by vascular tissue linked to the intestine by two strips of tissue. The narrowed anus has two lobes in Mozambique specimens; its margin is entire in Bahrain colonies.

The species is protandric. Some colonies were in a male stage (Fig. 2C). The testes are made of two to four lobes, not deeply divided, while those of Bahrain are well divided. In other *Symplegma* species, for example *S. brakenhielmi* (Michaelsen, 1904), the number and shape of the indentations of the testis lobes vary between different colonies or different regions. The sperm duct is thin and long. The ovary contains only one large oocyte at a time, even when several larvae are brooded. The oviduct is wide and short. The larvae do not deform the body wall.

The colony collected on dead coral at Ibo is not mature, but it clearly differs from *S. rubra* Monniot C., 1972 by its shorter gut.

#### *SYMPLEGMA RUBRA* MONNIOT C., 1972

*Symplegma rubra* Monniot C., 1972: 622, figs 2E,F, 3 – Bermuda; Monniot F. & Monniot C., 1999: 26, fig. 15 pl. 3B,C – Tanzania & Mozambique, 2001: 315, fig. 87, 127B,C – Micronesia and Palau.

#### Material

Mozambique, Ibo Island, sea grass bed and subtidal cliff in the south of Matemo Island, coll. C. Monniot, 1995.

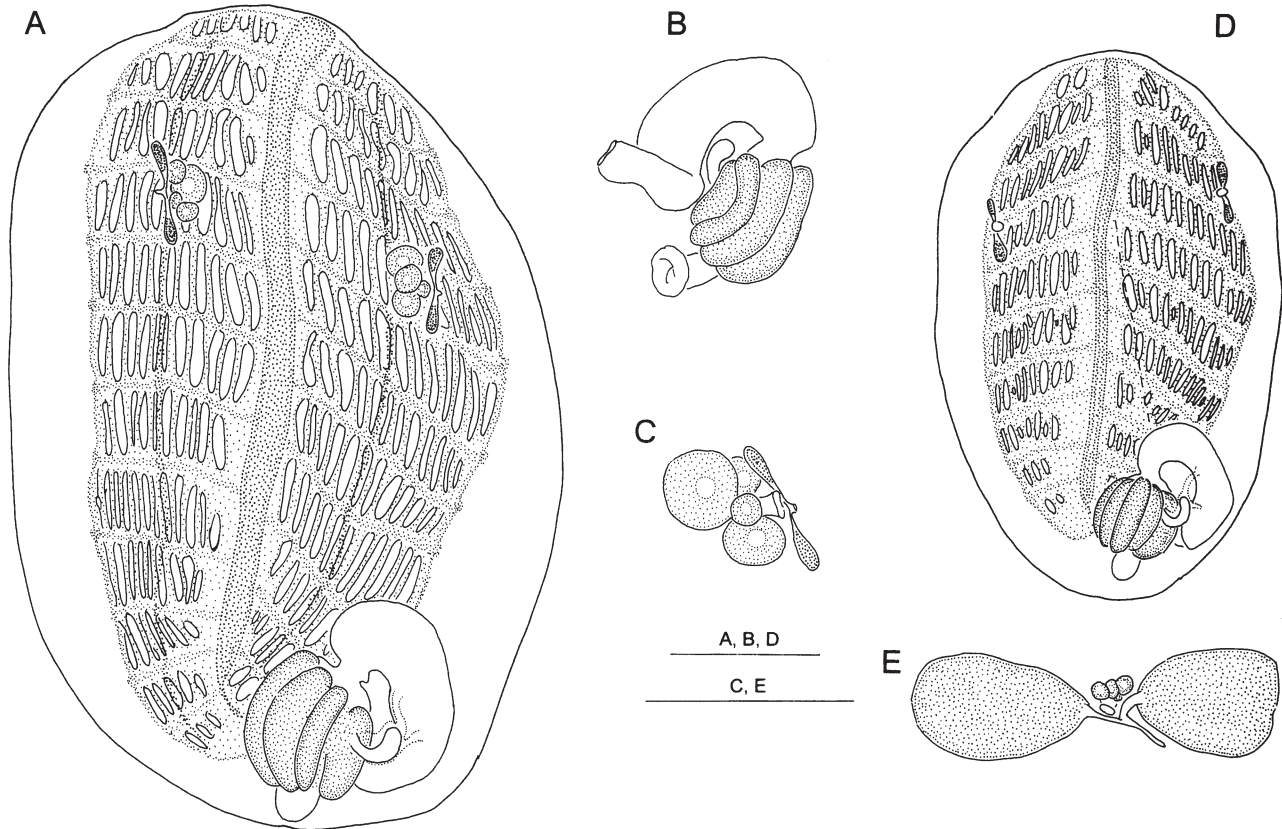
#### Remarks

This cosmopolitan species, either pink (type specimen) or ochre, has a characteristic feature: a red ring encircling both siphons. It is mostly abundant on large leaves of marine phanerogams.

#### *SYMPLEGMA ZEBRA* SP. NOV. (Figs 3, 4A,B)

#### Material

Holotype: MNHN S1 SYM 56, paratype MNHN S1 SYM 75: Madagascar: Nosy-Be, Sakatia Bay, 18 m, coll. P. Laboute, 1993.



**Figure 3.** *Symplegma zebra* sp. nov. holotype: A, ventral side of a zooid. B, internal side of the gut. C, detail of a gonad. D, paratype: ventral side of a zooid. E, gonad of a specimen from the Maldives Islands. Scale bars = 0.5 mm.

Other material examined: Maldives Islands, 04°11.43'N–73°25.05'E, 7 m, coll. CRRF, 1997.

#### Description

The two colonies from Madagascar were attached to dead corals; the Maldives colonies incrustated an alga. The holotype colony has a very dark general colour, violet to black with radiating gold-yellow lines (Fig. 4A). Others colonies have a violet colour with patches of cream colour (Fig. 4B).

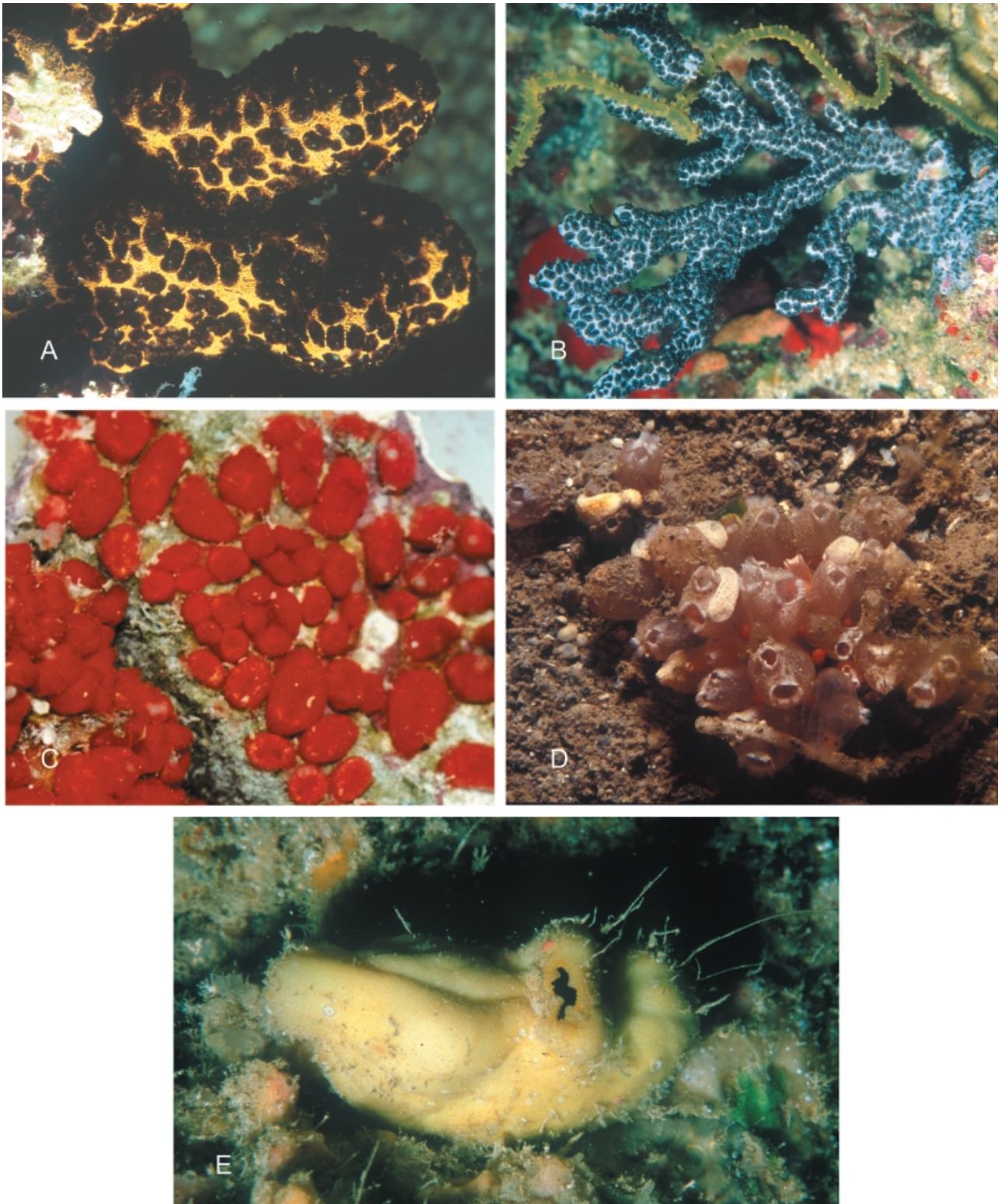
Between the zooids the pigment is contained in vascular ampullae. The vascular ampullae fringing the colonies are elongated, parallel, and particularly visible. When fixed in formalin, the tunic becomes transparent and the pigmented lines disappear. The yellowish zooids have an opaque network of blood lacunae full of brown pigment cells in the body wall, in the branchial vessels, and in the bottoms of the stomach grooves.

In the holotype the zooids (Fig. 3A) are each 3 mm in length with 12 rows of stigmata, while in the other Malagasy colony the zooids are 2 mm long with 10 rows of stigmata (Fig. 3D).

The body wall is particularly thin and fragile. The muscles are poorly developed. There are 12 oral tentacles in two orders of size. The prepharyngeal band makes a dorsal V. The dorsal tubercle opens in a simple hole. The dorsal lamina is clearly displaced on the left side. There are 12 rows of stigmata on the right side and 11 on the left. The first left longitudinal vessel joins the dorsal lamina at the eighth stigmata row and the second vessel at the tenth row.

The gut is small and in a posterior position (Figs 3A,D), the top of the loop reaching the eighth row of stigmata. The globular stomach (Fig. 3B) has eight grooves. The curved caecum is linked to the intestine by two strips of tissue. The anus has a smooth edge.

The gonads are developed differently in the three colonies. They have either a reduced testis made of two undivided lobes with a very short sperm duct and an ovary containing several oocytes (Fig. 3C), or a large testis with two lobes and an incompletely developed ovary (Fig. 3E). The largest oocytes do not reach the common size of the eggs in other *Symplegma* species.



**Figure 4.** A, *Symplegma zebra* sp. nov. holotype. B, *Symplegma zebra* sp. nov. colony from the Maldives Islands. C, *Metandrocarpa manina*. D, *Stolonica multitestis*. E, *Polycarpa madagascariensis*.

The base of the cloacal siphon is encircled by a ring of very thin tentacles.

#### Etymology

The specific name reflects the pigment design.

#### Remarks

The two-lobed testis shape with its round outline is characteristic of this species. In species having divided testis lobes, this becomes visible early in gonadogenesis. But *S. zebra* is in other ways close to *S. viride* Herdman (1886) (s.s.) from the tropical Atlantic, in which the testis lobes are not divided. The main differences between these two species are a larger gut in *S. viride*, its long sperm duct, and a difference of at least one stigmata row in the location of the gonad in this species.

Another species, *S. reptans* (Oka, 1927b), has a testis with two simple lobes. Nishikawa (1991) re-described this species after examining numerous specimens. This species seems highly variable in the number of stigmata rows (8–11) and stomach folds (9–13). Nishikawa figured several different shapes of the stomach, all having incomplete folds near the caecum, but this is not the case in *S. zebra*. Kott's description (1985) of *S. reptans*, as noted by Nishikawa (1991), corresponds to a very different species that has two unique characters in the *Symplegma* genus: zooids arranged in systems, and longitudinal branchial vessels on the left side reaching the bottom of the branchial sac.

#### Remarks on the colonial genera of Styelidae

Kott (1985) modified several diagnoses of Styelidae genera, among them three genera of colonial Styelidae that we report about here: *Metandrocarpa* Michaelsen, 1904; *Amphicarpa* Michaelsen, 1922; and *Stolonica* Lacaze-Duthiers & Delage, 1892. The earlier diagnoses (Michaelsen, 1922) were very precise and are founded on clear-cut characters: absence of branchial folds and separated male and female gonads in *Metandrocarpa*; branchial folds and hermaphroditic gonads only on the right side in *Stolonica*; branchial folds and female or hermaphroditic gonads on both body sides in *Amphicarpa*.

Kott (1985) placed the species *M. agitata* Kott, 1985, which has branchial folds, in the genus *Metandrocarpa*. The species would normally be included in the genus *Amphicarpa*. Kott (1990: 277) gathered the genera *Amphicarpa* and *Stolonica* in a single genus *Stolonica*, excluding as a criterion the gonad distribution which she considers variable. We do not agree with her position and keep both genera, based on the

presence of ovaries on one or both sides of the body wall.

*METANDROCARPA MANINA* MONNIOT C. & MONNIOT F., 1987 (Figs 4C, 5)

*Metandrocarpa manina* Monniot C. & Monniot F., 1987: 109, fig. 41 – Polynesia; Monniot C., 1988: 180 – New Caledonia.

#### Material

Mozambique: Ibo Island, external reef slope, coll. C. Monniot, 1995.

#### Description

This species is commonly found on the underside of flat corals. The colonies are made of red half-spheres 3 mm in diameter, 2–5 mm apart; they are linked by thin stolons (Fig. 4C). The colour persists in formalin. The body wall is thin with a network of blood vessels and irregularly arranged muscle fibres. We counted eight thick oral tentacles in two orders. The prepharyngeal band has a single blade and lacks a dorsal curve; in fact, dorsally it lies closer to the tentacle ring. The dorsal tubercle, urn-shaped, opens by a round hole posterior to the prepharyngeal band. The neural ganglion lies somewhat posteriorly.

The dorsal lamina is smooth and high. The branchial tissue is flat. There are eight regularly-spaced longitudinal vessels on each side. These longitudinal vessels are high. The eight rows of long stigmata are crossed by parastigmatic vessels. There is an average of three to four stigmata per mesh.

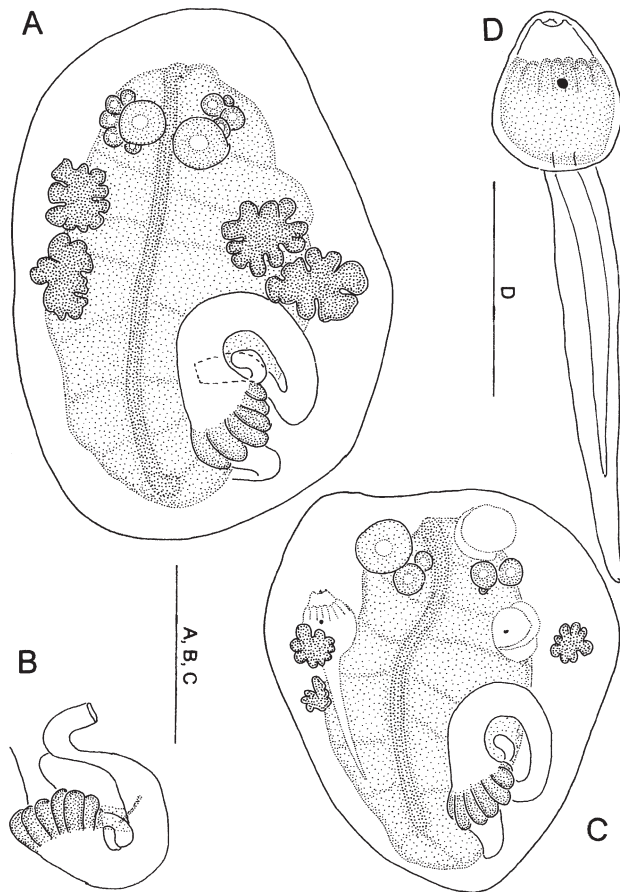
The gut (Fig. 5A,B) forms a short closed loop that is folded on itself. The stomach is conical with 12 short folds. The caecum is large, curved, with a terminal ampulla (Fig. 5B). The pyloric duct opens in the middle of the caecum. The rectum is short and the smooth-edged anus does not surpass the level of the top of the intestinal loop.

Generally, there is on each side a testis made of two deep lobes with a large sperm duct and an ovary anterior to the testis. Small endocarps are scattered over the whole internal side of the body wall.

The larvae are brooded in the cloacal cavity (Fig. 5C). They have a single sensory organ, three small adhesive papillae, and a crown of anterior ampullae (Fig. 5D).

#### Remarks

The testes in Mozambican specimens are more deeply lobed than those from Polynesia and New Caledonia. The others characters – colour, colony structure,



**Figure 5.** *Metandrocarpa manina*: A, ventral side of a zooid. B, internal side of the gut. C, ventral side of a brooding zooid. D, larva. Scale bars: A,B,C = 1 mm, D = 0.5 mm.

branchial sac, gut and gonad arrangement – are similar.

*METANDROCARPA REDUCTA* MONNIOT C.,  
1988 (Fig. 6)

*Metandrocarpa manina reducta* Monniot C., 1988:  
180, fig. 7F,I – New Caledonia.

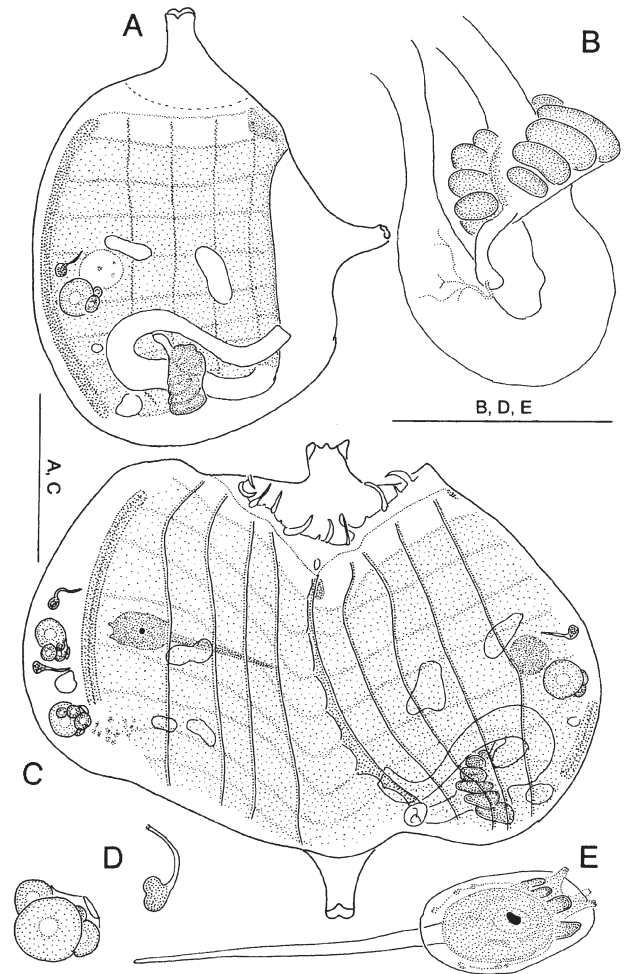
*Metandrocarpa reducta* Monniot C., 1991: 8, Fig. 1C –  
New Caledonia.

*Material*

Mozambique: Ibo Island, external reef slope, a colony  
on *Polycarpa mytiligera*, coll. C. Monniot, 1995.

*Description*

The zooids are spheres 2–3 mm in diameter, covered  
with sediment and linked by thin stolons. Seen  
through the sand grains, the tunic is clear, a charac-



**Figure 6.** *Metandrocarpa reducta*: A, left side of a zooid. B, internal side of the gut. C, zooid ventrally opened. D, male and female parts of a gonad. E, larva. Scale bars: A,C = 1 mm, B,D,E = 0.5 mm.

ter that helps to differentiate this species from species  
of *Amphicarpa*.

The body wall is thin and in its transparency reveals  
the gut, the gonads and even the branchial tissue. The  
muscles form a network of thin fibres. Both siphons  
four-lobed are well apart. Sixteen oral tentacles were  
counted in three orders of size, the smallest sometimes  
reduced to mere buttons. The prepharyngeal band has  
a single crest and makes a dorsal V. The dorsal tubercle,  
oval and flat, has a simple hole. The neural gland  
extends along the sides of the ganglion.

The dorsal lamina is long, with a plain margin  
increasing in height down to the oesophagus.

The branchial sac has eight rows of stigmata and  
four longitudinal vessels on each side. The last row of  
stigmata is not complete: it does not reach to the  
dorsal lamina.



We counted this arrangement of stigmata in a mid-pharynx row:

RE 9 v 6 v 6 v 5 v 6 v DL 5 v 6 v 6 v 7 v 7.EL.

The stigmata are elongated and sometimes cut by a thin parastigmatic vessel.

The gut (Fig. 6A,B) forms a horizontal loop, the anus opening slightly posteriorly to the top of the loop. The oesophagus is long and slightly curved. The stomach is wide and short, well protruding, with about ten large folds. The caecum is long and curved (Fig. 6B). The intestine narrows at the level of the pyloric gland. The anus is smooth, opening at the level of the sixth stigmata row. The male and female gonads are separated. There are two hermaphroditic gonads on the right side and one on the left (Fig. 6C,D). There are some endocarps scattered on the body wall (Fig. 6C).

The larvae (Fig. 6E) are incubated in the cloacal cavity. They are small, 0.4 mm for the trunk, with three pointed adhesive papillae placed in a triangle, and some epidermal ampullae. In addition, small lateral ampullae occur. There is only one sensory organ in the cerebral vesicle. The larvae adhere to the body wall in an area of small papillae containing numerous cells (Fig. 6C). In the specimen shown there are two patches of such papillae on the right side, one under the larva (and not depicted) and one where a larva was removed when the animal was dissected and, on the left side, there is one under the dividing eggs.

#### Distribution

This inconspicuous species was only known from New Caledonia, but it is certainly widely distributed in the Indo-Pacific.

#### AMPHICARPA INHACAE (MILLAR, 1956)

*Polyandrocarpa inhacae* Millar, 1956: 927, fig. 14 – Mozambique, Inhaca.

*Amphicarpa inhacae*: Monniot F. & Monniot C., 1999: 27, fig. 16, pl. 3D – Mozambique and Tanzania, and synonymy.

#### Material

Mozambique: Ibo Island; coll. C. Monniot, 1995.

#### Remarks

This species is covered with sand that coats a purple tunic. The zooids reach 1 cm and more when relaxed. They are united by stolons which are also covered with sediment. This species inhabits the undersides of dead corals, and also lives under *Agaricia* species and often

on *Polycarpa* species on the external slope of coral reefs.

#### AMPHICARPA PROLIFERA (SLUITER, 1905) (Fig. 7)

*Stolonica prolifera* Sluiter, 1905: 12, pl. II,5 – Djibouti; Obok.

#### Material

Mozambique: Ibo Island, south of Matemo, external reef slope and cliff, coll. C. Monniot, 1995.

Djibouti: Musha Island, 3–15 m, coll. C. Monniot, 1996.

Suez Gulf: Raz el Kanisa, 3 m, coll. Tel Aviv University.

#### Description

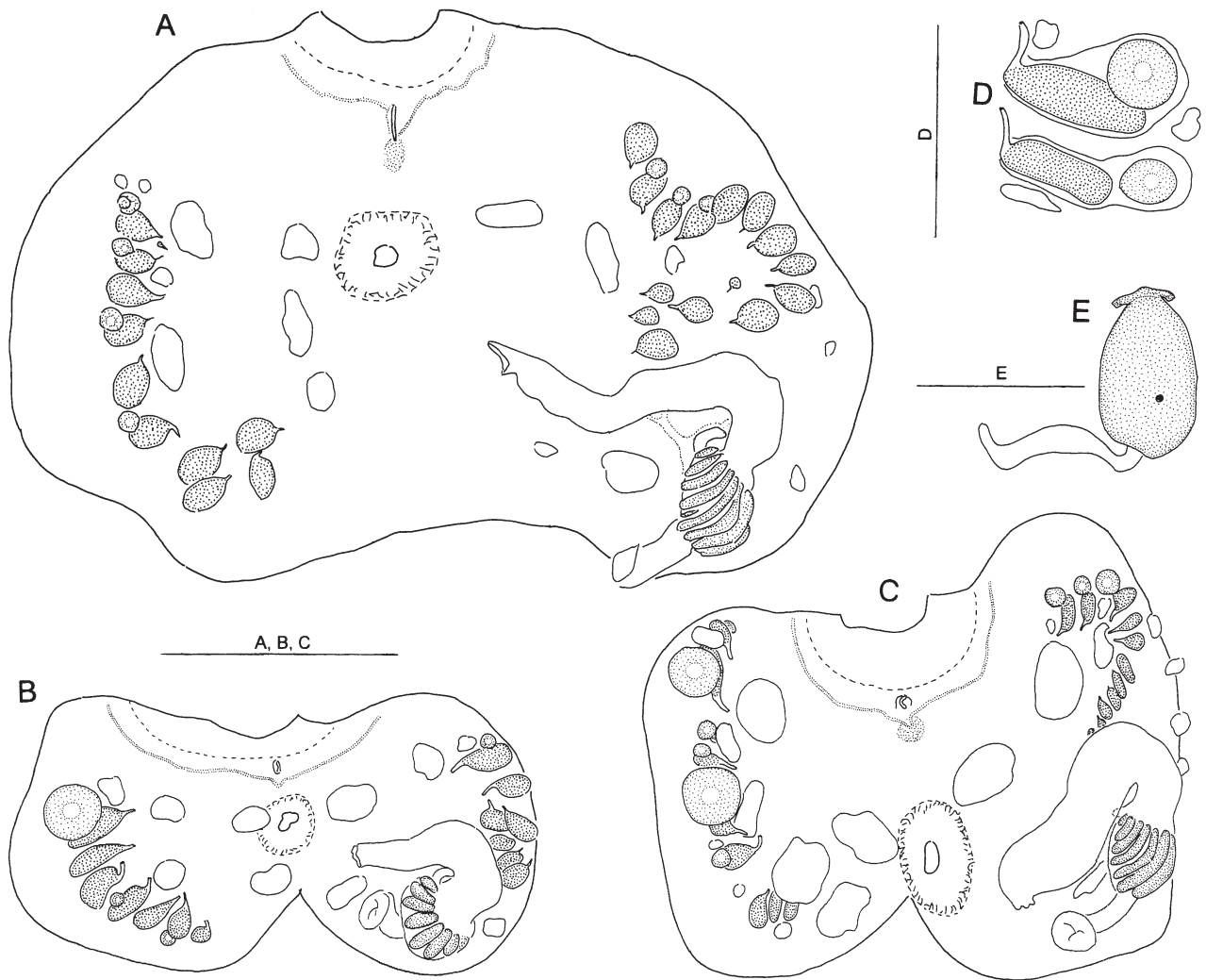
*Amphicarpa prolifera* is a species that is difficult to recognize amongst the other small Styelidae covered with sand. It makes little colonies of a few zooids 2–4 mm in height, linked by stolons. This species often grows on other ascidians or mixed with *Amphicarpa inhacae*. This habit may cause some confusion with young specimens.

The body wall is thick, deeply pigmented in brown, and has a strong musculature. There are about 30 curved oral tentacles, in two or three orders of size with their bases joined. The prepharyngeal band is a single blade that makes a dorsal V. The dorsal tubercle is protruding and opens in a longitudinal slit. The neural gland extends beyond the round neural ganglion on each side.

The dorsal lamina is high. The branchial sac has two or four folds on each side. When the branchial sac has four folds on each side, folds no. 2 and 4 are thinner and lower and disappear posteriorly. There are generally six tightly arranged longitudinal vessels on folds 1 and 3 but only one or even no vessels between the folds. Parastigmatic vessels are present everywhere. There are about 15 rows of stigmata.

The gut (Fig. 7A–C) forms a very short loop. The wide, short stomach has a dozen ridges that become shorter near the typhlosole. The finger-like caecum is short. The intestine is wide and short, the anus simple.

There is a row of gonads on each side (Fig. 7A–C). On the right side it is close to and parallel to the endostyle. On the left side and anteriorly, it is close to the endostyle, and more posteriorly on the left it makes a loop above the gut (Fig. 7A,C). The polycarps all have a pyriform male lobe ending in a small sperm duct that protrudes into the cloacal cavity (Fig. 7D). Only some polycarps, either on the right or on the left side, have an ovary (Fig. 7A–C) as well, which contains a large oocyte sometimes lying beside a smaller oocyte.



**Figure 7.** *Amphicarpa prolifera*: A, specimen from Djibouti: ventrally opened. B, C, small specimens from Mozambique. D, two polycarps. E, larva. Scale bars: A, B, C = 2 mm, D = 0.5 mm, E = 1 mm.

The ovary is located on the internal and posterior side of the testis (Fig. 7D). The oviducts have not been found, they may appear by a rupture of the ovarian envelope. The most anterior polycarps have the largest oocytes.

Some large endocarps are scattered on the body wall. The base of the cloacal siphon is circled by a row of thin tentacles.

The larvae (Fig. 7E) are large, and generally only one is well developed at a time. The trunk is 1 mm long. The three adhesive papillae are set well apart. The sensory organ lies in the posterior third of the trunk.

#### Remarks

Sluiter's species is re-collected for the first time. It has been compared to the type colony held in the MNHN,

no. S1 STO 14, and corresponds on all points. Sluiter's description corresponds well to the type colony.

By size, the zooids's disposition, the way the tunic is covered with sediment, and the body wall's pigmentation, this species is very close to *A. inhacae* (Millar, 1956). It differs in the structure of its polycarps and the number of longitudinal branchial vessels.

#### *EUSYNSTYELA HARTMEYERI* MICHAELSEN, 1904

*Eusynstyela hartmeyeri* Michaelsen, 1904: 38, 114, pl. 1, fig. 1 – Mozambique 1918: 38 – Red Sea and Mozambique.

*Polyandrocarpa violacea* Sluiter, 1905: 10, pl. 1 fig. 3 – Djibouti.

*Eusynstyela hartmeyeri*: Monniot C. & Monniot F., 1997: 1639, fig. 8 – Bahrain.

*Eusynstyela aliena* Monniot C., 1991: 18, fig. 6 – New Caledonia, Nouméa harbour.

*Eusynstyela hartmeyeri*: Monniot F. & Monniot C., 2001: 314 – Hong-Kong.

#### Material

Mozambique: Ibo Island, 20 m, coll. C. Monniot, 1995. Djibouti, 3–6 m, coll. C. Monniot, 1996.

#### Description

The zooids are joined by fusion of their tunic along the sides. The top side may be more or less protruding, depending on the substrates where the colony is attached. The deep red tunic is very resistant.

The internal anatomy is as described by Monniot (1991). The body wall is pigmented and muscular with big sphincters around the siphons. There are four oral tentacles that are clearly longer than the others. The branchial tissue is thin, linked to the body wall by long thin strips. The endostyle is not attached to the body wall. The gut forms a closed, elongated loop with the anus near the oesophagus entrance. The gastric caecum is finger-like. The gonads lie along a line on each side, parallel to the endostyle. The polycarps are oval or round, longer when the ovary is well developed and the two testis lobes regressed. The endocarps are scattered over the body wall. There is a ring of thin tentacles around the base of the cloacal siphon.

#### Remarks

Our collections from Djibouti and Mozambique persuade us now to place the species *Eusynstyela aliena* Monniot C., 1991, from Nouméa Harbour, New Caledonia, in *E. hartmeyeri*.

We have examined the type specimen of *Polyandrocampa violacea* Sluiter, 1905 from Djibouti, MNHN S1 POL.A 4, and we found that species, too, is a synonym of *Eusynstyela hartmeyeri*. The colour, the body size, the shape of the zooids and the features of the stomach are the same.

#### Distribution

The natural geographical distribution of *H. hartmeyeri* seems to be restricted to the Indian ocean; the specimens collected in New Caledonia and Hong Kong harbours were probably imported on ship hulls.

*EUSYNSTYELA MINIATA* (SLUITER, 1905) (Fig. 8)

*Styela miniata* Sluiter, 1905: 11, pl. 1 fig. 4–4C – Red Sea.

*Polycarpa coccus* Michaelsen, 1919: 89, pl. 1 figs 13–15 – Red Sea.

? *Polycarpa steindachneri* Michaelsen, 1919: 93, pl. 1 fig. 16 – Red Sea.

#### Material

Mozambique: Ibo Island, 20 m, coll. C. Monniot, 1995. Djibouti, 10–35 m, coll. C. Monniot, 1996.

#### Description

The colonies are made either of zooids closely packed together with their tunics fused or of zooids isolated from each other, flattened on the substrate. The colour is vermilion red. The top side is naked. The siphons are well apart and slightly protruding. The body size is highly variable in a same colony.

The tunic is very resistant. The body wall is thin and does not adhere very much to the tunic. The lining of the siphons is covered by protruding vesicles. Ten to 16 oral tentacles in two orders of size are planted on a blade-like ridge.

The single prepharyngeal crest is indented in a deep V around an elongated dorsal tubercle with an aperture forming an antero-posterior slit.

The branchial sac has four folds on each side, of unequal height. Folds no. 1 on each side of the dorsal lamina are the most developed but they are not very high. Two branchial formulae of two big specimens:

From Djibouti: RE 1 (4) 2 (6) 2 (4) 1 (8) 0 DL 0 (8) 2 (4) 2 (7) 3 (6) 1 EL

From Mozambique: RE 1 (6) 3 (10) 2 (4) 1 (12) 1 DL 1 (10) 2 (5) 2 (11) 3 (8) 1 EL

The gut is a short, simple loop. It occupies only the very posterior part of the body (Fig. 8A). The oesophagus is short. The stomach is globular with well-marked folds and a very small, button-like caecum. The intestine is of a constant diameter and ends in a wide anus that is thinly lobed, located against the oesophagus entrance.

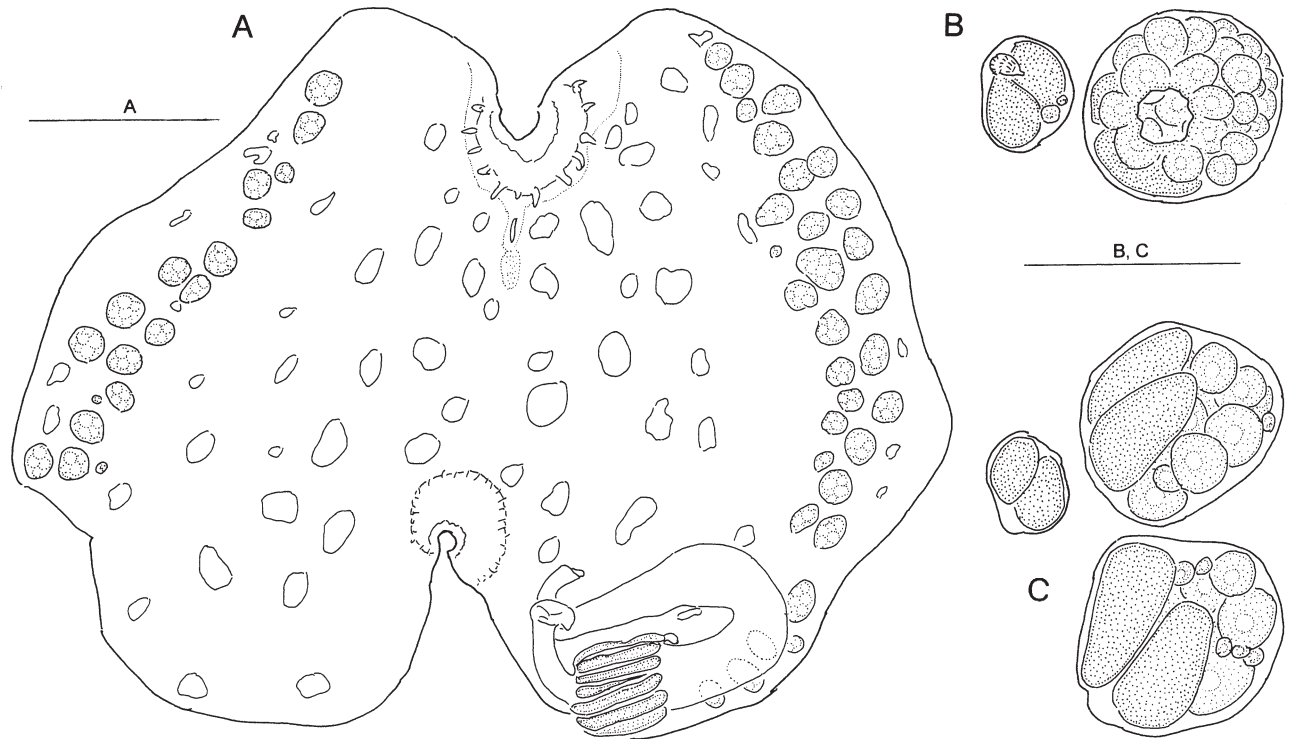
The rounded polycarps (Fig. 8A) protrude from the body wall. The gonads lie in an irregular single or double row along the ventral line of the body, very near the endostyle. Each polycarp comprises two joined testis lobes (Fig. 8C) and one ovary that entirely covers the testis when mature (Fig. 8B). The ovarian opening is on a protruding papilla.

The internal body wall has numerous and widely distributed endocarps (Fig. 8A).

The base of the cloacal siphon is encircled by thin tentacles.

#### Remarks

The specimens from Djibouti and Mozambique correspond well to Sluiter's description and to the type colony (MNHN S1 STY 267).



**Figure 8.** *Eusynstyela miniata*: A, specimen ventrally opened. B, internal side of two polycarps. C, external side of three polycarps. Scale bars: A = 2 mm, B,C = 0.5 mm.

*Polycarpa coccus* Michaelsen (1919) is certainly a synonym, and Michaelsen himself pointed out its similarity to *Eusynstyela miniata*.

*STOLONICA MULTITESTIS* MONNIOT C., 2001  
(Figs 4D,9)

*Stolonica multitestis* Monniot *et al.*, 2001: 86, figs 4F,43 – South Africa.

*Material*

Madagascar: Nosy-Be, 20 and 29 m, coll. P. Laboute, 1992.

Maldives: Feydoo Island, 18 m, 4°12.88'N–73°29.27'E, coll. CRRF, 1997.

*Description*

The erect zooids are grouped on stolons; they have a pink tunic and are naked or with a few epibionts (Fig. 4D). The average size of the zooids is 1 cm. The body wall is thin and transparent. The branchial sac has three folds on the right side and two folds on the left. An example of a branchial formula for a specimen from Madagascar is:

RE 1 (5) 2 (5) 3 (7) 3 DL 0 (7) 3 (6) 6 EL

There are four to seven stigmata per mesh between the folds; they are cut by a parastigmatic vessel.

The stomach has about 30 folds and a curved caecum (Fig. 9D,E).

The gonads lie in a row on each side of the body, parallel to the endostyle (Fig. 9A–D). The polycarps are round or oval, and only male on the left side. On the right side the most anterior polycarps are male and the posterior ones hermaphroditic. Some zooids have incubated tadpoles in the cloacal cavity on the right side.

Endocarps are scattered on the body wall (Fig. 9D).

*Remarks*

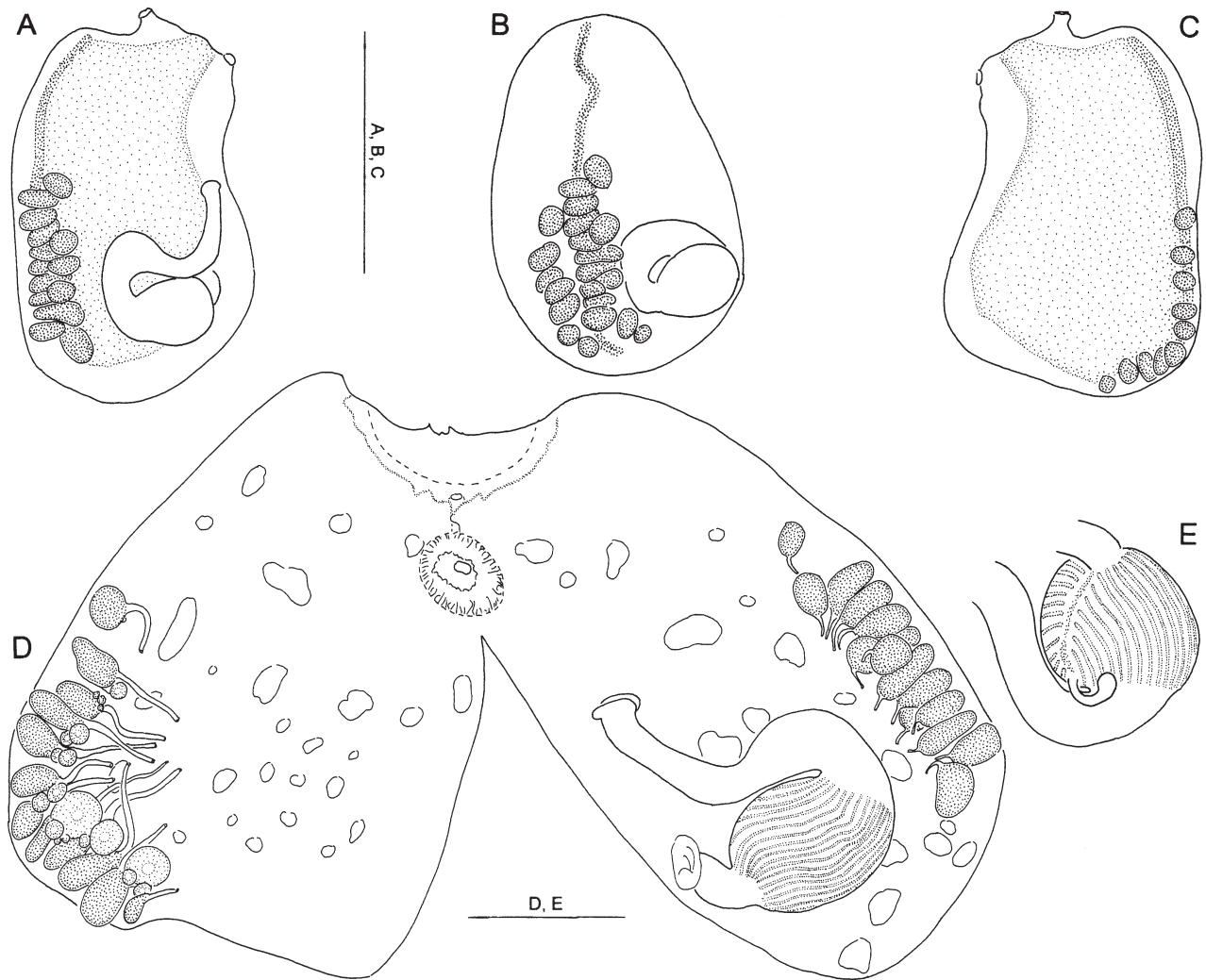
All characters described from South African specimens are found again here, and especially the long sperm ducts of the polycarps located on the right side of the body.

These records appreciably enlarge the distribution of this species.

*STOLONICA LAEVIS* SP. NOV. (Fig. 10)

*Material*

Mozambique: Ibo Island, 10–20 m, reef near the pass, two colonies, coll. C. Monniot, 1995.



**Figure 9.** *Stolonica multitestis*: A,B,C, left, ventral, and right sides of the body removed from the tunic. D, zooid ventrally opened. E, internal side of the gut. Scale bars: A,B,C = 5 mm, D,E = 2 mm.

#### Description

The colonies are made of joined globular zooids, 1 cm in diameter, linked only by thin stolons. The tunic is thin and wrinkled and carries some sediment and diverse epibionts mostly around the base of the zooids. Both siphons open at a same level and are not protruding.

The body wall is thin, somewhat transparent, revealing the gut and gonads. The thin musculature is evenly distributed. The oral siphon has a velum and at its base a circle of about 30 tentacles plus tiny buttons. The prepharyngeal band is a high blade, curved into a deep, wide dorsal V. The dorsal tubercle is round with an oblique slit. The branchial tissue is thin and flat. The dorsal lamina has a plain edge; its height increases posteriorly and it turns around the oesophagus entrance on the left side. The longitudinal

vessels are numerous and regularly spaced. There is an obvious, but rather low fold, on each side of the dorsal lamina, a slightly more marked fold on the left side only in the anterior half of the body, and on the right side two poorly defined folds that disappear in the posterior part of the branchial sac.

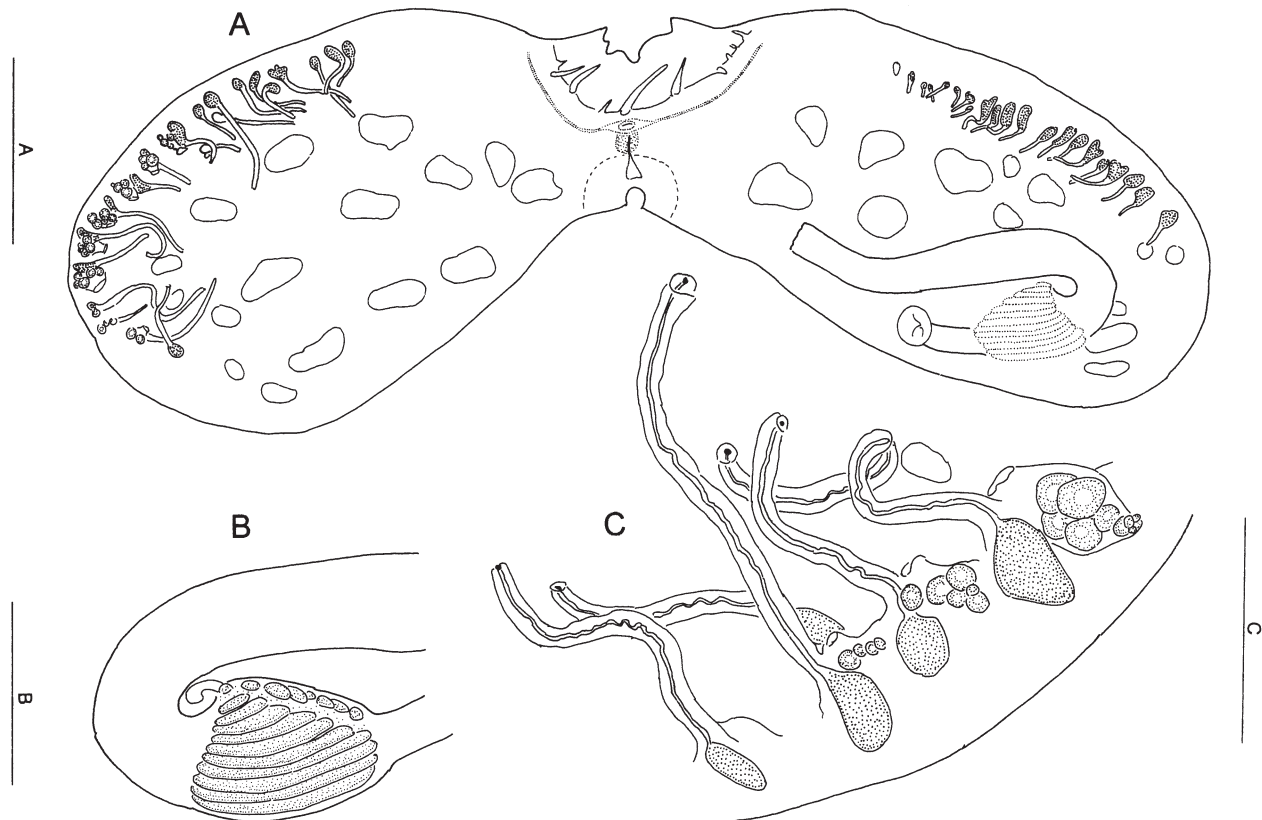
At one quarter of the way down the branchial sac we counted:

RE 8 (7) 9 (7) 9 10 6 DL 10 (11) 10 (6) 6 EL

Three-quarters of the way down:

RE 31 (11) 9 dl 9 (11) 19 EL

Some longitudinal vessels are incomplete anteriorly or posteriorly. The stigmata are cut by parastigmatic vessels. The gut is a simple loop in the posterior part of the body (Fig. 10A). The rounded stomach has inter-



**Figure 10.** *Stolonica laevis* sp. nov.: A, zooid ventrally opened. B, stomach. C, some polycarps of the right side of the body. Scale bars: A = 2 mm, B = 1 mm, C = 0.5 mm.

nal folds and a caecum that forms a hook (Fig. 10B). A pyloric duct unites the two intestinal limbs. The anus has a plain edge. The gut is feebly linked to the body wall.

The gonads lie in a line on each side of the endostyle (Fig. 10A). On the left side the round polycarps are male with rather short sperm ducts. On the right side the line of polycarps curves posteriorly; the most anterior polycarps only have a testis lobe, while the polycarps in the middle of the body are hermaphroditic. All polycarps on the right side have very long gonoducts (Fig. 10C).

Endocarps with a wavy outline protrude from the internal side of the body wall, and one or two of them may occur in the intestinal loop.

A muscular ring surrounds the base of the cloacal siphon. Numerous thin cloacal tentacles lie at the base of a velum there.

#### Remarks and etymology

*Stolonica laevis* sp. nov. has the size and aspect of *S. multitestis* Monniot C., 2001. The gonad distribution is the same, but the branchial sac is very different. In

all dissected specimens an obvious branchial fold was found on each side and half-folds were present in the anterior part of the branchial sac. The longitudinal vessels are particularly close together both on and between the folds. This unusual structure gives the branchial tissue a particularly flat appearance (hence the species name).

#### *POLYCARPA ANGUINEA* (SLUITER, 1898)

*Styela (Polycarpa) anguinea* Sluiter, 1898: 52 – South Africa.

*Polycarpa anguinea*: Monniot C. & Monniot F., 1994: 82, fig. 5 – Sierra Leone, and synonymy.

#### Material

Mozambique: Ibo Island, 1995, 2 specimens, coll. C. Monniot, 1995.

The specimens collected at Ibo are solitary, attached to dead corals. Their anatomy corresponds well to that of other specimens described from the Indian and Atlantic Oceans. The species is widely distributed in the tropics.

*POLYCARPA ARGENTATA* (SLUITER, 1890) (Fig. 11)

*Styela argentata* Sluiter, 1890: 340 – Indonesia.  
Synonymy: see Monniot F. & Monniot C., 1996: 247,  
fig. 52, pl. 8H – Palau & Papua New Guinea, 2001:  
322, fig. 128A – Palau; Philippines.

*Material*

Mozambique: Ibo Island, 5–20 m, 6 specimens, coll. C. Monniot, 1995.

*Distribution*

This species, collected several times in the western Pacific Ocean, also occurs on the west coast of

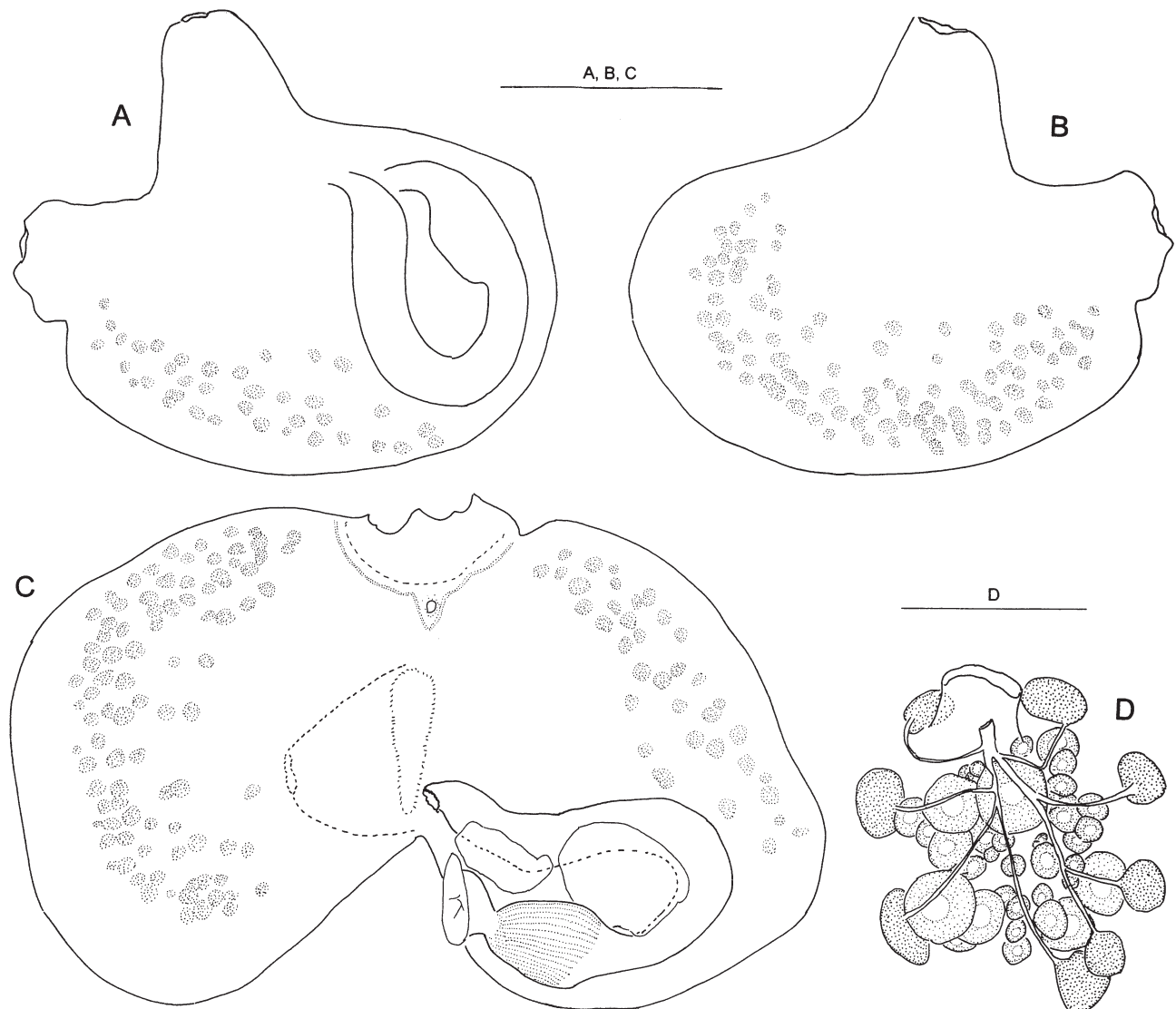
Australia (Kott, 1985). Its presence in Mozambique greatly extends its tropical distribution. The anatomical characters are the same in Mozambique as in the Pacific Ocean (Fig. 11).

*POLYCARPA ARNOLDI* (MICHAELSEN, 1914) (Fig. 12)

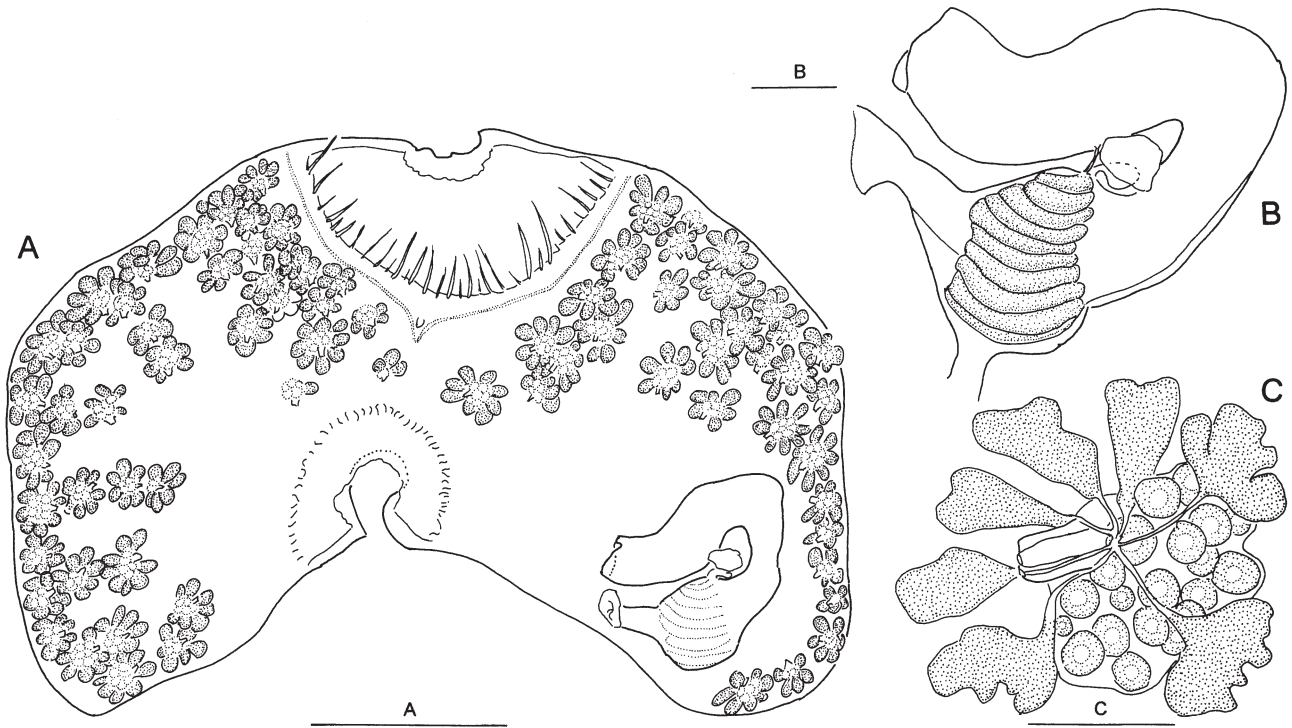
*Pandocia arnoldi*: Michaelsen, 1914: 426 – west coast of Africa.

*Polycarpa arnoldi*: Michaelsen, 1915 Annobon: 407, pl. 16, fig. 2, pl. 18, figs 40–44; Van der Sloot (1969) – Antilles; Monniot C., 1983 – Antilles; Goodbody, 1984a: 38 – Antilles; 1984b: 71 – Antilles.

*Polycarpa crossogonima* Millar, 1962 – Antilles.



**Figure 11.** *Polycarpa argentata*: A,B, both sides of a specimen removed from the tunic. C, specimen ventrally opened. D, detail of a polycarp. Scale bars: A,B,C = 1 cm, D = 0.5 mm.



**Figure 12.** *Polycarpa arnoldi*: A, specimen ventrally opened. B, detail of the gut. C, polycarp. Scale bars: A = 5 mm, B = 1 mm, C = 0.5 mm.

#### Material

Mozambique: Ibo Island, 1 specimen, coll. C. Monniot, 1995.

Yemen: Socotra Island, 2 specimens, coll. C. Monniot, 1997.

#### Remarks and distribution

The specimens collected in the Indian Ocean correspond exactly to the original description and to the specimens collected in the Caribbean Sea. One of the two specimens from Socotra is particularly large: 4 cm.

This species, with its characteristic gonads (Fig. 12A,C), and small gut (Fig. 12B), is recorded in the Indian Ocean for the first time.

#### *POLYCARPA GRADATA* SP. NOV. (Figs 13,14A)

#### Material

Holotype: MNHN S1 POL.B 435, Mozambique: Inhaca Island, 2 m, coll. Berggren, 1986, Other material examined: Madagascar: Tulear, 50 m, coll. R. Plante, 1970.

Djibouti, 15 m, coll. C. Monniot, 1996.

#### Description

In the Mozambican type material (Fig. 14A), six pedunculate individuals arise from a common stolon.

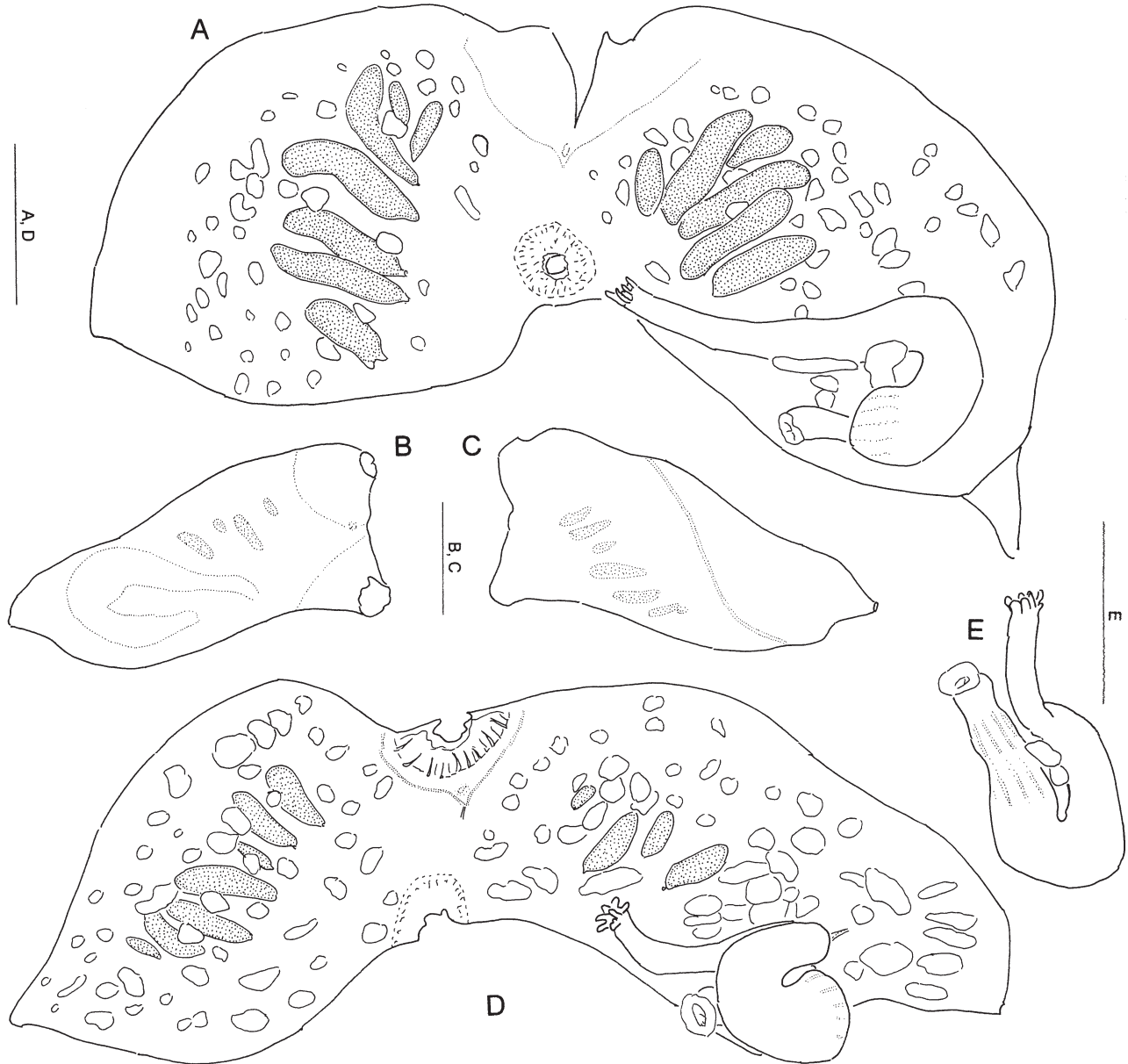
The specimen from Djibouti has only two individuals on a common base. A single pedunculate specimen comes from Madagascar.

The largest body reaches 1.5 cm in length on a peduncle of same length and width. The other lobes present either a single body on a narrow peduncle or one body atop a basal part that contains an incompletely developed individual. In all specimens the tunic is corrugated and naked in its anterior part, while some sand and epibionts occur only on the lower tunic. The apical but well-separated siphons do not protrude (Fig. 14A).

The following description is that of the largest individual arising from the upper part of a lobe of the type colony. The tunic is thick, solid but flexible. Removed from the tunic, the body is oval, and the siphons lie opposite a prolongation of the body wall that penetrates a short way into the peduncle.

The body wall is opaque, with an evenly distributed musculature. There is a large oral velum. At its base about 30 long thin tentacles alternate with others that are clearly smaller. The prepharyngeal band curves in a dorsal V where the dorsal tubercle, has a C-shaped slit opening anteriorly. The dorsal lamina is high with a smooth edge. The branchial tissue is thin. There are four round folds on each side, wide and low, carrying uncrowded longitudinal vessels. We counted up to five stigmata in a mesh on the folds.





**Figure 13.** *Polycarpa gradata* sp. nov.: A, holotype ventrally opened. B,C, both sides of a specimen from Djibouti. D, specimen from Djibouti ventrally opened. E, unfolded gut of a specimen from Djibouti. Scale bars: A,B,C,D = 5 mm, E = 2 mm.

There is an average of two longitudinal vessels between the folds, separated by eight stigmata. The branchial formula is:

$$\text{RE } 2 \ (7) \ 2 \ (8) \ 2 \ (7) \ 3 \ (8) \ 1 \ \text{DL} \ 2 \ (9) \ 2 \ (6) \ 3 \ (7) \\ 5 \ (2) \ \text{EL}$$

The gut lies in the posterior part of the body (Fig. 13A). The elongated stomach has internal folds. The primary intestinal loop is closed, but the secondary loop is wider, and the long rectum opens near the anteriorly placed cloacal aperture. The anus has finger-like

lobes. The gonads lie in a line on each side of the body (Fig. 13A,D). The ovaries are internal, while the testis lobes lie externally against the body wall. The sperm ducts arising from each testis lobe join into a common duct opening against the female papilla at the apical extremity of the gonad. The polycarps are loosely attached to the body wall and consequently protrude well into the cloacal cavity. Their number varies with the individuals. For example, in the same Mozambican colony seven polycarps are on the right and six on the left (Fig. 13A), or three gonads are on

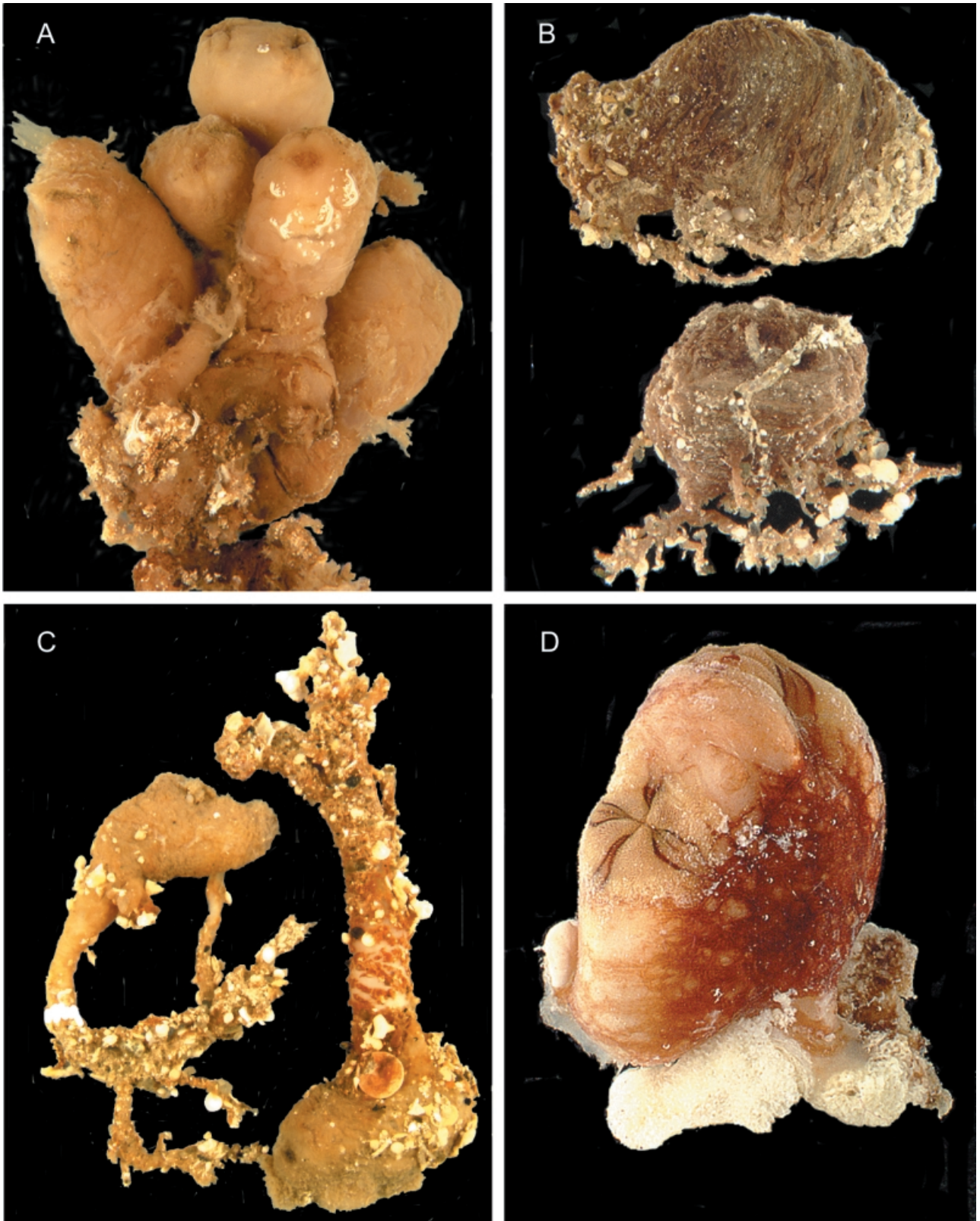


Figure 14. A, *Polycarpa gradata* sp. nov. holotype. B, *Polycarpa plantei* sp. nov. specimens from Madagascar. C, *Polycarpa pori* sp. nov. D, *Pyura gangelion* sp. nov.

the right and two on the left, and in a Djibouti specimen seven gonads lie on the right and four on the left (Fig. 13B–D).

Numerous endocarps are scattered over the internal body wall, and also lie in the gut loop. They are leaf-shaped, with a thin wall, and very protruding. They are a little larger and more numerous posteriorly in the body.

At the base of the cloacal aperture, a wide annular area carries numerous filiform papillae (Fig. 13A).

In the peduncle of this body from the type specimen, posteriorly and after a slightly marked narrowing, was a second body. We extracted it only with difficulty from the thick tunic at this level. It has two parts: an anterior round thorax, with two small prominences corresponding to the siphons, and a cylindrical posterior prolongment, lying deep in the posterior tunic. The thorax has a thin body wall without muscular fibres, with some endocarps protruding internally in the posterior part. Some short oral tentacles form a circle. There is a thin prepharyngeal band with a small dorsal curve where a dorsal tubercle lies, pierced by a simple hole. The branchial tissue in this little body is very thin. Round stigmata are distributed irregularly not in orderly lines, between some thin longitudinal vessels that are not gathered into folds. The long endostyle is clearly visible, but the dorsal lamina is not differentiated.

The posterior tubular part of the little body contains the gut. The oesophagus is short, followed by a thick ridged stomach. Farther down still, the tissues are thick and dense and without defined shape. But a long thin rectum comes out of this mass, and extends anteriorly in the peribranchial cavity.

The cloacal siphon does not seem to be open.

No trace of gonad was observed in this deep-seated zooid.

#### Remarks

This arrangement of two superimposed bodies occurs in at least two lobes of the Mozambican colony. It is hard to say whether the posterior individual is a bud or a body that is regressed or regenerating. Close by, another body has an achieved adult structure except that the gut is missing. It is not possible to say whether the evisceration that created this gutless arrangement occurred by accident when the specimen was collected or if it was a natural evisceration, a phenomenon observed in other *Polycarpa* species, for example *P. mulilans* (Herdman, 1906) or *P. papillata* (Sluiter, 1898).

#### Etymology

From the Latin, *gradatus*: arranged in stairs.

*POLYCARPA MADAGASCARIENSIS* MICHAELSEN, 1912  
(Figs 4E, 15, 16)

*Pandocia (Polycarpa) madagascariensis* Michaelsen, 1912: 139 – Madagascar, Nosy-Be.

*Polycarpa rubida* (Sluiter, 1898): Monniot C. & Monniot F., 1976: 376 – Mozambique.

Part of *Polycarpa olitoria*: Kott, 1985: 180.

*Polycarpa papillata*: Vasseur, 1969: 925 – Madagascar, Tulear.

#### Material

Madagascar, Nosy-Be, coll. R. Plante, 1968 and P. Laboute, 1992

Mozambique, Ibo Island, coll. C. Monniot, 1995

Mayotte, coll. M. Aknin, 1998

Mauritius, 19°57.72'S–57°36.23'E, 30 m, coll. CRRF, 1999.

#### Description

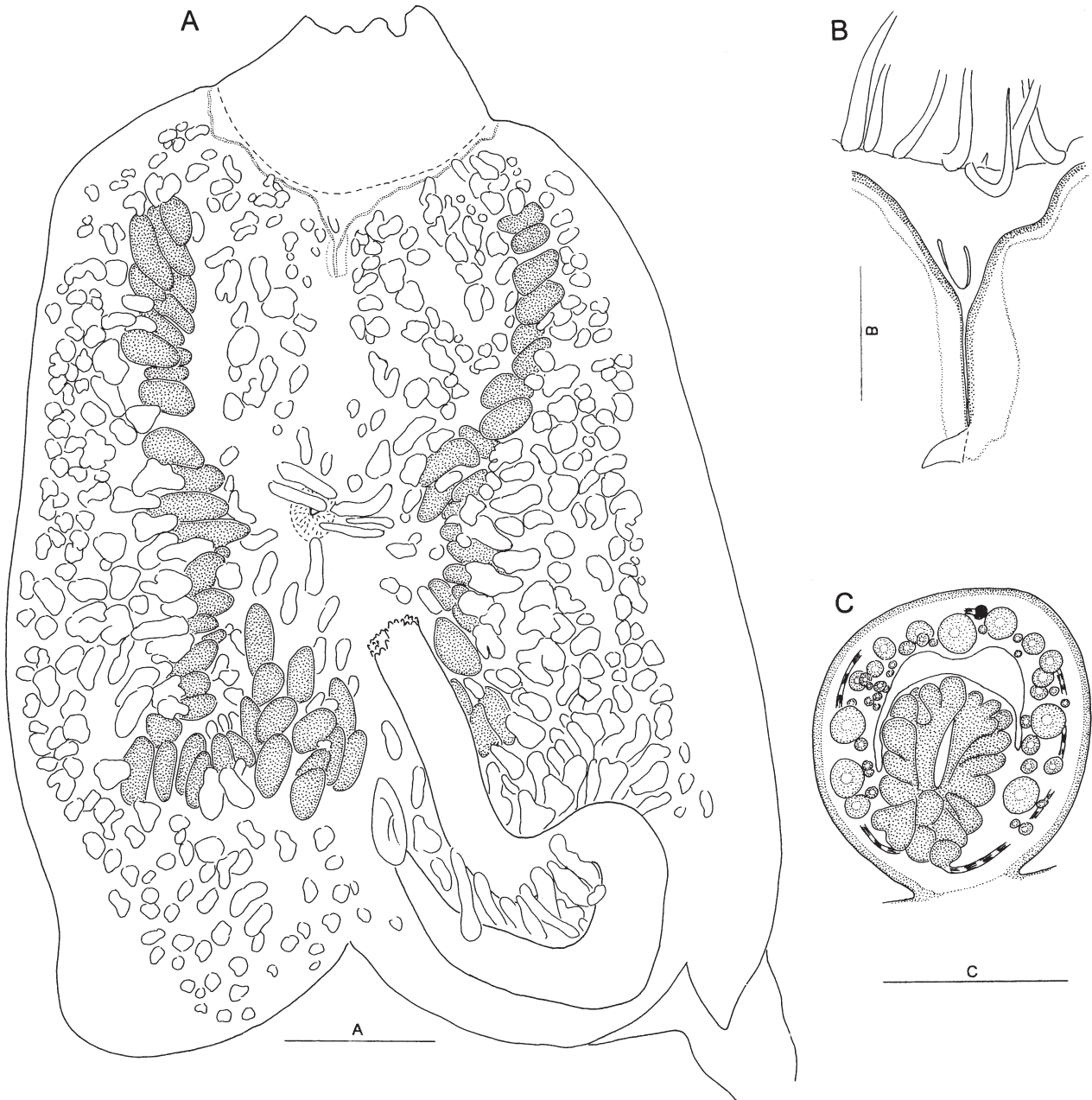
Several specimens collected on different substrates have different sizes, colours and shapes. The bodies of the largest individuals are 8 cm long plus a 1–3 cm peduncle. On soft sediment the animals have a long and thin peduncle ending in encrusted ramifications. On rocks (Fig. 4E), the peduncle is shorter, sometimes almost absent, replaced by a thick extension of the tunic. The body is always elongated, and its cloacal siphon opens in the middle of the dorsal side (Fig. 4E). The tunic is thicker at the level of the siphons and in the posterior part of the body. Its surface has grooves delimiting swellings and lacks epibionts. A small postero-ventral part of the body is sometimes encrusted with sediment. There are no spines on the siphons. The body's tunic is brown-red or beige, and the peduncle is darker. In formalin some specimens are discoloured, while others turn black.

The body wall is totally opaque, thick, and breaks easily. The external layer contains regularly spaced muscles, while the internal layer is thin and transparent. Both siphons have a short velum.

About 30 long oral tentacles, irregularly spaced, with small ones between them, arise far inside the oral siphon. The prepharyngeal band is a single high blade that lies close to the tentacle ring and draws a dorsal Y (Fig. 15B). The dorsal tubercle has a simple shape.

The long dorsal lamina is low in its first third, then higher posteriorly, and turns around the oesophagus entrance. The endostyle is attached to the body wall by a thin membrane. There are four high folds on each side of the branchial sac, but they do not cover each other. The longitudinal vessels are regularly spaced between the folds and at the bases of the folds, so the folds' limits are difficult to find. The number of longitudinal vessels varies with body size.

In a large specimen were counted:



**Figure 15.** *Polycarpa madagascariensis*: A, specimen from Madagascar ventrally opened. B, neural area of the same. C, section through a polycarp. Scale bars: A = 1 cm, B = 3 mm, C = 1 mm.

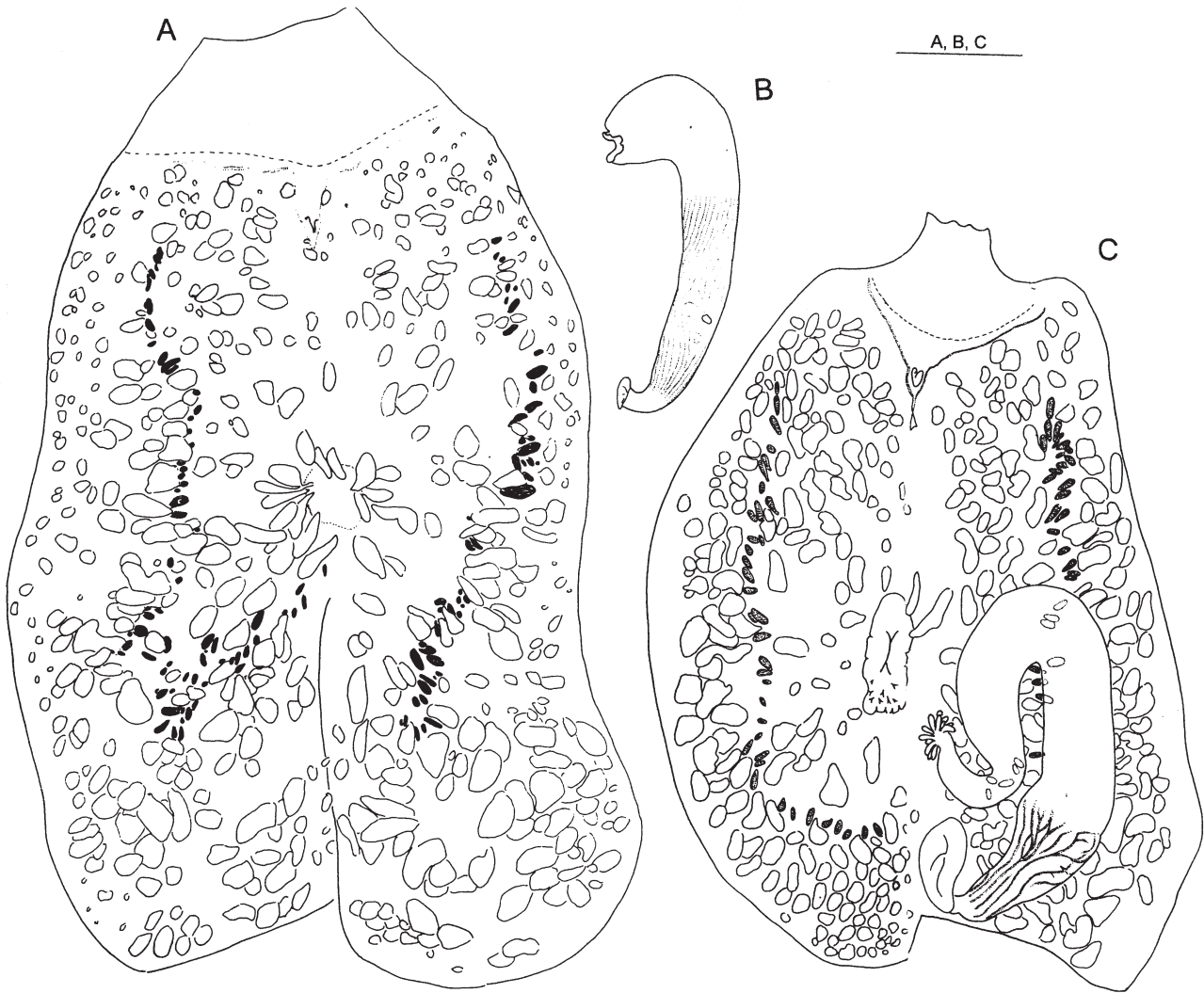
RE 8 (20) 9 (20) 8 (22) 8 (16) 5 DL 5 (16) 9 (20) 10  
(21) 9 (20) 8 EL

Between the folds the meshes contain up to ten short stigmata.

Exceptionally, parastigmatic vessels can occur in a large branchial sac.

The gut, very variable in shape and size (Figs 15A,16B,C), occupies only a small part of the left posterior side of the body. The oesophagus progressively

changes into a stomach that widens toward its pyloric end but still remains narrow, without a caecum. There is no pyloric bridge in the gut loop. The gaping anus has a lobed rim (Figs 15A,16C). The digestive tract is connected to the body wall only by some trabeculae at the stomach level and a membrane along the rectum. In several specimens, in different stations, the gut is not functional and regressed, almost completely isolated from the body wall (Fig. 16B). Sometimes it is absent.



**Figure 16.** *Polycarpa madagascariensis* specimen from Mauritius: A, ventrally opened. B, regressed gut. C, specimen from Mozambique. Scale bars = 1 cm.

The rounded hermaphroditic polycarps lie in a long longitudinal line in the middle of each side of the body (Figs 15A,16A,C); this line extends from the prepharyngeal band to the gut where it curves slightly toward the cloacal siphon. The gonads are linked to the branchial sac by thin trabeculae. They are very protruding, only narrowly attached to the body wall (Fig. 15C). The testis lobes lie toward the body wall, covered by the ovary. The male and the female papillae open together at the dorsal pole of each polycarp, and they are sessile. All the internal side of the body wall is covered by large, leaf-shaped endocarps (Figs 15A,16A,C), even below the gut and down to its extension into the peduncle, where it is full of a dense tissue.

Thread-like tentacles are distributed on a velum around the base of the cloacal siphon.

#### Remarks

The present species is referred to *Polycarpa madagascariensis* Michaelsen, 1912 even though the type specimen was the only one collected. The type specimen has fewer gonads but is smaller. Its anatomical characters correspond to those of the newly collected specimens from the type locality. The geographical distribution now comprises the northern part of Mozambique (Ibo Island), the Comoros (Mayotte Island), the north of Madagascar (Nosy-Be), and Mauritius.

*Polycarpa rubida* (Sluiter, 1898) is a closely similar species but 'colonial', with zooids included in a common tunic or on a common base, it is distributed from Mozambique to Natal. In that species, the siphons are close together, so the rectum is clearly longer. The gonads are less numerous and the endo-

carps less dense. The dorsal tubercle of *P. rubida* has a more complex opening.

Two others species from the western Pacific Ocean look like *P. madagascariensis* and have gonads in a line on each side of the body. Of these, *P. captiosa* (Sluiter, 1898) has no peduncle, multiple openings of the dorsal tubercle, and a smooth anal rim. The other, *P. olitoria* (Sluiter, 1890), is well characterized by horny spinules on both siphons. *P. papillata* (Sluiter, 1885) does not have gonads in a line and has a characteristic pale tunic with red stripes (Monniot & Monniot, 2001).

*POLYCARPA MYTILIGERA* (SAVIGNY, 1816)

*Cynthia mytiligera* Savigny, 1816: 98, pl.8, fig. 2 – Suez.

*Polycarpa mytiligera*: Monniot F. & Monniot C., 1999: 29, fig. 17 – Tanzania and synonymy; Monniot C. *et al.*, 2001 – Natal.

*Pandocia (Polycarpa) seychellensis* Michaelsen, 1912: 148 – Seychelles.

*Polycarpa seychellensis*: Monniot C. & Monniot F., 1976: 373, fig. 3A – Mozambique.

Not *Polycarpa mytiligera*?: Monniot C., 1987: 284 – New Caledonia.

*Material*

Red Sea, coll. ISRSE, 1962.

Mozambique: Ibo Island, coll. C. Monniot, 1995.

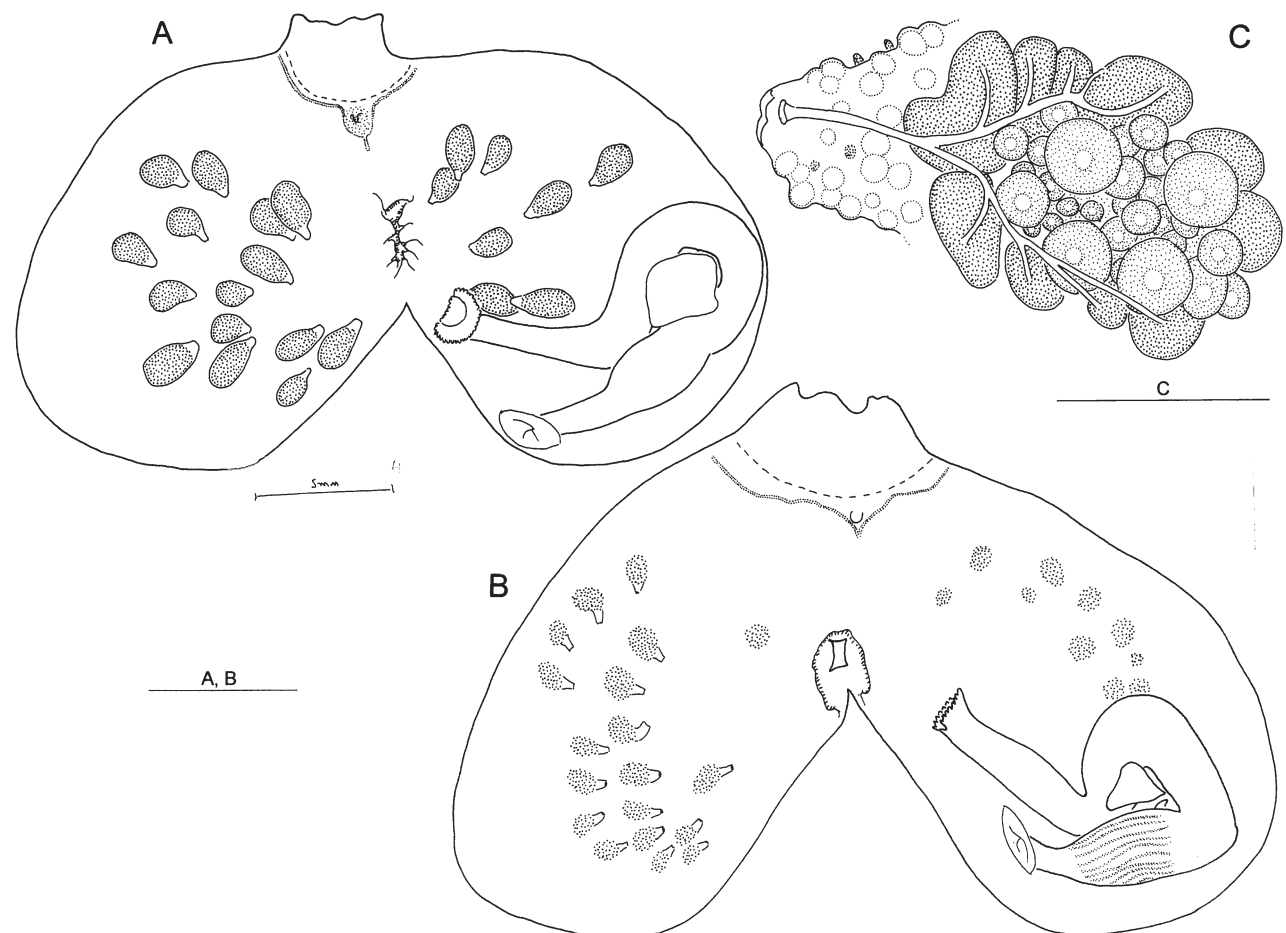
Djibouti, 3–30 m, coll. C. Monniot, 1996.

Yemen: Socotra, coll. C. Monniot, 1997.

This species is common in the western Indian Ocean from the north to the south.

*POLYCARPA NIGRICANS* HELLER (1878) (Fig. 17)

*Polycarpa nigricans* Heller, 1878: 174, fig. 8 – Mauritius; Hartmeyer, 1905: 390, pl. 1, figs 1,2,14;



**Figure 17.** *Polycarpa nigricans*: A, specimen with gonads protruding into the cloacal cavity. B, specimen with gonads included in the body wall. C, detail of a polycarp. Scale bars: A,B = 5 mm, C = 0.5 mm.

Vasseur, 1967: 115, pl. 5, figs 37–40 – Mauritius; Monniot F. & Monniot C., 1999: 31 – Tanzania.

Not *Polyandrocarpa nigricans*: Tokioka, 1970: 91, fig. 5 – Philippines = *Polycarpa tokiokai* Monniot F. & Monniot C., 1996.

Not *Polycarpa nigricans*: Kott, 1985; Monniot C., 1987; Monniot C & Monniot F., 1989 = *Polycarpa tokiokai*.

#### Material

Mozambique: Ibo Island, coll. C. Monniot, 1995.

#### Description

The individuals are either isolated or aggregated into plaques that are more or less united by the tunic at their base. In life they are brick-red with darker areas, almost black at the base of the body. The internal side of the tunic has the same colouration but paler. The specimens are often covered with varied epibionts. When fixed in formalin, the tunic becomes dark-brown, almost black. Even when individuals are strongly pressed against each other, they can be separated, and debris gets lodged between the tunics. Traces of regeneration were not found, and so this species is placed in the genus *Polycarpa*.

The tunic is soft, the internal side somewhat gelatinous. The body wall is opaque, dark-brown, with whitish granules on its internal side; these granules are more or less abundant according to the individual, but sometimes virtually absent. They are denser around the dorsal tubercle, and on the gonads and gut.

The oral tentacles, 25–40 in three orders, may be missing in some parts of some oral siphons. The prepharyngeal band has two thick crests, and is deeply indented dorsally. The dorsal tubercle does not occupy the whole peri-tubercular area; its opening is generally U-shaped, but sometimes a little ramified. The dorsal lamina, smooth and low, begins after a short groove. The branchial sac has four low folds. There are no grouped vessels between the dorsal lamina and the first right fold.

Two branchial formulae:

RE 2 (5) 2(7) 2 (8) 2 (10) 1 D.l. 1 (7) 2 (10) 2 (10)  
3 (9) 2 EL

RE 1 (8) 2 (11) 2 (11) 3 (9) 1 D.l. 1 (7) 2 (12) 2 (12)  
3 (10) 2 EL

The folds progressively disappear near the oesophagus entrance. 8–10 stigmata were counted per mesh between the folds and 5–8 on the folds. There are no parastigmatic vessels.

The gut (Fig. 17A,B) forms a closed loop. The stomach is oval, with internal folds that can be seen from the outside, and that disappear progressively toward the pyloric end (Fig. 17B). The caecum is just

a rather large button. The slightly transparent intestine ends in an anus with small lobes (Fig. 17A,B), at a short distance from the cloacal siphon.

The gonads contain a central ovary surrounded by testis vesicles. Two lateral sperm ducts unite in a common duct opening near the oviduct (Fig. 17C). According to the specimen, the gonads may be totally included in the body wall thickness (Fig. 17B), or partially (Fig. 17A) or totally protrude into the cloacal cavity. Even when the gonad is included in the body wall, the large oviduct protrudes and its wall is filled with granules and shows papillae (Fig. 17C). There is a large endocarp in the intestinal loop. The internal side of the cloacal siphon is lined with fleshy lobes having small tentacles.

#### *POLYCARPA PLANTEI* SP.NOV. (Figs 14B,18)

#### Material

Holotype: MNHN S1 POL B 439, Madagascar: Nosy-Be, coll. R. Plante, 1968.

Other material examined: Madagascar, Nosy-Be, coll. R. Plante, 1966 and 1968; Seychelles: Mahé, anse à la Mouche, coll. Central Africa Museum.

#### Description

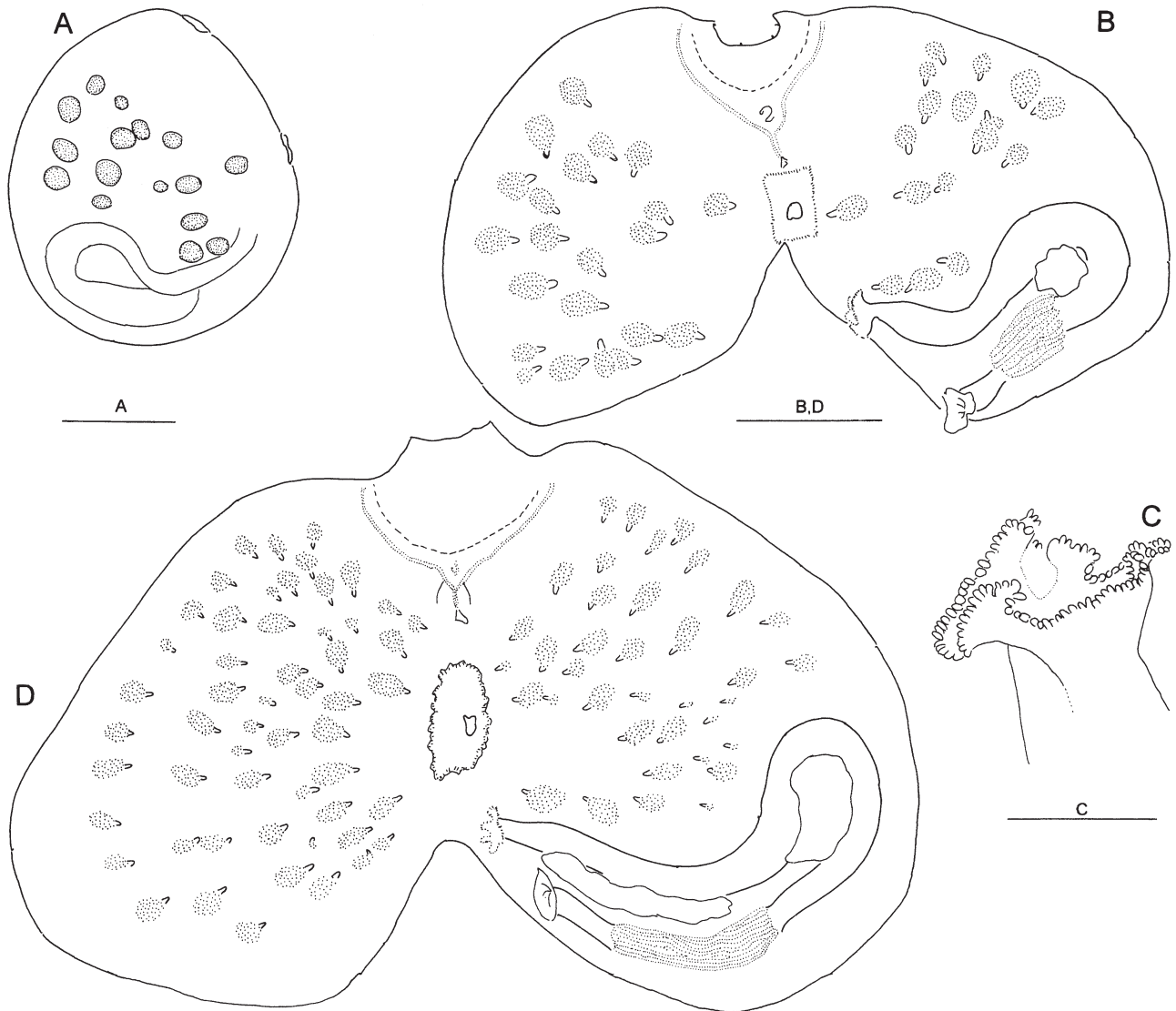
This species has a dark, soft tunic (Fig. 14B). Bodies 1–3 cm in diameter were collected over several years in the same place at Nosy-Be by R. Plante. Two larger specimens, 5 cm in diameter, come from the Seychelles, and one of them has a pale colour.

The corrugated anterior part of the tunic lacks epibionts or sediment, but the ventral part is more or less covered with varied debris. The inconspicuous siphons are separated by half the body width. Opposite to the siphons the soft and thin tunic extends thick ramifications and filaments encrusted with sediment, or it makes a short, thick peduncle (Fig. 14B). The body wall is slightly transparent and reveals the gonads and gut (Fig. 18A). The musculature is weak. In Madagascar specimens preserved in formalin, each siphon has a large velum with a black rim. The roughly 40 oral tentacles are thin and long, distributed in two rather similar orders, separated by much smaller tentacles.

The dorsal V of the prepharyngeal band is sharp. The dorsal tubercle does not protrude and opens in a S-shaped slit. The smooth-edged dorsal lamina increases in height toward the oesophagus. The endostyle is long, without a postendostylar appendix. The four branchial folds on each side are high, but do not cover each other.

In a specimen 2 cm across the formula is:

RE 2 (8) 2 (10) 2 (10) 2 (9) 0 DL 1 (6) 2 (8) 2(9) 1  
(6) 2 EL



**Figure 18.** *Polycarpa plantei* sp. nov.: A, left side of a specimen from Madagascar. B, the same ventrally opened. C, anus. D, specimen from the Seychelles. Scale bars: A,B,D = 1 cm, C = 2 mm.

There are 12–15 stigmata in a mesh between the folds. The transverse vessels are distributed in three orders and contain muscular fibres. There are no parastigmatic vessels. The elongated gut loop lies in the posterior half of the left side (Fig. 18B,D). The oesophagus is narrow and cylindrical. The stomach is spindle-like with internal folds easily seen from outside (Fig. 18A,D). The caecum is very small; the distal part of the long intestine widens into a kind of corolla made of many small lobes (Fig. 18C). The gastro-intestinal duct is wide. The posterior part of the intestine makes an accentuated secondary loop, linked to the body wall only by thin bridges. A single endocarp in shape of a flat cushion lies in the bottom of the gut loop in Madagascar specimens (Fig. 18B); two of

them are present in a larger specimen from the Seychelles (Fig. 18D).

The round polycarps lie within the body wall on both sides of the body. In a 3 cm specimen 21 polycarps were counted on the right side (Fig. 18B). The ovary is internal and the testis lobes form a cluster. Both genital papillae are close together and project free in the cloacal cavity. There are no endocarps among the gonads. The internal layer of the body wall contains multiple clear vesicles. There are no cloacal tentacles.

#### Remarks

The distinctive characters of the species are a soft tunic, longitudinal branchial vessels that lie distant



from each other, a long gut loop enclosing a single endocarp, and numerous round polycarps entirely included within the body wall.

This new species has some similarities to the Pacific species *Polycarpa cryptocarpa* (Sluiter (1885) and *Polycarpa obscura* Heller, 1878, which are larger and have two endocarps in the gut loop.

*P. plantei* sp. nov. is also similar to *P. nigricans* Heller, 1878 which has aggregated zooids that are not pedunculated, a muscular and opaque body wall, a lower dorsal lamina, and a shorter gut loop.

#### Etymology

This species is dedicated to Raphael Plante who was the first to collect this ascidian.

#### **POLYCARPA PORI** SP. NOV. (Figs 14C,19)

*Cnemidocarpa hemprichi*, part: Michaelsen, 1919: 76  
– Red Sea.

#### Material

Syntypes: MNHN S1 POL B 428, Red Sea: Marmar Island, coll. 'Calypso' cruise.

Other material examined: Suez Canal: Great Bitter Lake, coll. F.D. Por.

Madagascar: Nosy-Be, 12 specimens, coll. R. Plante, 1968.

#### Description

All the specimens from the Red Sea are the same. They are oval and measure 1.5–2 cm in length, without peduncle (Fig. 14C). The specimens from Madagascar measure 4–6 cm, the body being 2 cm in length; they were collected on a sedimentary bottom. In all cases, the tunic is very thick and corrugated, sometimes with some sediment, especially encrusted on the peduncle and its basal ramifications (Fig. 14C). The siphons are not protruding. The oral siphon is terminal, the cloacal siphon half-way down the dorsal side of the body.

Removed from the tunic, the body is ovoid. The siphons have a darker pigmentation than the remainder of the opaque body.

The tentacles, in three orders, have a variable length in different specimens. There is a short oral velum. The prepharyngeal band has a dorsal V in which a dorsal tubercle opens anteriorly in a wide C. The dorsal lamina is low with a smooth edge.

The branchial sac has four well-spaced folds on each side. The branchial formula in a specimen from the Suez Canal is:

RE 1 (7) 1 (9) 2 (8) 2 (8) 2 DL 2 (9) 1 (8) 1 (10) 1 (9)  
1 EL

In a larger specimen from Madagascar the formula is:

RE 3 (11) 3 (17) 4 (15) 4 (17) 3 DL 3 (17) 3 (15) 4 (15)  
4 (12) 3 EL

In both cases, the transverse vessels of first order are wide, there are two other orders of transverse vessels, and some parastigmatic vessels.

The branchial sac is linked to the body wall by numerous trabeculae. The endostyle is attached to the body wall. There is a postendostylar appendix, curved but not rolled.

The gut has a rather long oesophagus, and a long stomach with irregular internal folds. The intestine forms a closed primary loop (Fig. 19A,B) bridged by a pyloric trabeculum. The long intestine makes an accentuated secondary loop (Fig. 19A,B). The anal rim is undulated or scalloped.

The interior body wall is covered by numerous polycarps mixed with protruding endocarps (Fig. 19A,B). The hermaphrodite polycarps are round or oval. Each has a protruding genital papilla. The ovaries are internal and at their surface the sperm ducts converge to open against the female papilla. The polycarps are irregularly intercalated but do not form longitudinal rows (Fig. 19A,B).

A cloacal velum has thin cloacal tentacles.

#### Remarks

This species has several characters in common with *Cnemidocarpa hemprichi* Hartmeyer, 1916; and *Cnemidocarpa* sp. nov.: the general body shape (but the size here is smaller), the tunic structure, numerous polycarps and endocarps, an elongated stomach, and an intestine in a double loop with a long rectum. But *Polycarpa marerubrum* sp. nov. differs in having short, round polycarps, putting the species in the genus *Polycarpa*.

#### Etymology

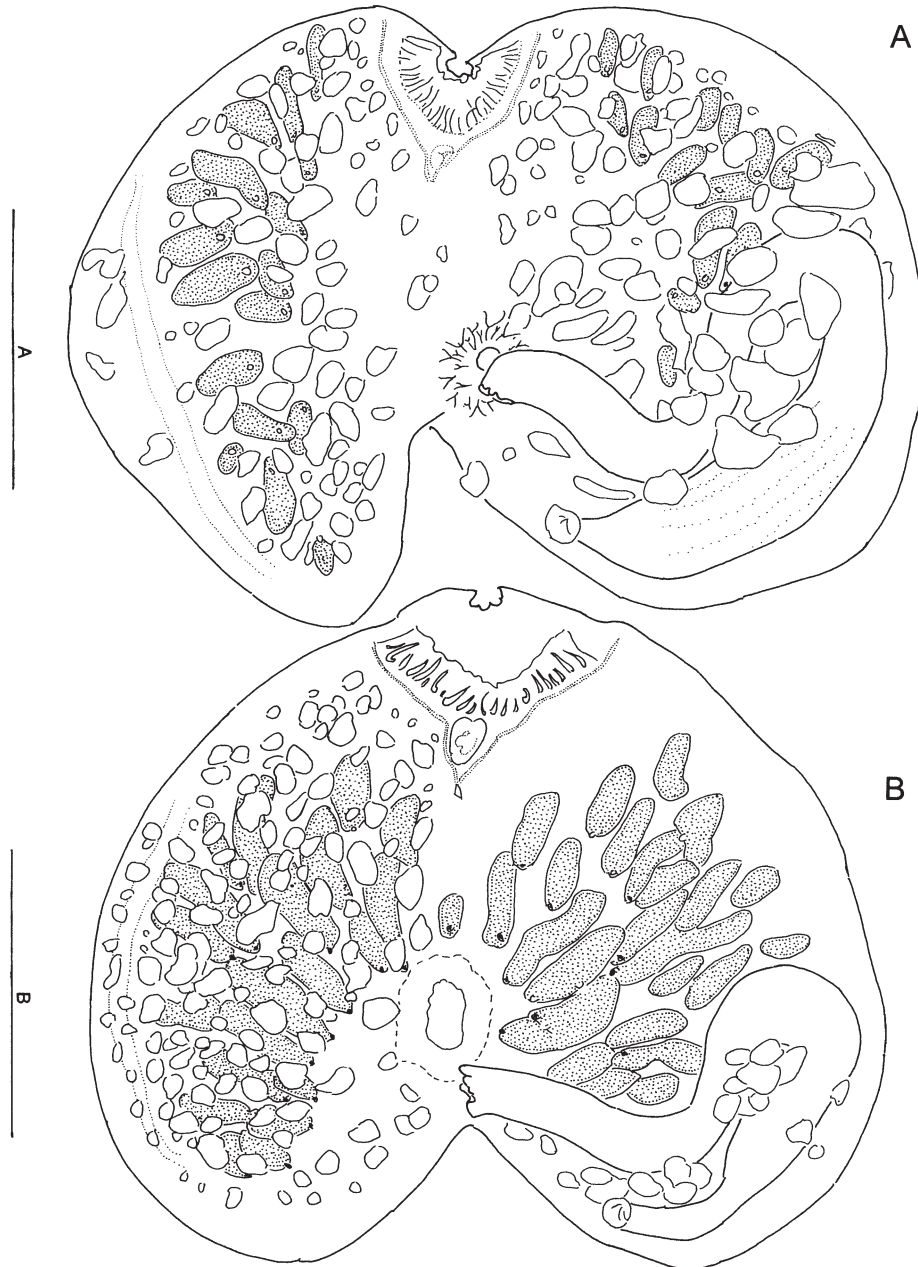
This new species is named after F.D. Por, its first collector.

#### *POLYCARPA STIRPES* KOTT, 1985 (Fig. 20)

*Polycarpa stirpes* Kott, 1985: 202, fig. 95 – Australia; Monniot C., 1987: 278, fig. 1C,D – New Caledonia; Monniot F. & Monniot C., 2001: 333, figs 97,129B – Philippines.

#### Material

Mozambique: Ibo Island, Matemo cliff, 5–10 m, coll. C. Monniot, 1995.



**Figure 19.** *Polycarpa pori* sp. nov.: A, specimen from the Red Sea ventrally opened. B, specimen from Madagascar, endocarps on the left body side are not figured. Scale bars: A = 5 mm, B = 1 cm.

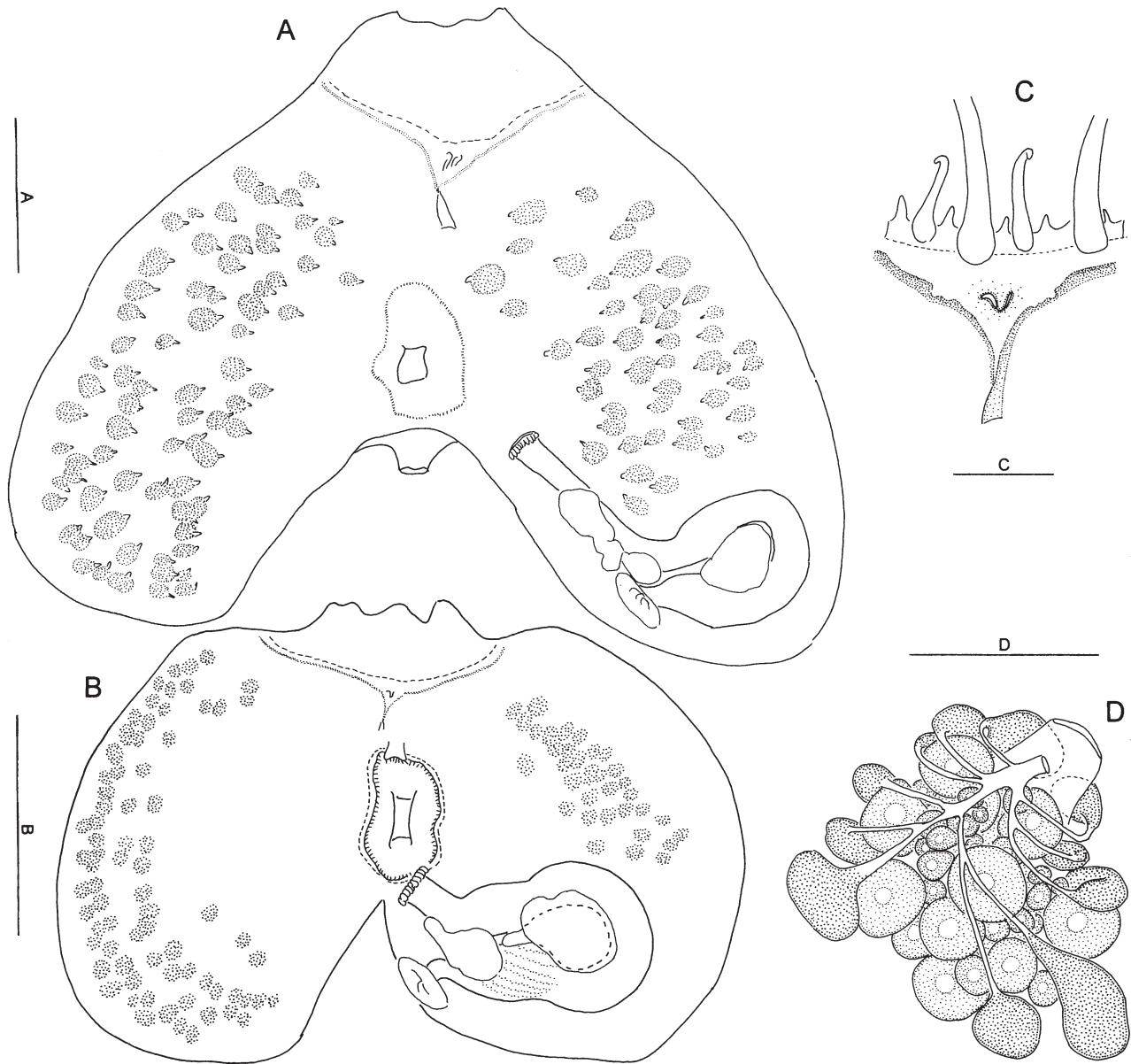
#### *Description*

In life the tunic is brown and the siphons black, interiorly spotted with white, but these colours disappear in formalin. After fixation the rather thick tunic is soft, greyish, and translucent internally. The body wall is thin, without granules, light brown, darker on the siphons. The musculature is weak and the gonads can be seen in an unopened body.

Thirty long and stout oral tentacles regularly alternate in three orders. The largest are as long as the

siphon. They are planted on a crest. The prepharyngeal band is a single rod-like ridge that curves dorsally in a V that is prolonged by a groove (Fig. 20C). The dorsal tubercle is flat (Fig. 20C).

The height of the dorsal lamina progressively increases posteriorly. The branchial sac remains light brown when fixed in formalin. It has four well-formed folds on each side, but they do not cover each other. The first longitudinal vessel on the right side clearly diverges from the dorsal lamina posteriorly.



**Figure 20.** *Polycarpa stirpes*: A, the largest specimen ventrally opened. B, small specimen ventrally opened. C, detail of the neural area. D, polycarp. Scale bars: A,B = 1 cm, C = 1 mm, D = 5 mm.

Three to four vessels between the dorsal lamina and the first fold on the right side converge to form a kind of low fold in the posterior part of the body, and in this specimen the formula then becomes:

RE 2 (8) 3 (9) 3 (10) 3 (9) 1 (3) DL 2 (8) 3 (12) 3 (11)  
3 (9) 3 EL

At the oesophagus entrance, the branchial vessels fuse and the folds progressively flatten. The transverse meshes contain 10–12 stigmata between the folds and 4–8 on the folds. There are no parastigmatic vessels.

The primary gut loop is closed but the secondary loop is only slightly curved (Fig. 20A,B). The gut is linked to the body wall only at the level of the oesophagus and rectum. The oval stomach has about 15 grooves that are hardly visible externally. There is a short caecum in the shape of a hook. The anal rim is lobed and rolled (Fig. 20A,B). There are one or two endocarps in the gut loop (Fig. 20A,B).

The gonads (Fig. 20A,B), more numerous ventrally than dorsally, are included in the body wall. In one specimen 74 of them were counted on the right side and 34 on the left. The ovary is central, surrounded by

testis lobes. The sperm ducts irregularly converge into a common duct ending in a short papilla that opens at some distance from the female papilla (Fig. 20D). The gonoducts do not protrude into the cloacal cavity; they are sessile.

After staining with haemalum, very small clear vesicles appear on the internal layer of the body wall.

A ring of thin tentacles lies at the base of the cloacal velum (Fig. 20A,B).

#### Remarks

The species is closely similar to *Polycarpa argentata* (Sluiter, 1890). It has only been recorded from the western Pacific Ocean. Its occurrence in the western part of the Indian Ocean considerably increases its geographical distribution.

*POLYCARPA SUESANA* MICHAELSEN, 1919 (Fig. 21)

*Polycarpa anguinea* var. *suesana* Michaelsen, 1919: 85  
– Red Sea.

#### Material

Gulf Ras Mesalle, coll. L. Boutan, 1891.

Gulf of Aden, st. 236, 45 m, coll. Meteor cruise, 1987.

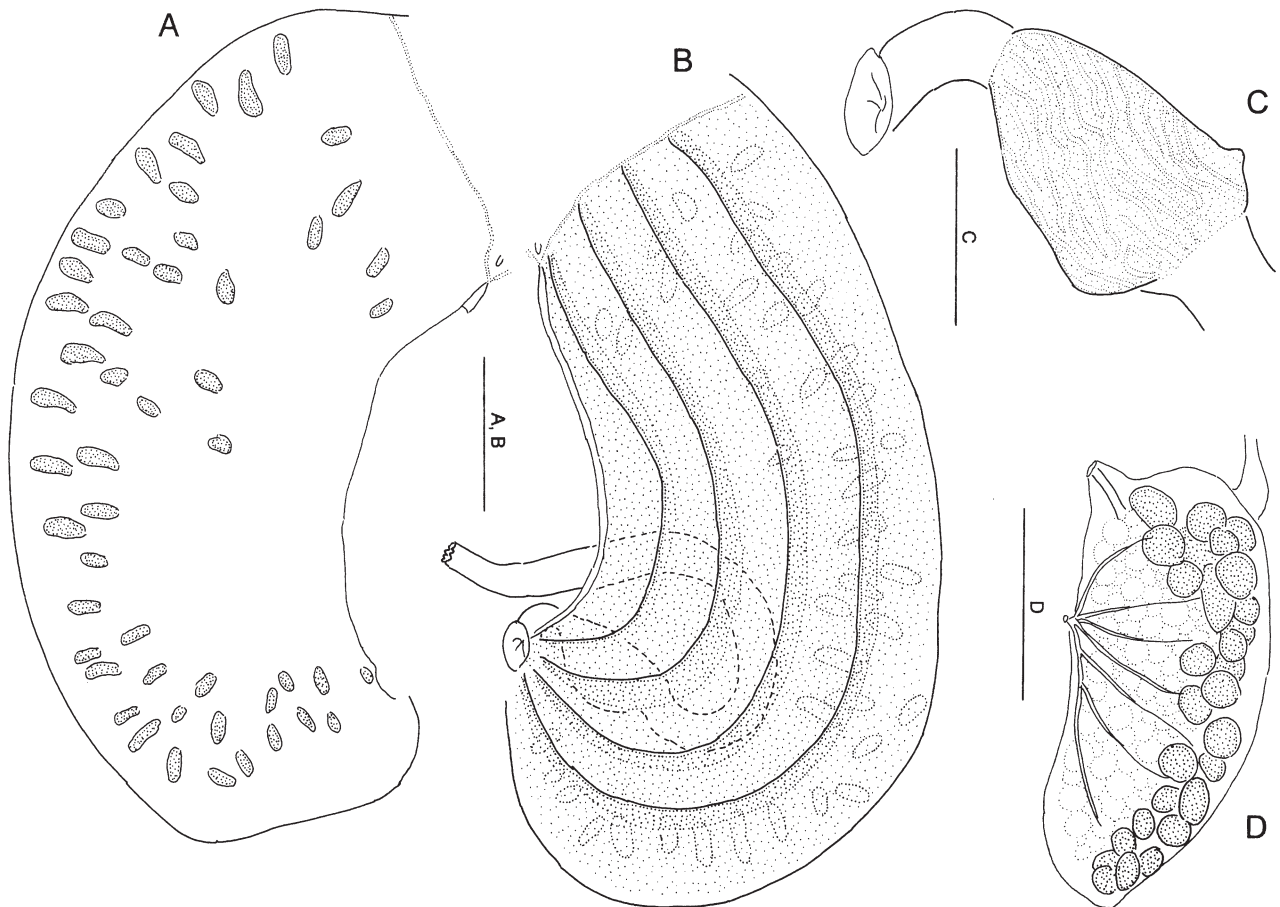
#### Description

The specimens from the Gulf of Aden are very damaged. Those from the Gulf of Suez are covered with coarse sediment and broken shells; the largest is 5 cm in length and 2.5 cm in width, with siphons 3.5 cm apart. The smallest is 4 × 2 cm. Both siphons are short. The tunic is thin but resistant. The body wall is thin with muscles limited to the siphons. The dorsal tubercle is in shape of a C opening anteriorly, located in a deep V of the prepharyngeal band.

The branchial sac is large, very thin, with the folds widely separated (Fig. 21B) The formula of the largest specimen on the left side is:

E-11 (16) 12 (17) 11 (18) 12 (11) 1/8 – DL

On the left side, the space between the long dorsal lamina and the first fold increases posteriorly; it con-



**Figure 21.** *Polycarpa suesana*: A, right internal side of the body, branchial sac removed. B, internal left side of the body. C, stomach. D, polycarp. Scale bars: A,B = 1 cm, C = 5 mm, D = 1 mm.

tains only one longitudinal vessel anteriorly and eight at the oesophagus entrance. There are parastigmatic vessels.

The gut forms a wide, closed loop (Fig. 21B), without a secondary curve. The stomach has numerous sinuous folds and no caecum (Fig. 21C). The anus is lobed. The gonads are oval or slightly elongated polycarps, orientated transversally. They lie intercalated in a double row on each side, along the ventral side of the body wall (Fig. 21A,B). They numbered about 40 on each side. They are only linked to the body wall by thin stripes. Some are present posteriorly to the gut (Fig. 21B). In each polycarp (Fig. 21D), the testis is made of a double longitudinal line of vesicles, located against the body wall. The ovary covers internally the testis. The female papilla is distal and dorsal. The male ducts converge to join a single male papilla, opening on the ovary, but at some distance of the female papilla (Fig. 21D).

There are no endocarps.

#### Remarks

This description corresponds very well to the specimen described by Michaelsen (1919), in the same region. The main differences with *P. anguinea* consist of larger and isolated individuals of *P. suesana*, more numerous polycarps arranged in double rows and extending posteriorly to the gut.

The other anatomical characters are very similar in both species.

The material from the Red Sea confirms Michaelsen's observations of his single specimen and justifies placing it within this species.

#### *CNEMIDOCARPA CONCHA* SP. NOV. (Fig. 22)

Part of *Cnemidocarpa hemprichi*: Michaelsen, 1919: 76, pl. 1, fig. 9.

#### Material

Syntypes: MNHN S1 CNE 189, Yemen: Socotra Island, coll. C. Monniot (1997).

Other material examined: Djibouti, coll. F. Jousseume & H. Coutière, 1897. Gulf of Suez, coll. R. Ph. Dollfus, 1929.

#### Description

The largest of nine specimens is 9 cm in length. The body is pear-shaped, the anterior part narrower than the posterior part that contains the digestive tract. The cloacal siphon opens in the middle of the dorsal side. The tunic is very hard, thick, of a brownish red colour, with large longitudinal swellings. There are few epibionts.

In formalin the body wall is pale in colour except for the siphonal rim which is darker. Its tissue is opaque and thick. The oral siphon is short. About 30 oral tentacles are irregularly distributed, in two orders of size.

The prepharyngeal band has two blades, the posterior one higher. The dorsal tubercle is large and occupies a large part of the deep V drawn by the prepharyngeal band. The aperture is convoluted.

The four branchial folds on each side lie well apart from each other. An average of 30 longitudinal vessels were counted on the folds and ten between the folds. Between the folds there are six stigmata per mesh, cut by a parastigmatic vessel. The branchial sac extends posteriorly to the oesophageal opening. The dorsal lamina is a blade of equal height along its length. The endostyle is wide, curved along the posterior part of the branchial sac. Its edges fuse a little before the oesophagus entrance. Then it forms a closed appendix, coiled like a snail, protruding into the cloacal cavity against the oesophagus (Fig. 22C).

The gut occupies the posterior quarter of the body, in a double loop (Fig. 22A). The stomach is spindle-like, passing evenly into a narrower intestine that remains cylindrical along its whole length. There is no caecum. When the intestine reaches the oesophagus level, it curves in a rather long narrow loop (Fig. 22A). The lobed anus is close to the cloacal aperture (Fig. 22A).

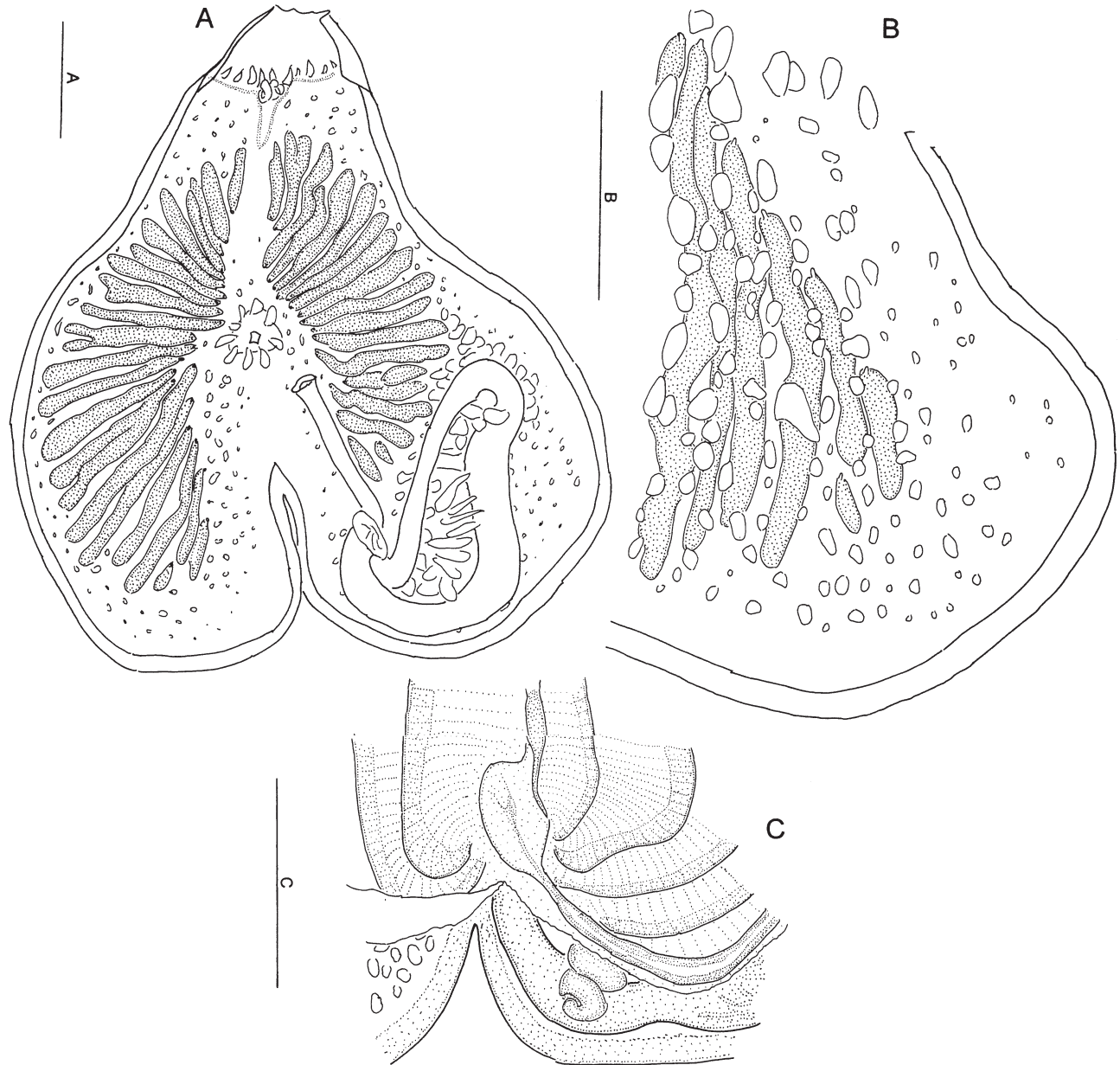
The gonads are elongated, straight, parallel, and very numerous (Fig. 22A,B). Few of them are ramified. The genital openings, at the apex of each gonad, are aligned along a wide curve around the cloacal aperture (Fig. 22A). The gonads are included within the opaque internal layer of the body wall.

Numerous endocarps are distributed over the whole internal side of the body wall, both among the gonads and in the gut loop (Fig. 22A,B). They are transparent vesicles of irregular shapes.

#### Remarks

This species differs from all described *Cnemidocarpa* species by its voluminous snail-like coiled postendostylar appendix. An uncoiled endostylar appendix of equivalent structure occurs in *Ciona intestinalis* (MacDonald, 1859; Roule, 1884; Millar, 1953; Hoshino & Tokioka, 1967). This kind of structure has only been mentioned by Michaelsen (1919) in *Cnemidocarpa hemprichi* Hartmeyer, 1916. I think that Michaelsen (1919) assembled under this name several similar species. Among them the largest specimens, with numerous radiating gonads, belong to the new species *C. concha*.

*Cnemidocarpa concha* differs from *C. hemprichi* by the large size of its specimens, its very thick body wall,



**Figure 22.** *Cnemidocarpa concha* sp. nov.: A, large specimen ventrally opened, all endocarps not figured. B, detail of the posterior part of the right side with gonads and endocarps. C, oesophagus entrance and postendostylar appendix. Scale bars = 1 cm.

and the convoluted aperture of its dorsal tubercle. The branchial sac, which has many more longitudinal vessels on and between the folds, may be taken to have the same structure, taking in account the larger size of the *C. concha* specimens. In *C. concha* the gonads are more numerous than in *C. hemprichi*, they are in long tubes, and regularly arranged with their genital papillae on a circle.

The geographical distribution of *C. concha* covers the Red Sea from Suez to Djibouti and extends to Socotra Island.

#### *Etymology*

From the Latin, *concha* = shell, to refer to the snail-like postendostylar appendix of this species.

*CNEMIDOCARPA HEMPRICHI* HARTMEYER, 1916  
(Fig. 23)

*Cnemidocarpa hemprichi* Hartmeyer, 1916: 218, figs 6,7 – Red Sea.

Not *Cnemidocarpa hemprichi*: Michaelsen, 1919: 76; not Monniot C., 1973: 51, fig. 1 = *Cnemidocarpa schumacheri* sp. nov.

*Cnemidocarpa madagascariensis* Hartmeyer, 1916: 222, figs 8,9 – Madagascar; Vasseur, 1967: 116, pl. 5, figs 41–43 – Mauritius.

*Material*

Yemen: Socotra Island, 1 specimen, coll. C. Monniot, 1997.

*Description*

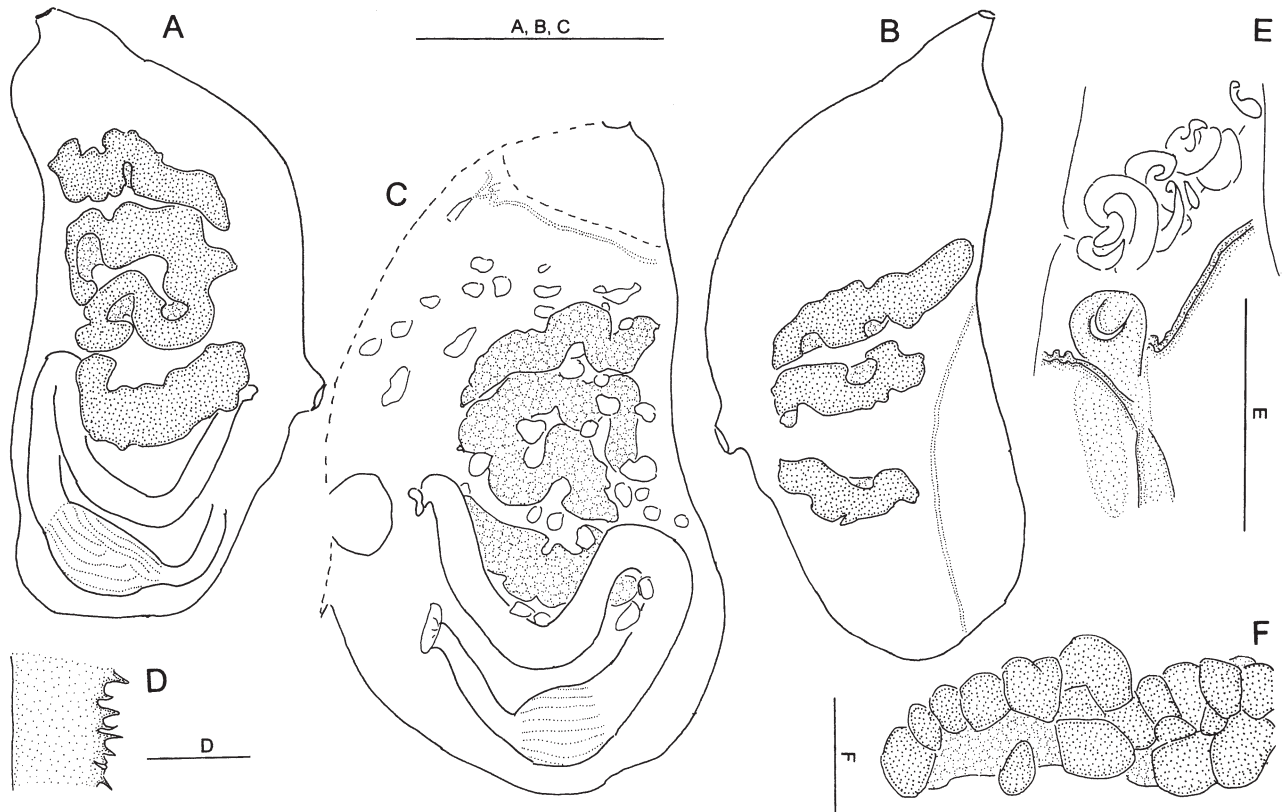
The specimen measures 3 cm in length. The tunic is thin, soft but resistant, with a wrinkled surface without epibionts. The internal anatomy corresponds exactly to Hartmeyer's description. The oral tentacles are numerous, in three orders of size. The dorsal tubercle opens in a C-shaped slit (Fig. 23E). The dorsal

lamina is high with a denticulate edge (Fig. 23D). The four folds on each side of the branchial sac are clearly separated. The branchial formula on the right side is:

DL 4 (16) 5 (16) 5 (15) 5 (10) 4 E

The gut is long and occupies the posterior third of the left side of the body (Fig. 23A,C). The primary loop is closed, and the secondary loop accentuated with a long rectum. The anus opens close to the cloacal aperture. The elongated stomach is not well defined; it has inconspicuous internal folds. The gonads are elongated and sinuous (Fig. 23A–C). There are three gonads on the right side (Fig. 23B), and three gonads on the left side; but on the left side the median one comprises two lobes distally united in a common oviduct, giving the appearance of four gonads there (Fig. 23A,C). Each gonad has a central ovary protruding into the cloacal cavity and placed atop the testis (Fig. 23F). The short oviducts are directed toward the cloacal siphon.

Numerous endocarps are distributed over the body wall, both among the gonads and in the primary gut loop.



**Figure 23.** *Cnemidocarpa hemprichi*: A,B external view of the left and right sides of the body. C, internal view of the left side. D, part of the dorsal lamina. E, dorsal tubercle. F, apex of a gonad showing the testis vesicles. Scale bars: A,B,C = 1 cm, D = 1 mm, E, F = 2 mm.

*Remarks*

The *Cnemidocarpa* specimen collected at Socotra has many characters in common with those other species of this genus that have more numerous gonads. Michaelsen (1919) gathered under the name *C. hemprichi* numerous specimens constituting, in his opinion, a continuous series of variable specimens. The examination of new material from Socotra and the Red Sea shows different sizes and different anatomical characters permitting its separation into several species.

*Cnemidocarpa madagascariensis* Hartmeyer, 1916 was described from a single specimen of small size, with four gonads on the right side and five on the left side. The specimen, as well as that described by Vasseur (1967), certainly belongs to *C. hemprichi*.

*CNEMIDOCARPA IRENE* (HARTMEYER, 1906)

*Styela irene* Hartmeyer, 1906 – Japan.

*Cnemidocarpa irene*: Monniot C. & Monniot F., 1994 – Cape Verde; Nishikawa, 1991: 96 – Japan and synonymy; Kott, 1998: 204 – Australia and synonymy.

*Material*

Mozambique: Ibo Island, coll. C. Monniot, 1995.

This species is widely distributed in the Pacific Ocean and is also present in the Atlantic in the Antilles and Cape Verde. It was recorded in the Indian Ocean at Sri Lanka by Herdman (1906: 316) under the name *Styela areolata* Heller, 1878, as Nishikawa concluded in 1991. The presence of *C. irene* at Ibo confirms its occurrence in the Indian Ocean.

*CNEMIDOCARPA MARGARITIFERA* MICHAELSEN, 1919 (Fig. 24)

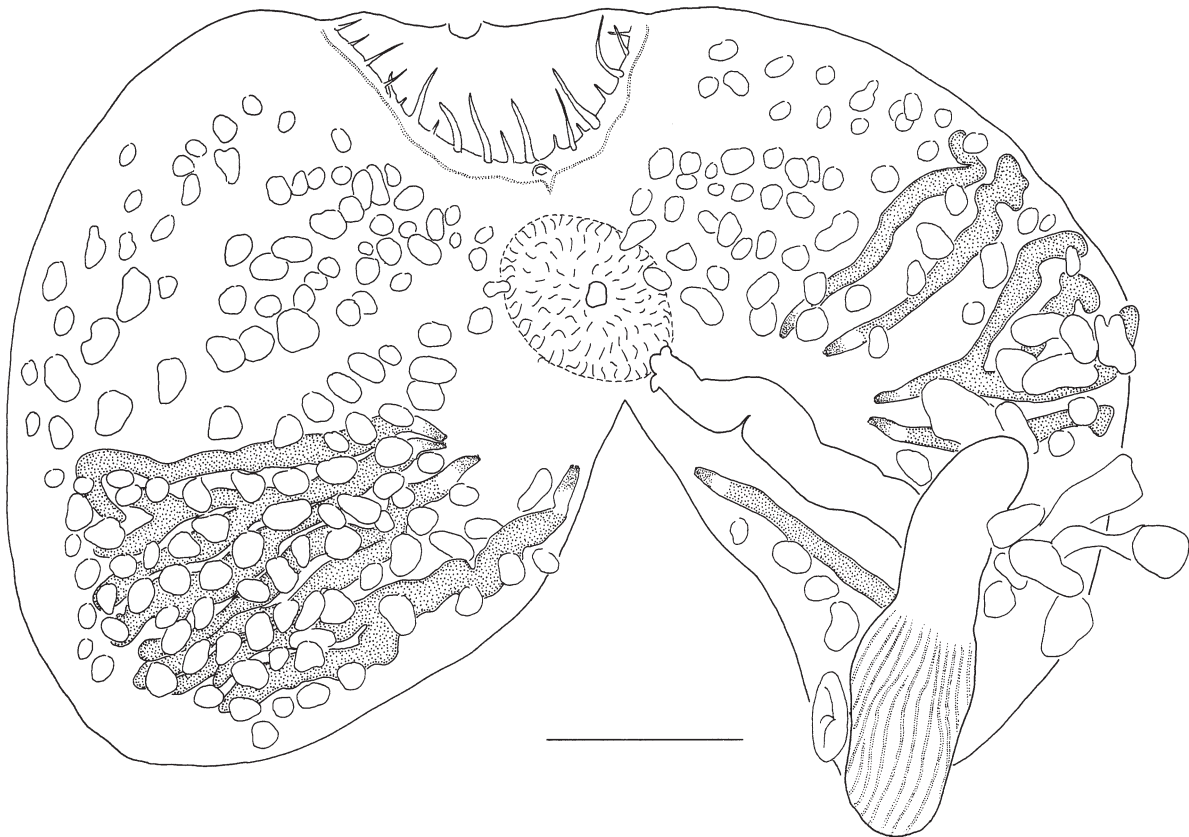
*Cnemidocarpa margaritifera* Michaelsen, 1919: 67, pl. 1, figs 17,18, t. fig. 10 – Red Sea; Monniot C., 1973: 53: fig. 2 – Red Sea.

*Material*

Mozambique: Ibo Island, coll. C. Monniot, 1995.

*Description*

The largest of the erect specimens is 2.5 cm in length. The beige tunic is resistant. There are red patches on



**Figure 24.** *Cnemidocarpa margaritifera*: specimen ventrally opened, branchial sac removed. Scale bar = 5 mm.



the internal side of the siphons. The body wall is opaque and whitish in formalin. About 20 short oral tentacles were counted in three orders of size, well spaced on a high crest (Fig. 24). The prepharyngeal band is a rod-like ridge. The small dorsal tubercle is protruding, with a C-shaped opening. The dorsal lamina is a high blade. A branchial formula on the right side is:

E 6 (14) 5 + 10 (22) 8 (26) 8 (19) 4 + 5 DL

The folds are rounded and low with closely packed longitudinal vessels. The first vessel is parallel to the dorsal lamina. The digestive tract has an elongated stomach whose wall has thin longitudinal grooves (Fig. 24). Its diameter is not much wider than the intestine. The long rectum ends in a lobed anus.

The gonads are long, and their proximal extremity is often ramified. The genital papillae are red.

The endocarps are numerous on the whole body wall (Fig. 24).

#### Remarks

The Mozambican specimens are the same as those from the Red Sea. The species distribution is now extended to the tropical eastern African region.

#### *CNEMIDOCARPA SCHUMACHERI* SP. NOV. (FIG. 25)

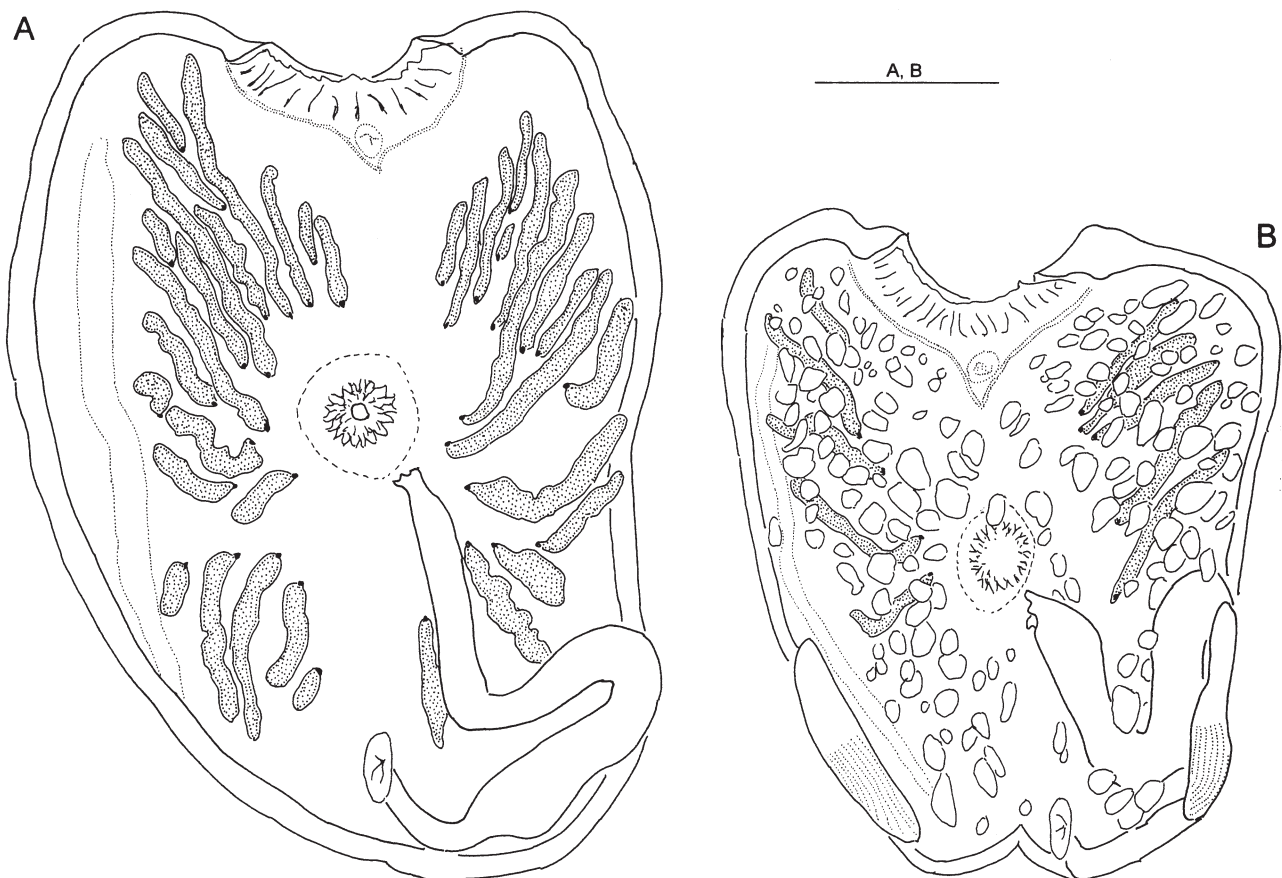
*Cnemidocarpa hemprichi*: Monniot C., 1973: 51, fig. 1 – Eilat.

#### Material

Type: MNHN S1 CNE 11, Eilat coll. H. Schumacher.

Other material examined: Djibouti, 1 specimen, coll. C. Monniot, 1996.

Recent collecting in the Indian Ocean has proved the existence of several Styelidae species that are very similar in their aspect and internal anatomy. Some of these were gathered together by Michaelsen (1919) under the name *Cnemidocarpa hemprichi* Hartmeyer,



**Figure 25.** *Cnemidocarpa schumacheri* sp. nov.: A, specimen from Eilat, endocarps not figured. B, type specimen from Djibouti. Scale bars: A, B = 5 mm.

1916. Michaelsen put together specimens of very different sizes and a variable number of polycarps, and he did not mention the placement of the genital papillae. This combination of circumstances has prompted us to look especially closely at the new material and in consequence to isolate several species.

#### Description

The description of *C. hemprichi* Hartmeyer, 1916 corresponds to large size ascidians recently collected off Yemen. The much smaller specimen from Djibouti and those described by Monniot (1973) have more numerous, elongated gonads (Fig. 25A,B).

A re-examination of the material from Eilat, described in 1973, confirms the previous observations: many very elongated parallel polycarps arranged in a row on each side of the body and each opening by an apical papilla dorsally (Fig. 25A). The specimen from Djibouti has the same external shape as those from the Red Sea. Its body is 2 cm long and was attached by its whole ventral side. The tunic is hard, wrinkled, and thick. The short siphons stand well apart. The body wall is thick and opaque. There is a large oral velum. The oral tentacles, very unequal in length, are distributed in four orders. The C-shaped dorsal tubercle occupies the whole peri-tubercular area. The dorsal lamina is long and low. The wide endostyle is fused to the body wall. Numerous dermatobranchial bridges unite the branchial sac to the polycarps. On each side, there are four low branchial folds, each with a wide base, not well delimited from the remainder of the branchial tissue. Each fold carries a dozen longitudinal vessels. There are two to three vessels between the folds.

The gut forms a closed primary loop, and then a wide secondary loop (Fig. 25B). The long rectum ends in a gaping anus with a wavy rim. The elongated stomach has longitudinal internal folds, only visible when its wall is cut.

The many polycarps are very long, parallel to each other, and in a row on each side, each with an apical papilla at its dorsal extremity (Fig. 25B). This gonadal structure places the species in the genus *Cnemidocarpa*. Very numerous endocarps protrude over the whole internal side of the body wall, among the gonads and inside the gut loop (Fig. 25B).

At the base of the cloacal siphon, protruding papillae of the body wall are arranged in several circles. Each papilla is topped by a thin filament (Fig. 25A,B).

The only difference between this specimen from Djibouti and those from Eilat is the smaller number of gonads in them.

#### Etymology

This new species is dedicated to Dr H. Schumacher.

#### *STYELA CANOPUS* (SAVIGNY, 1816)

##### Material

Mozambique: Ibo Island, Matemo cliff, 10–20 m, coll. C. Monniot, 1995.

Djibouti, northern lagoon and wrecks, coll. C. Monniot, 1996.

Yemen: Socotra Island, coll. C. Monniot, 1997.

This cosmopolitan species is very abundant, both as isolated individuals and in aggregated masses.

#### *STYELA METEORIS* SP.NOV. (Fig. 26)

##### Material

Holotype: MNHN S1 STY 274, Aden, st. 249, 12°29.5'N–45°38.7'E, 1299–1314 m, Meteor cruise, 1987.

##### Description

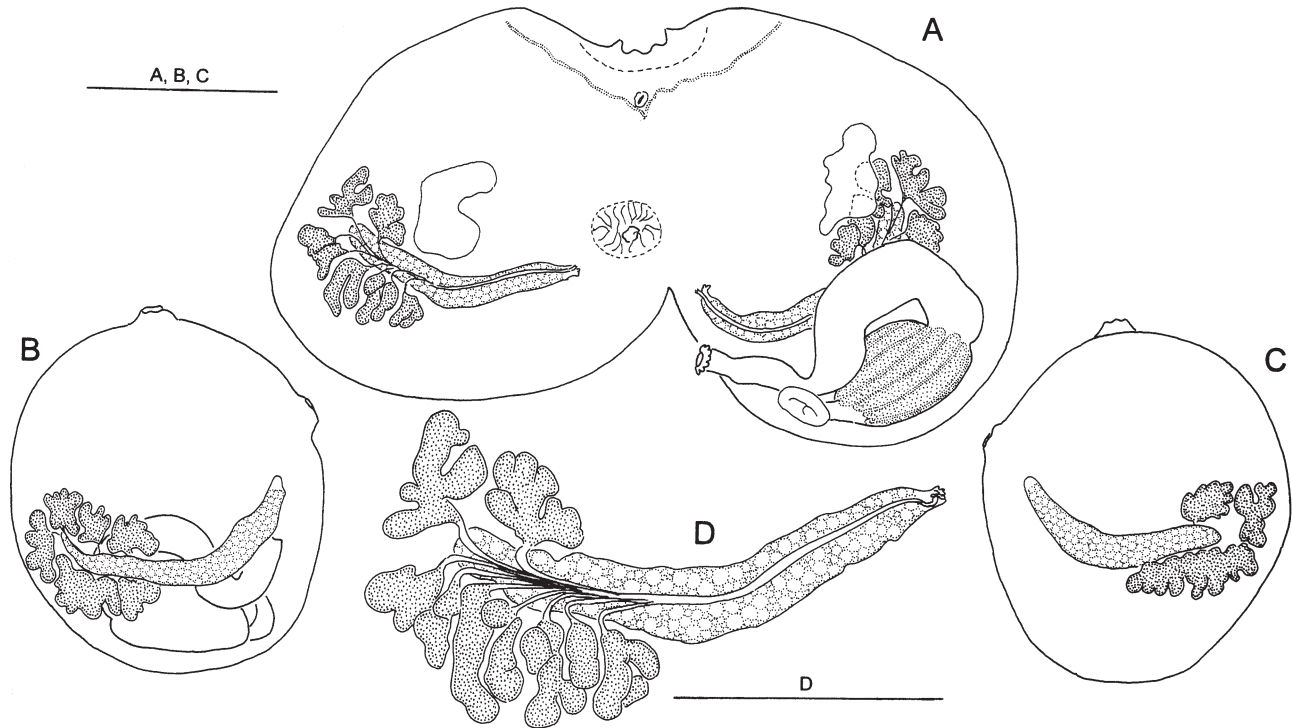
The ovoid body is 7.5 × 6.5 mm across, its naked dorsal side variably lumpy. The sessile siphons are 4 mm apart; they show four flat lobes. Around the equator of the body is a belt of nonramified rhizoids, 3–4 mm long, without adhering sediment. Just anterior to this belt, the tunic is covered with a thin layer of mud. On the ventral side of the specimen the rhizoids are shorter and fewer. The tunic itself is thin and transparent.

The body wall musculature is made of strong bundles, about 30 ribbons at each siphon. Those located near the cloacal aperture are the most developed. The radiating lateral muscles, coming from both siphons, are thinner and anastomosed. Between the siphons the muscular fibres are not gathered in bundles but rather make a network. There are no transverse fibres on the ventral side of the body.

The oral tentacles are planted at the base of a short velum, very anteriorly in the siphon. Twenty of them in four orders are obviously curved. The prepharyngeal band has two very close equal crests, and forms a dorsal V. The button-shaped dorsal tubercle opens by a straight but oblique slit. The neural ganglion is elongated. The dorsal lamina is long with a plain edge, and progressively increases in height to the oesophagus entrance. The branchial tissue is thin, with three folds on each side, but only the two first ones from the dorsal lamina are well formed. The formula is:

RE 4 (4) 8 (8) 10 (12) 1 DL 3 (9) 10 (9) 8 (4) 3 EL

The folds do not converge around the oesophagus entrance but instead end against the retro-pharyngeal line. On each side, fold number one is particularly high. On the left side the first longitudinal vessel is parallel to the dorsal lamina and separated from it by six stigmata. On the right side the first longitudinal



**Figure 26.** *Styela meteoris* sp. nov.: A, specimen ventrally opened. B,C, external view of the left and right sides of the body. D, gonad. Scale bars: A,B,C = 3 mm, D = 2 mm.

vessel diverges from the dorsal lamina; it is separated from it by eight stigmata anteriorly and posteriorly 13 stigmata. The branchial meshes are antero-posteriorly elongated with only 2–3 stigmata between each longitudinal vessel. There are parastigmatic vessels.

The gut makes a closed loop (Fig. 26A). It is linked to the body wall only by thin strips of tissue. In an unopened body, viewed from the exterior, the gut seems to cross the gonad (Fig. 26B). The stomach is obviously widened, with a dozen accentuated folds and a small finger-like caecum. The intestine is covered with a well-developed pyloric gland. The lobed anus is not linked to the dorsal lamina.

There is one long gonad on each side (Fig. 26A–C). The ovary is slightly curved (Fig. 26D). The testis lobes are grouped around the apical end of the ovary (Fig. 26D). The sperm ducts converge one third of the way down the ovary length to form a common sperm duct full of spermatozooids (Fig. 26D). The small male papilla protrudes above the short oviduct.

There is only one large endocarp on each side, anterior to the gonad (Fig. 26A).

The cloacal tentacles are long and thread-like.

#### Remarks

The bathyal and abyssal Styelidae are diversified, with about 20 species. These species differ in their branchial structure, and the number and disposition of their gonads and endocarps. Four species from the Indian Ocean share common characters with *Styela meteoris*:

*S. ordinaria* Monniot C. & Monniot F., 1985a from the south of the Indian Ocean has similar gonads but longer genital ducts. It has in common a single endocarp anterior to each gonad. *S. ordinaria* is entirely covered with rhizoids, has no branchial folds, and has an open gut loop, eight stomach folds, and a hooked caecum.

*S. longiducta* Monniot C. & Monniot F., 1985b; collected near the Comores and Reunion Islands, has similar muscles, a branchial sac with two obvious folds and a third fold poorly developed, and only one endocarp on each side. The gonads have only two distal testis lobes on a short ovary; the gonoducts are longer than the whole gonad length.

*S. charcoti* Monniot C. & Monniot F., 1973 has only one or two branchial folds, a stomach with five to six folds, and a large, curved caecum ending in an

ampulla. There are one or two endocarps on the right and one on the left side.

*S. gagetyleri* Young & Vazquez, 1997 has a single branchial fold on each side, 18 folds on the stomach, and numerous endocarps.

#### Etymology

This species is named after the oceanographic vessel 'Meteor'.

#### *STYELA PLICATA* (LESUEUR, 1823)

*Ascidia plicata* Lesueur, 1823: 5, pl. 3, fig. 13.

Synonymy: see Kott, 1985: 116.

#### Material

Suez Gulf, coll. R.Ph. Dollfus, 1927

This cosmopolitan species inhabits all temperate and warm seas; it is often recorded as a fouling species.

#### FAMILY PYURIDAE HARTMEYER, 1908

*PYURA GANGLION* (SAVIGNY, 1816) (Figs 14D, 27A)

*Cynthia ganglion* Savigny, 1816: 90–147 – Red Sea.

*Halocynthia ganglion*: Sluiter, 1905: 15 – Djibouti.

*Pyura ganglion*: Monniot C., 1973: 57 – Red Sea; Monniot F. & Monniot C., 2001: 344, figs 106, 108A and 130B.

*Pyura (Halocynthia) sansibarica* Michaelsen, 1908: 251 – Zanzibar.

*Pyura sansibarica*: Michaelsen, 1918: 8 – Red Sea; Millar, 1956 – Mozambique; Vasseur, 1969: 926 – Madagascar.

*Pyura obesa* not Sluiter, 1912; Hartmeyer, 1919: 14 – Western Australia; Kott, 1985: 315 – Australia.

*Pyura robusta* Hartmeyer, 1922; Kott, 1998: 185 and synonymy – Australia.

*Pyura albanyensis* Michaelsen, 1927: 193 – Albany; Hartmeyer & Michaelsen, 1928: 435; Monniot C., 1989: 490 – New Caledonia and synonymy; Monniot C. & Monniot F., 1991: 441 – New Caledonia; Monniot F. & Monniot C., 1996: 263 – Papua New Guinea; Kott, 1992: 645 – Australia.

#### Material

Red Sea, Eilat, coll. ISRSE, 1962.

Mozambique: Ibo Island, coll. C. Monniot, 1995.

Djibouti, 3–35 m, coll. C. Monniot, 1996.

#### Description

The mature specimens measure 1.5 cm to 6.5 cm across. They are attached by their ventral side. The

largest have epibionts. The thick tunic is reddish-brown, with deep ridges. The youngest specimens have lower protuberances that are more regularly spaced on the sides of the body, and they show double brown lines between the four pale lobes of the siphons (Fig. 14D). The sessile siphons are well apart with obvious spinules. The spinules are dense, about 100 µm in length (Fig. 27A).

The internal anatomy corresponds to the descriptions by Monniot (1973) and Monniot & Monniot (1996). The oral tentacles have few ramifications. The prepharyngeal band has two thick crests. The round dorsal tubercle opens in a C. The branchial sac has six high folds on each side, each with 25 longitudinal vessels, and each fold is separated by three to five vessels. There are parastigmatic vessels.

The gut does not widen much at the stomach. The hepatic gland is made of several lobes. One of the lobes, on the pyloric stomach wall is particularly voluminous, in the shape of a cauliflower, with a green colour that remains in formalin. The gaping anus has a plain edge.

There is one gonad on each side, made of numerous lobes. The left gonad lies in the gut loop.

Endocarps are present above the gonads, along the outer curve of the intestine, and on each side of the heart.

#### Remarks

This species is widely distributed in the Pacific and Indian Oceans. Among *Pyura* species with six branchial folds, it is characterized by the disposition of the endocarps and by its siphonal spinules. Its recent collection in the Indian Ocean allows a diverse synonymy to be established here.

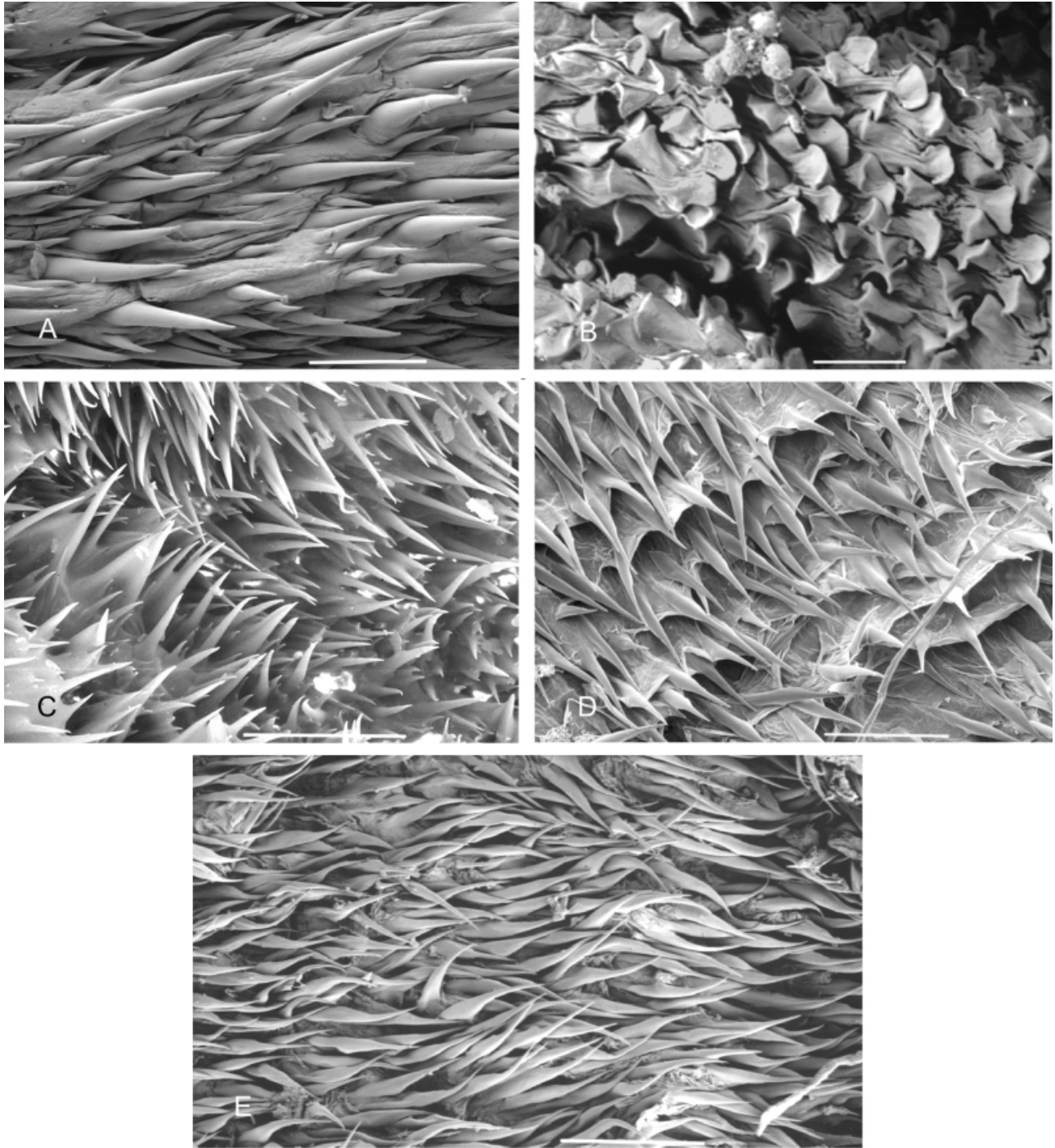
#### *PYURA MOZAMBICA* SP. NOV. (Fig. 28)

#### Material

Holotype: MNHN S2 PYU 402, tunic, body on microscope slides S2643–644, Mozambique: Ibo Island, coll. C. Monniot, 1995.

#### Description

The single specimen is spherical, 12 mm in diameter. The tunic is red, hard and thick. Its surface is irregularly corrugated, with bumps that are more defined around the siphons. The siphons are sessile. The thin body wall reveals the internal organs in transparency. The musculature comprises strong sphincters at the siphons and radiating ribbons, strong and regularly spaced at their origin and dividing down the sides of the body into thinner fibres that reach the medio-ventral line.



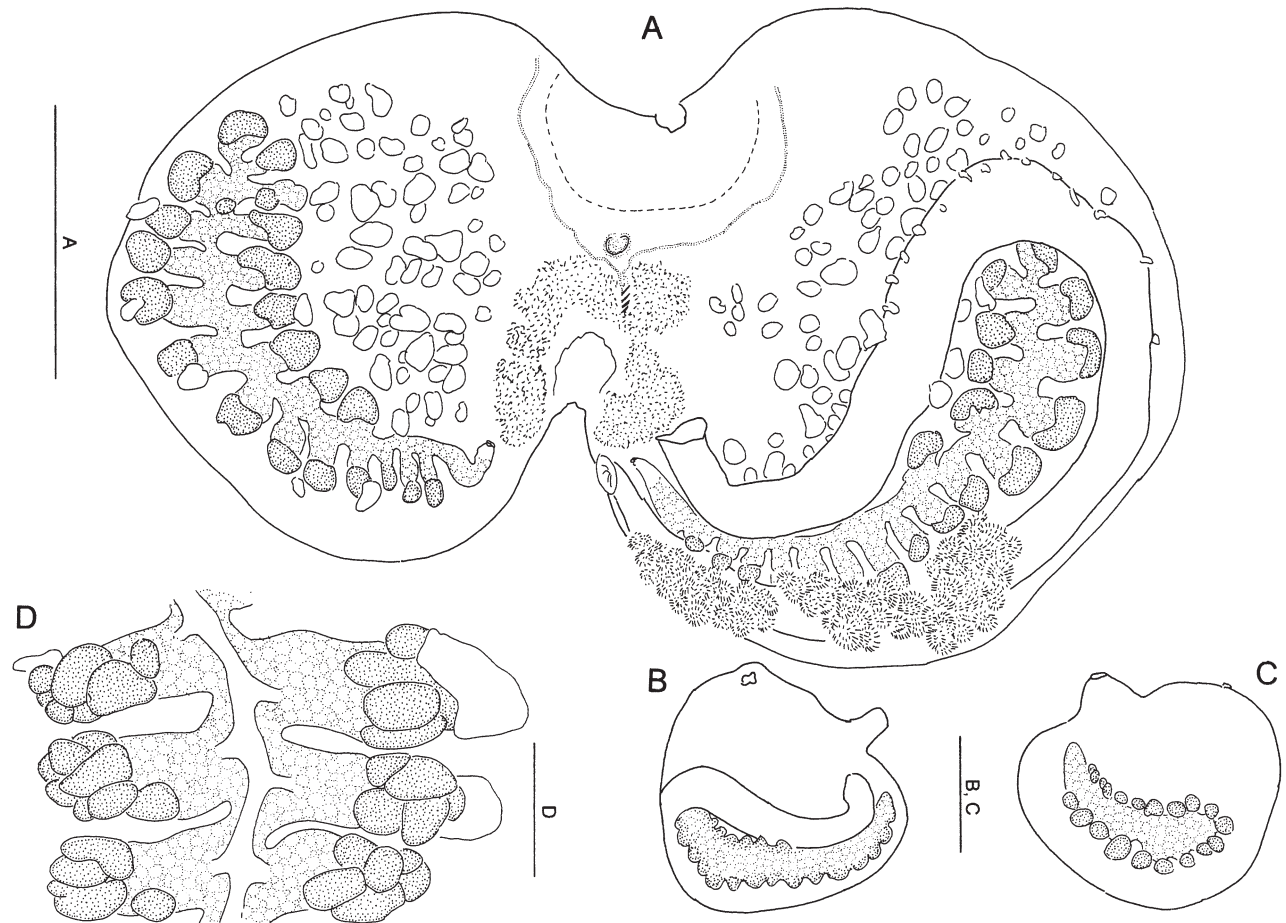
**Figure 27.** Siphonal spinules: A, *Pyura gangelion*; B, *Pyura scortea*; C, *Pyura tongae*; D, *Microcosmus madagascariensis*; E, *Microcosmus pupa*. Scale bars: A,C,D,E = 100  $\mu\text{m}$ , B = 20  $\mu\text{m}$ .

There are a dozen long oral tentacles with only short first order ramifications, intercalated with some much shorter tentacles with lateral buttons, and between them one or two orders of very small tentacles that are not ramified. The prepharyngeal band has two equal

rims. It curves in a dorsal V and extends as a groove at the start of the dorsal lamina.

The dorsal tubercle, flat and discoid, opens anteriorly in a C (Fig. 28A).

The branchial sac has six high, wide folds on each



**Figure 28.** *Pyura mozambica* sp. nov.: A, body ventrally opened. B,C, both sides of the body, the tunic removed. D, part of a gonad. Scale bars: A,B,C = 5 mm, D = 1 mm.

side, each with 13–15 longitudinal vessels; the folds are separated from each other by two vessels. The folds are not well delimited. There are parastigmatic vessels. The dorsal lamina is made of long densely-packed languets.

The digestive tract makes a wide loop on most of the left side of the body (Fig. 28A). The hepatic gland is divided into several lobes along half of the ascending limb of the gut (Fig. 28A). The anus is gaping with a smooth rim that is not rolled.

There is a voluminous gonad on each side (Fig. 28B,C), the left one totally included in the gut loop (Fig. 28A). The right gonad is ventral, parallel to the endostyle. In each gonad, the ovary is made of regularly spaced lobes perpendicular to a straight axial part. On the top of each ovarian lobe a few testis vesicles make a cap (Fig. 28D). Each testicular element produces a duct joining a common sperm duct that runs along the surface of the ovarian axis. Male and female papillae are united.

The internal layer of the body wall is covered with numerous, more-or-less elongated endocarps, as well as with the gonads and gut (Fig. 28A).

The cloacal siphon's internal opening is surrounded by a network of large ramified tentacles.

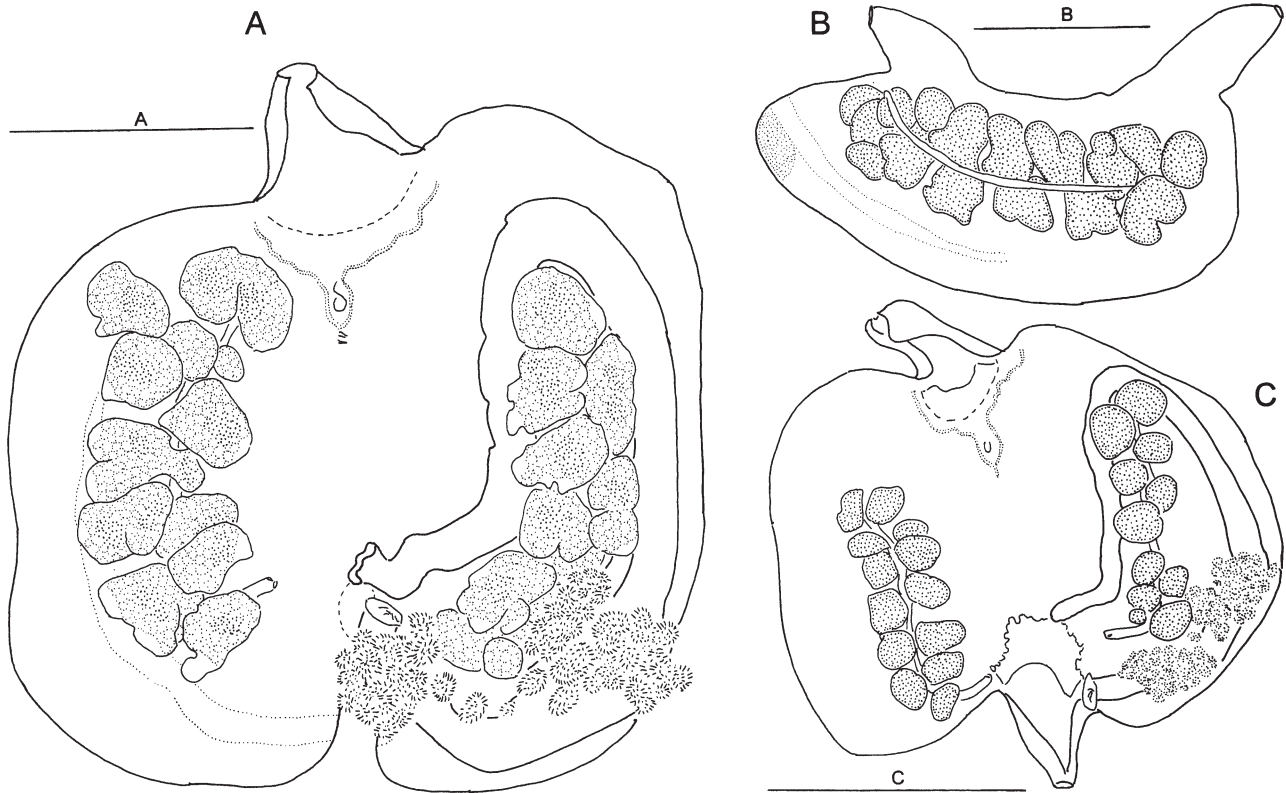
This new species differs from congeners mainly by the large number of its endocarps and the very large and branched cloacal tentacles.

#### *Etymology*

The species name refers to the geographical origin of the species.

#### *PYURA SCORTEA* KOTT, 1985 (Figs 27B,29)

*Pyura scortea* Kott, 1985: 324, fig. 159 – Western Australia; not Monniot C., 1989: 487 – New Caledonia.



**Figure 29.** *Pyura scortea*: A, specimen from the Seychelles ventrally opened. B, right side of the body. C, specimen from Djibouti. Scale bars = 1 cm.

#### Material

Seychelles: Mahé, anse à la Mouche.

Mozambique: Ibo Island, coll. C. Monniot, 1995.

Djibouti, coll. C. Monniot, 1996.

#### Description

The body lies in a thick, hard tunic that is corrugated at the surface. The body shape varies according to the substrate; the animal is fixed by its ventral side. The specimen collected in the Seychelles is 4 cm in diameter, the others are smaller. All have long, red siphons set apart by half the body length. The tunic lining of the siphons remains red in formalin. The siphonal spinules form conical scales with a straight edge (Fig. 27B).

The body wall is thin but contains a strong musculature. Longitudinal fibres coming from the siphons cross each other, and the most dorsal ones fuse. The oral tentacles are slightly branched. The prepharyngeal band forms a deep dorsal V prolonged by a groove. The slit of the round dorsal tubercle is C-shaped, opening anteriorly. The six high folds on each side contain about 20 vessels each. Each longi-

tudinal vessel ends in a papilla at the oesophagus entrance.

The gut forms a long, rather open loop, without a secondary curve (Fig. 29A,C). The anus rim is wavy. The hepatic gland is divided along the stomach into several lobes, resembling a cauliflower (Fig. 29A,C).

The gonads, one on each side, comprise lobes linked by thin ducts to a straight axial gonoduct (Fig. 29A–C). Only the terminal part of the sperm duct and oviduct are curved toward the cloacal aperture; they are narrow and do not contain gametes. The gonads are only loosely connected to the body wall.

There are no endocarps.

The cloacal velum is wide, arising from a scalloped basal membrane.

#### Remarks

The specimens collected in the western Indian Ocean correspond well to Kott's (1985) description. Monniot (1989) identified large specimens from New Caledonia as *P. scortea*. These specimens differ by having endocarps of variable number and size, and a

hepatic gland that forms a single mass. *P. scortea*'s constancy of anatomical characters in the Indian Ocean confirms the holotype description and indicates that the New Caledonian specimens belong to a different species.

*PYURA TONGAEA* MONNIOT C. & MONNIOT F., 1976  
(Figs 27C,30)

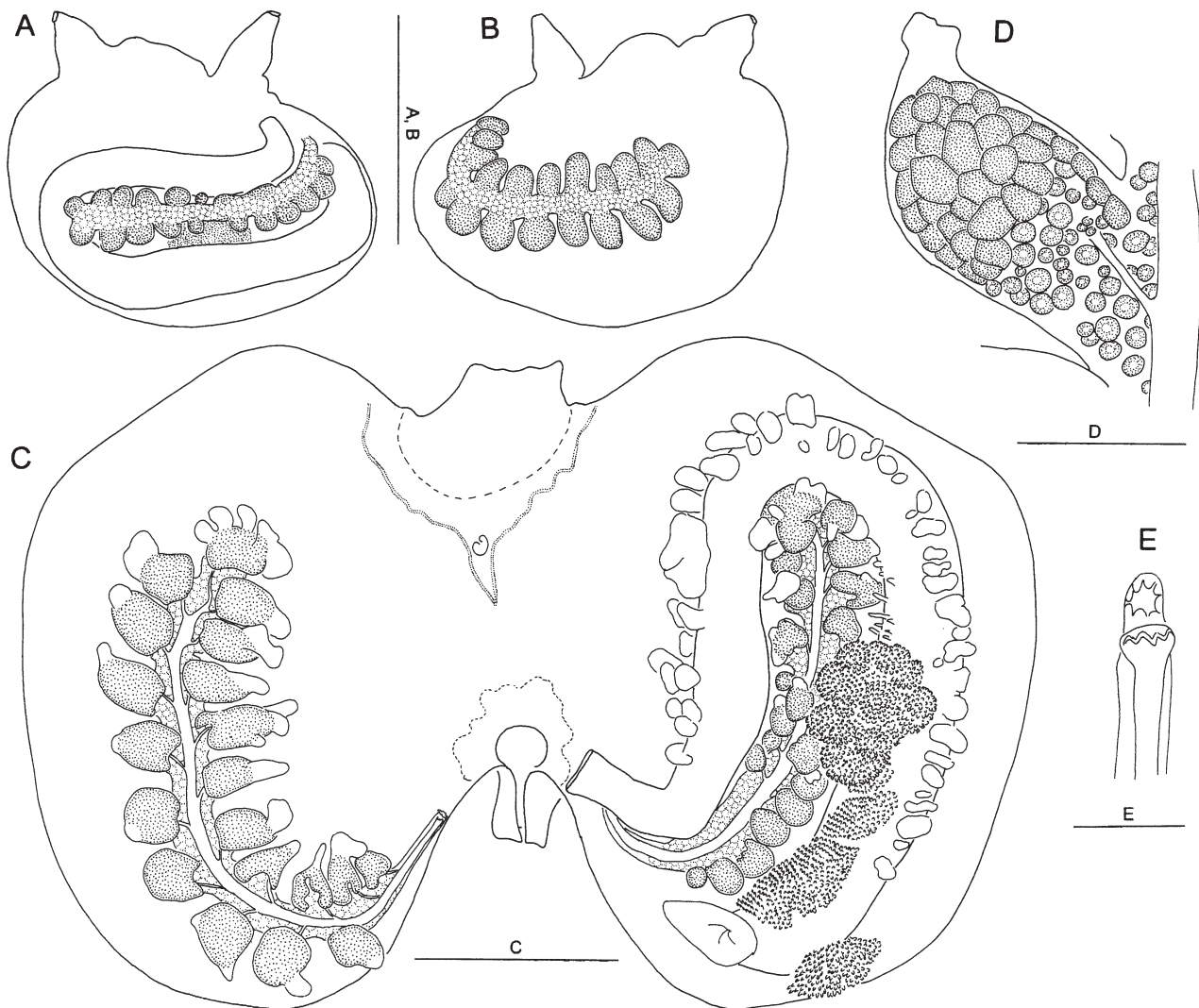
*Pyura tongae* Monniot C. & Monniot F., 1976: 381, fig. 6A – Mozambique; Millar, 1988: 840 – Mozambique.  
*Pyura sansibarica*, not Michaelsen, 1908, Millar, 1956: 929 – Mozambique.

*Material*

Madagascar: Nosy-Be, coll. R. Plante, 1966  
Djibouti, coll. C. Monniot, 1996.

*Description*

The body, 1–2.5 cm in diameter, is covered with sediment. The short siphons have needle-shaped spinules (Fig. 27C). The tunic is about 1 mm thick, embedded with sand except for a thin, soft, internal layer. The body wall is transparent and shows a musculature comprising large fibres, regularly spaced and crossed, that issue from the siphons. The gonads and gut can be seen in transparency.



**Figure 30.** *Pyura tongae*: A,B, both sides of the body. C, body ventrally opened. D, part of the gonad. E, genital papillae. Scale bars: A,B,D = 1 mm, C,E = 0.5 mm.



Both siphons have a large velum.

About 20 oral tentacles are arranged in three orders of size and are twice ramified. The prepharyngeal band has two unequal rims, the anterior one thick and the posterior one a blade. The dorsal tubercle forms a button with a C-shaped opening, that lies in a dorsal indentation. The long dorsal lamina is cut into sharp languets.

The branchial sac has six high folds on each side. 18–20 longitudinal vessels were counted on the folds and 3–4 vessels between the folds. These vessels end around the oesophagus entrance in long, sharp papillae. There are parastigmatic vessels.

The oesophagus is very short (Fig. 30C). The hepatic gland presents several very branched lobes along an unobvious stomach. The hepatic lobe located on the pyloric side of the stomach is the most voluminous lobe; it is pedunculated and of a pale colour. The long primary loop of the intestine reaches almost to the anterior limit of the branchial sac (Fig. 30C). The rectum curves in a short secondary loop. The anus is wide open and simple.

The gonads are in the shape of an arc on each side of the body (Fig. 30A–C). The left gonad occupies the intestinal loop (Fig. 30C). The gonads are made of lobes protruding from the body wall and alternating regularly on each side of a wide oviduct (Fig. 30C). Each lobe comprises an ovarian part and an apical testis (Fig. 30D). A common sperm duct lies on the ovarian axis. The genital papillae are close together, opening near the anus (Fig. 30E).

Variably numerous endocarps lie along the outer curve of the intestinal loop (Fig. 30C). They are only at the level of the stomach and rectum in small specimens, but all around the gut in larger animals. Small endocarps are also found on the gonad lobes, but none along the heart.

The cloacal velum is particularly well developed. There are no cloacal tentacles.

#### Remarks

The general organization of this species is very similar to that of *Pyura gangelion* (Savigny, 1816). It differs by having a smaller size, the constant presence of embedded sand in the tunic, and the absence of endocarps on the body wall itself.

*Pyura tongaea* is currently known only from the western tropical Indian Ocean.

*MICROCOSMUS EXASPERATUS* HELLER, 1878 (Fig. 31)

*Microcosmus exasperatus*: Kott, 1985: 348 – Australia, and synonymy; Monniot C., 1983: 1035 – Guadeloupe, 1989: 479, fig. 2, pl. 1 A – New Caledonia.

*Microcosmus pupa* (Savigny, 1816): Monniot, 1973: 58 part, fig. 4A – specimen from Eilat.

#### Material

Suez, coll. R.P.H. Dollfus, 1928.

Gulf of Aden.

Madagascar: Nosy-Be, 27 m, coll. P. Laboute, 1992.

Mozambique: Ibo Island, coll. C. Monniot, 1995.

Yemen: Socotra Island, coll. C. Monniot, 1997.

#### Description

The body shape varies with the substrate. The more-or-less red tunic may be naked or with epibionts; it is always wrinkled. The tunic is not thick but resistant, and has a nacreous lining. The siphons are short.

Despite its strong musculature, the body wall is thin and reveals the internal organs. The muscles form large bundles that issue from the siphons, and regularly cross each other.

The ramified tentacles arise at the base of a large velum. The dorsal tubercle is U-shaped with the anterior horns slightly rolled inwards; it lies in a dorsal V of the prepharyngeal band.

There are eight-to-nine high branchial folds on each side of a smooth edged dorsal lamina. The stigmata are cut by parastigmatic vessels.

The gut makes a closed primary loop (Fig. 31A–D) leading to a dorsally curved intestine that adheres to the dorsal lamina. The anus is smooth-edged.

One gonad lies on each side (Fig. 31A–D), made of three or four massive lobes linked only by the gonoducts. The left gonad crosses the intestine (Fig. 31A–D). Male and female papillae are short and close together and protrude from the body wall.

There are no endocarps on the internal layer of the body wall itself, but sometimes one or two of them lie on the ventral side of the stomach.

Filiform papillae cover a wide field around the base of the cloacal siphon.

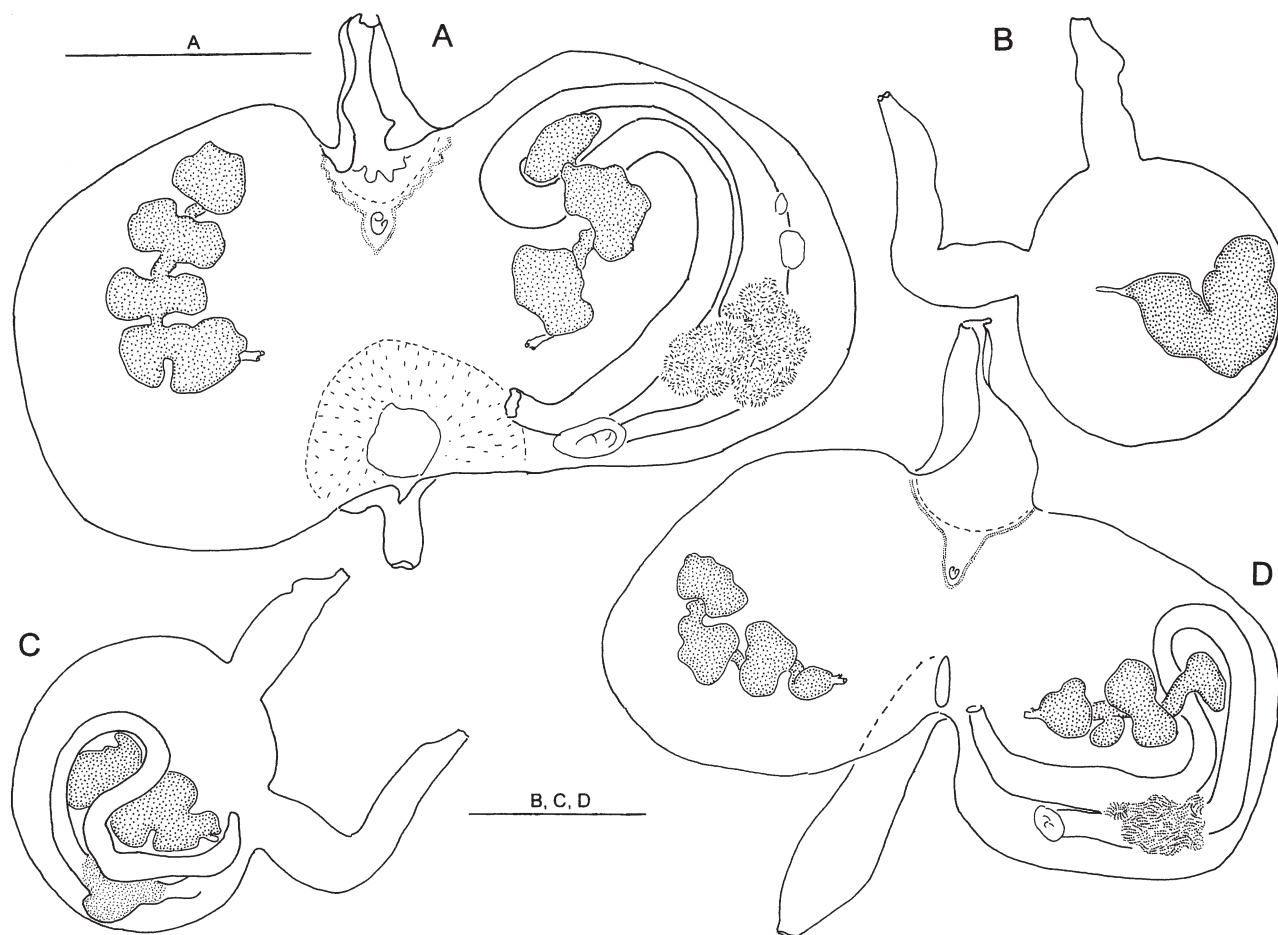
#### Remarks

*Microcosmus exasperatus* is cosmopolitan in warm waters. It differs from *Microcosmus pupa* (Savigny, 1816) by the absence in the former of endocarps and the shape of its gonads, made of lobes in a line.

*MICROCOSMUS MADAGASCARIENSIS* MICHAELSEN, 1918 (Figs 27D,32)

*Microcosmus madagascariensis*, Michaelsen, 1918: 20 – Madagascar, Nosy-Be; Vasseur, 1969, – Madagascar, Tulear.

Not *Microcosmus agglutinans* Hartmeyer, 1919: 26



**Figure 31.** *Microcosmus exasperatus*: A, specimen from Madagascar ventrally opened. B,C,D, specimen from Aden. Scale bars: A = 1 cm, B,C,D = 5 mm.

Not *Microcosmus madagascariensis*: Hartmeyer & Michaelsen, 1928: 398; Kott, 1985: 35.

#### Material

Madagascar, Nosy-Be, coll. R. Plante, 1967.

#### Description

The single specimen is 16 mm in diameter. The tunic is encrusted with coarse sediment and projects some long, hair-like extensions also encrusted with sand. The short siphons diverge at 90°. The siphonal spinules are very sharp spines issued from a wide base (Fig. 27D).

The body wall is rendered opaque by a dense musculature regularly distributed over the whole body. The oral velum is covered with button-like papillae.

Several orders of oral tentacles alternate; the largest tentacles have three orders of branching. The C-shaped dorsal tubercle opens to the left in the

middle of a deep V of the prepharyngeal band (Fig. 32D). The peritubercular area is papillate. The dorsal lamina is smooth.

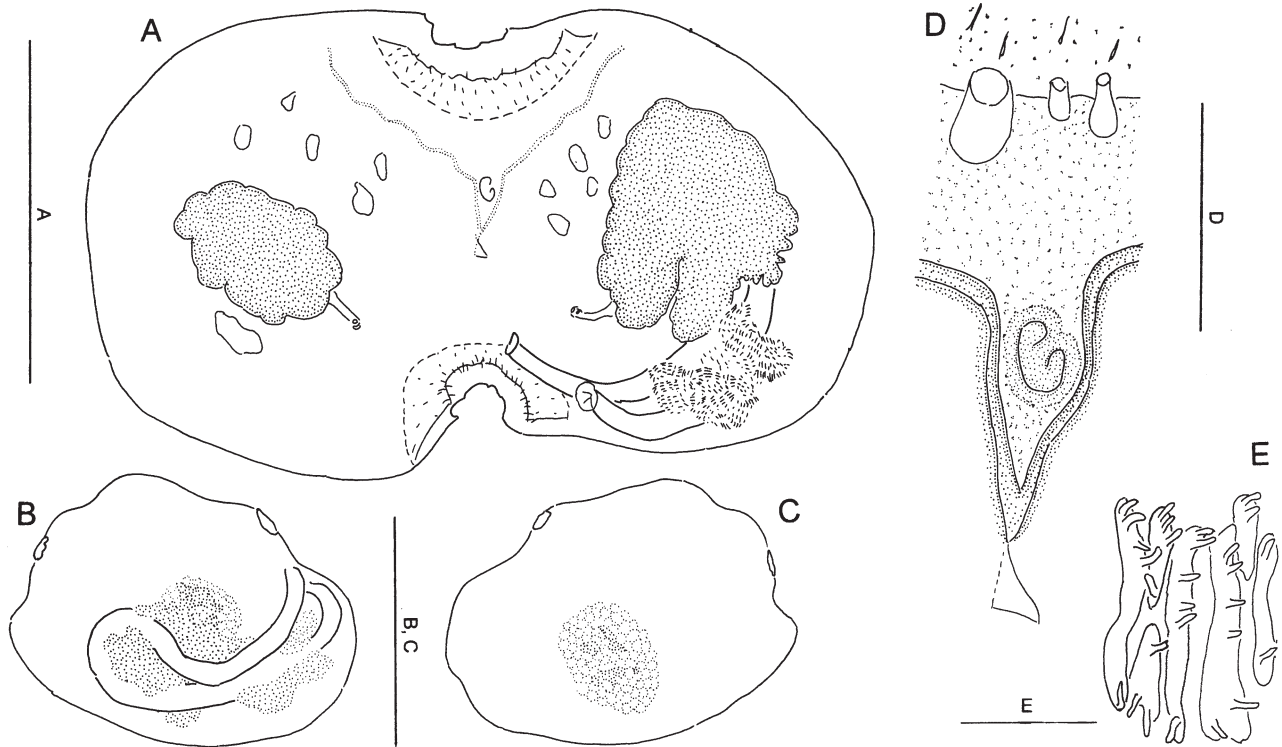
The branchial sac has seven high folds on each side, overlapping each other. The formula is:

RE (3)1(8)2(11)2(13)2(15)2(14)1(14)1 DL  
1(12)1(14)1(15)2(13)2(13)2(9)2(7) EL

Each longitudinal vessel ends in a short papilla. There are parastigmatic vessels.

The gut forms a well-closed loop, with the intestine applied to the stomach and the oesophagus (Fig. 32A). The intestine then curves to fuse with the dorsal lamina. The anus has a smooth rim. The hepatic gland is divided into two lobes (Fig. 32A). Its wall is lamellar, topped with filiform papillae (Fig. 32E).

There is one massive hermaphroditic gonad on each side (Fig. 32A–C). The right gonad has a rounded outline and lies in the middle of the right side (Fig. 32A,C). Its male and female structures are intermixed.



**Figure 32.** *Microcosmus madagascariensis*: A, body ventrally opened. B,C, external view of the left and right sides. D, dorsal tubercle area. E, detail of hepatic papillae. Scale bars: A,B,C = 1 cm, D = 2 mm, E = 0.5 mm

The sperm duct and oviduct are joined up to their openings. The left gonad drapes over the gut, extends inside the gut loop, and spreads widely on the left side of the body (Fig. 32A,B), its gonoducts directed towards the cloacal aperture.

The internal layer of the body wall has some endocarps anteriorly, as well as one posterior to the right gonad and one ventral to the stomach.

The cloacal velum has thin filiform tentacles on its rim.

#### Remarks

This description corresponds closely to previous ones by Michaelsen (1918) and Vasseur (1967) from animals also collected in Madagascar.

#### *MICROCOSMUS PUPA* (SAVIGNY, 1816) (Figs 27E,33)

*Cynthia pupa* Savigny, 1816: 151, pl. 5, fig. 2, – Suez. *Microcosmus pupa*: Michaelsen, 1919: 58, pl. 1, figs 10–12, – Suez; C. Monniot, 1973: 58 part, fig. 4B, – Suez;? Kott, 1985: 356, – Australia, Queensland.

#### Material

Suez Canal, coll. F.D. Por.

#### Description

The maximum size of the numerous specimens collected is 3 cm in diameter. The body is almost spherical, with sessile siphons. The wrinkled surface of the tunic is covered with sediment and epibionts. Its consistency is hard. The siphonal spines are thin and sharp, slightly curved (Fig. 27E).

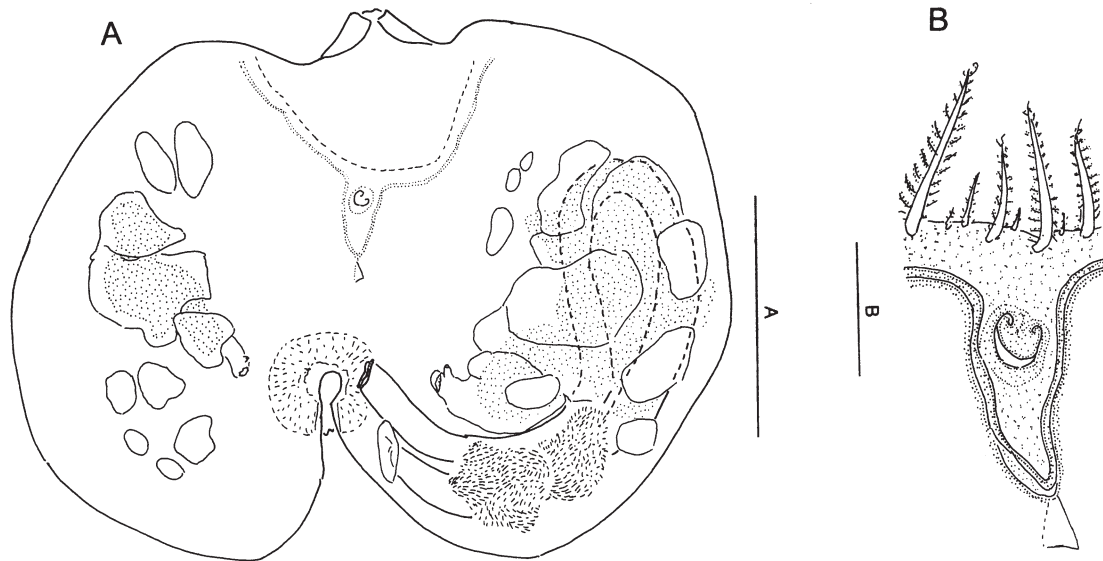
The body wall is made opaque by closely-packed and strong muscular fibres, shown well by Savigny. The tentacles are ramified, in two or three orders of size, arising from the base of a velum that is covered with filiform papillae. The space between the tentacles and the prepharyngeal band is raised into thin papillae. The prepharyngeal band makes a deep and wide V (Fig. 33B). The round dorsal tubercle bulges. The horns of its C-shaped aperture are interiorly rolled. The dorsal lamina has a smooth edge.

The branchial sac has seven high folds on each side. The formula in a 25 mm specimen is:

$$\text{RE } (10)3(12)3(17)3(17)2(17)1(16) \text{ DL} \\ 1(17)1(17)2(18)3(18)1(17)3(15)1(10) \text{ EL}$$

The stigmata are cut by parastigmatic vessels.

The gut forms a closed loop (Fig. 33A). The stomach is covered by the mass of a lamellar hepatic gland bristling with thin papillae. The rectum approaches



**Figure 33.** *Microcosmus pupa*: A, specimen ventrally opened. B, dorsal tubercle area. Scale bars: A = 1 cm, B = 2 mm.

the oesophagus and curves to attach to the dorsal lamina. The anus has a plain edge or sometimes two lobes. There are endocarps on the hepatic gland and on the pyloric side of the stomach.

There is a bulky gonad on each side, of irregular outline. The right gonad lies in the middle of that side of the body (Fig. 33A). The left gonad extends from the bottom of the intestinal loop, covers both intestinal limbs, and continues over the body wall in the middle of the left side (Fig. 33A). The gonoducts are short, and the male and female papillae are joined.

There are endocarps on both gonads, and three or four of them on the body wall on each side of the right gonad (Fig. 33A).

The whole internal layer of the body wall is raised in very thin, crowded papillae. A wide ring of filiform papillae encircles the base of the cloacal siphon.

#### Remarks

This species, very similar to *Microcosmus exasperatus*, differs from it by *M. pupa*'s massive gonads, and by the presence in it of endocarps on the body wall on the right side.

#### *MICROCOSMUS SQUAMIGER* MICHAELSEN, 1927

*Microcosmus squamiger* Michaelsen, 1927: 197 – Western Australia and Red Sea.

*Microcosmus squamiger*: Monniot *et al.* 2001: 109, figs 50C,D, 51DE – South Africa.

#### Material

Mozambique, Ibo Island, 10 m, coll. C. Monniot, 1995

This cosmopolitan species was already recorded from the Mediterranean Sea, the western Indian Ocean down to South Africa, and Australia. It is widely distributed in warm and temperate waters.

#### *HALOCYNTHIA SPINOSA* SLUITER, 1905

*Halocynthia spinosa* Sluiter, 1905: 16, pl. 2, fig. 8.

Synonymy: see Monniot *et al.*, 2001: 116, figs 55C,F, 56 – South Africa.

#### Material

Israel.

Mozambique, Ibo Island, coll. C. Monniot, 1995.

Djibouti, coll. C. Monniot, 1996.

Yemen, Socotra Island, coll. C. Monniot, 1997.

This species is widely distributed from the north to the south in the Indian Ocean.

#### *HERDMANIA COUTIERI* SP. NOV. (Figs 34,35A,B)

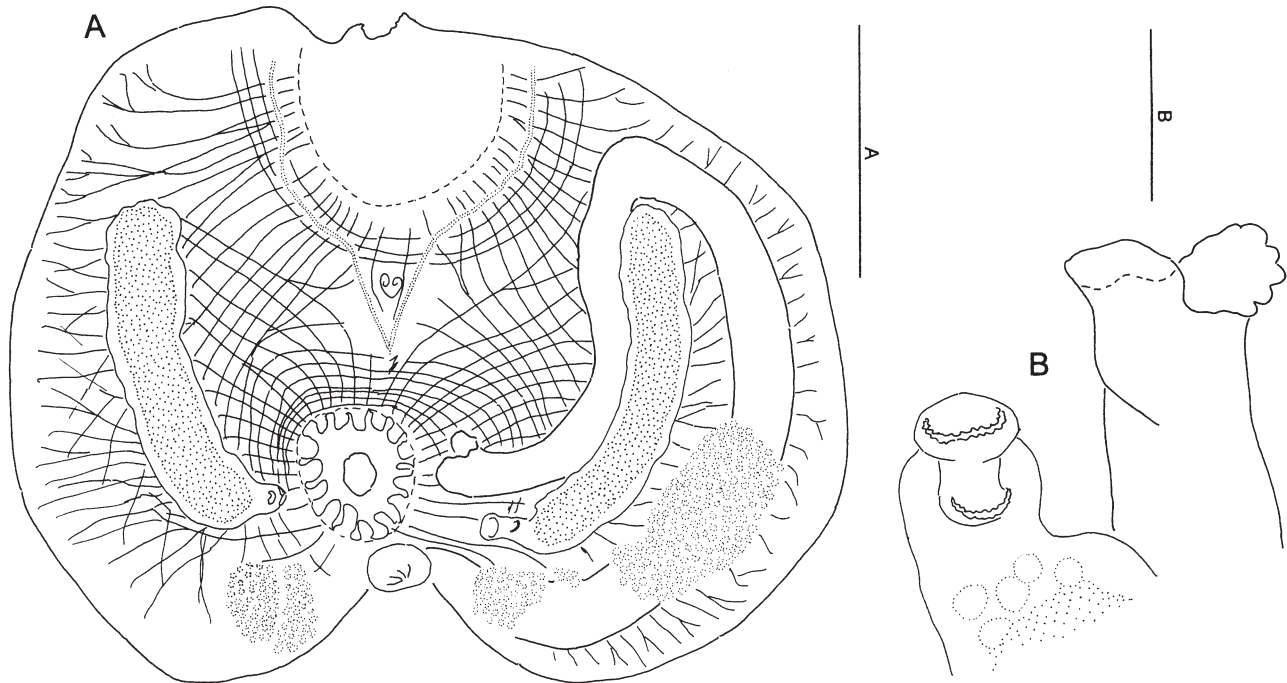
#### Material

Holotype: MNHN S2 HER 8, Bahrain, 5 m, coll. CRRF, 1994.

Other material examined: Djibouti, coll. H. Coutière, 1897.

Red Sea: coll. ISRSE, 1962.

Mozambique: Ibo Island, coll. C. Monniot, 1995.



**Figure 34.** *Herdmania coutieri* sp. nov.: A, specimen ventrally opened. B, anus and genital papillae. Scale bars A = 1 cm, B = 2 mm.

#### Description

The specimens measure 17–35 mm in diameter. The surface of the thick tunic is irregularly wrinkled and bumpy, and carries epibionts and sediment. The very short siphons make a 90° angle. The spicules (Fig. 35A,B) are slightly curved. The tunic is hard but flexible, with a nacreous interior surface. Removed from the tunic, the body is opaque. The musculature covers the whole body. It comprises strong sphincters circling each siphon and radiating bundles reaching the ventral line on each side. In addition, thin fibres make a network.

The oral tentacles have three orders of long, dense branchings. The prepharyngeal band is remarkable for its wide and deep V, in the middle of which lies a flat dorsal tubercle. The dorsal tubercle aperture is C-shaped, opened slightly on the right side and with horns that are slightly curved in.

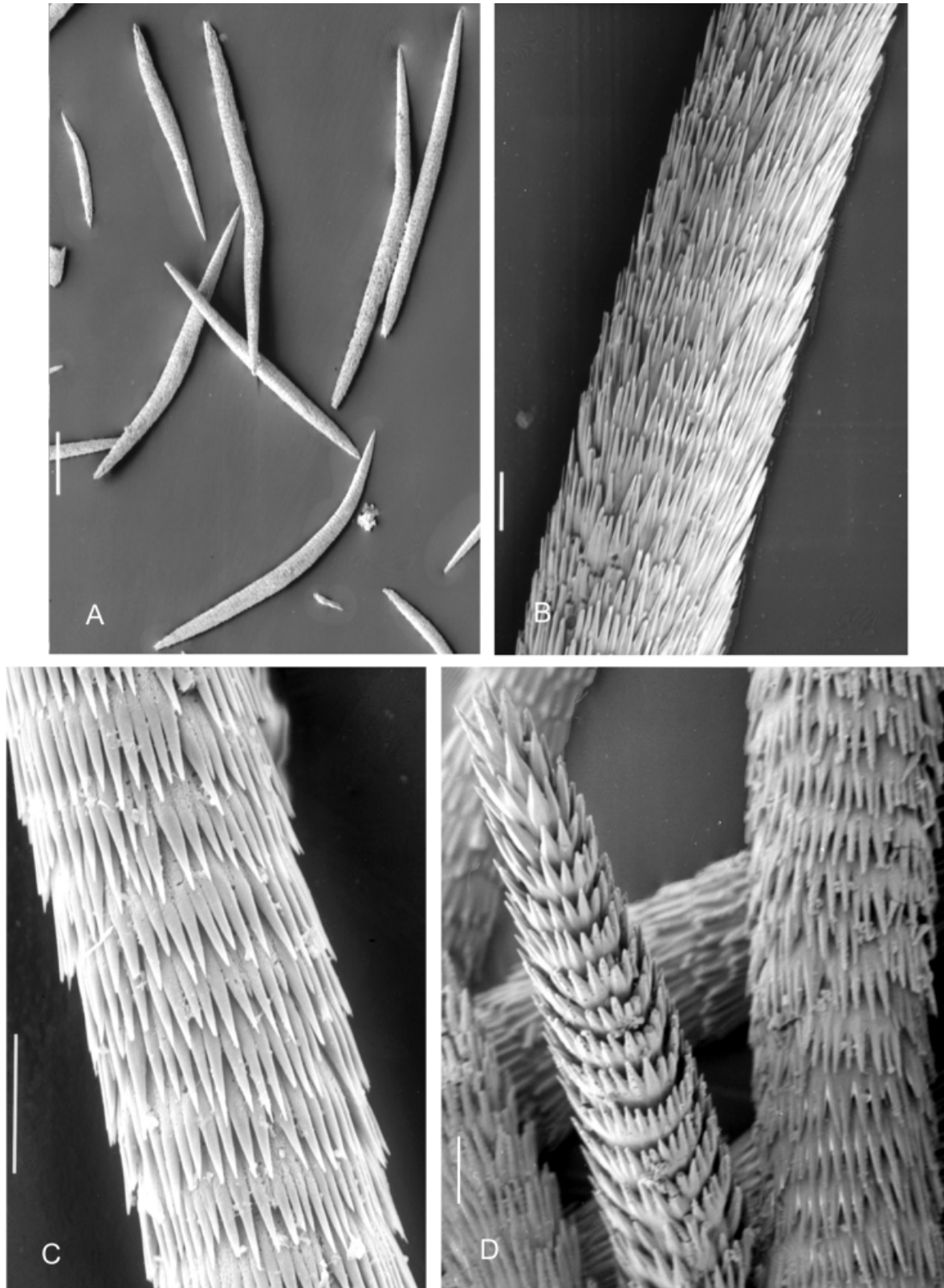
The short dorsal lamina has sharp languets. The branchial sac has 8–10 high folds on each side, covering each other. There is often one more fold on the right side than on the left side. There is a vertical slit on the right side of the dorsal lamina in all specimens. The branchial formula in the specimen from Bahrain is:

RE 1 (5) 1 (7) 1 (8) 1 (13) 1 (15) 1 (15) 1 (15) 1 (15)  
1 (13) 1 (9) 3 DL

DL 4 (10) 1 (14) 1 (16) 1 (15) 1 (15) 2 (11) 2 (8) 1 (7)  
1(3) EL

The gut forms a long open loop (Fig. 34A). The oesophagus is clearly distinct from a widened thin-walled stomach. The intestine has a constant diameter; it ends in a gaping anus with a variable edge that is divided into two or four lobes irregularly indented into smaller lobes (Fig. 34B). On the right side, the hepatic gland is divided into two lobes lying against the oesophagus (Fig. 34A). On the left side, three lobes lie on the inner side of the gut loop: one on the oesophagus, one on the stomach's cardia and a larger one on the rest of the stomach (Fig. 34A). The hepatic papillae are roundish, each topped by a long point.

The gonads are long and straight. That on the right side lies in the middle of the body (Fig. 34A). On the left side the gonad spreads over the whole length of the gut loop, lying against the descending limb of the intestine (Fig. 34A). The ovary is axial, surrounded and more or less covered with testis lobes. A common sperm duct follows the ovary axis, and its papilla opens just before and above the female papilla. Both genital papillae, with a thinly dented edge (Fig. 34B), are short and fused, the female papilla attached to the body wall. There is no membranaceous expansion associated with these papillae. The anus and



**Figure 35.** Spicules of internal tissues. A,B, *Herdmania coutieri* sp. nov., C, *Herdmania momus*, D, *Herdmania pallida*. Scale bars: A = 100  $\mu$ m, B, C, D = 10  $\mu$ m.

gonoducts open at the base of the cloacal siphon near the scalloped velum.

The heart is a long tube lying parallel to the endostyle.

#### Remarks

*H. coutieri* sp. nov. differs from *Herdmania pallida* collected in the same place in having a very large dorsal V of the prepharyngeal band, a different shape and size of the dorsal tubercle, more numerous hepatic lobes, more branchial folds for the same body size, and a musculature that spreads much farther down onto the ventral side.

#### Etymology

The species is dedicated to H. Coutière who collected many ascidians in the Red sea.

*HERDMANIA MOMUS*, (SAVIGNY, 1816) (Figs 35C,36)

*Cynthia momus* Savigny, 1816: 90, pl. 1, fig. 2, pl. VI, fig. 1 – Red Sea.

*Rhabdocynthia pallida*: Sluiter, 1905:14 – Djibouti, Obok and Musha.

*Halocynthia momus*: Sluiter, 1905: 15 – Djibouti.

*Pyura momus typica*: Michaelsen, 1919:54 – Red Sea.

*Pyura momus*: aut. mult.

#### Material

Type?: S2 HER 41 Red Sea, J.C. Savigny, 1801.

Other material examined: Red Sea: Mascate, coll. M. Maindron, 1877; Suez, coll. Letourneux, 1880; Perim Island, coll. F. Jousseume, 1891; Aden, coll. R.P.H. Dollfus, 1929; coll. ISRSE, 1962.

Djibouti: Musha Island, coll. C. Gravier, 1904; Djibouti, coll. C. Monniot, 1996.

Lebanon: Kafar Abida, 9 m, coll. G. Bitar, 1995; Beyrouth, coll. H. Zibrowius; Ibail, 15 m, coll. H. Zibrowius.

Cyprus: Famagouste Harbour, 7 m, coll. H. Zibrowius, 1998.

Yemen: Socotra Island, coll. C. Monniot, 1997.

Mozambique, coll. Heurtel, 1886; Ibo Island, coll. C. Monniot, 1995

#### Description

The external aspect is highly variable according to the place where the specimens have been collected. The tunic is always soft and somewhat sclerified at the surface, which is much corrugated. Epibionts are present on old specimens and those collected in harbours. The siphons are protruding, their spacing is variable. The tunic contains short spicules.

The body wall is thin. The musculature is mostly dorsal, with strong sphincters around the siphons and regularly spaced radiating fibres, that extend on the right side as far as the gonad and on the left side as far as the gut loop (Fig. 36A,E) The oral tentacles are tertially ramified; large and small tentacles alternate along the base of a velum. The prepharyngeal band forms a shallow dorsal V. The dorsal tubercle has a U-shaped opening with horns rolled in.

The dorsal lamina has sharp languets. The branchial sac has seven to nine high folds on each side, according to the body size.

The gut lies in the posterior part of the body on the left side, where it makes an open loop (Fig. 36A,E). The very short oesophagus leads to an inconspicuous stomach. The intestine does not curve in a secondary loop (Fig. 36A,E). The anus is far from the oesophagus and edged with round lobes, irregular in shape and in number (usually 10; Fig. 36D). The hepatic gland is made of one lobe on the right side of the oesophagus and two linked lobes lying along half the length of the ascending limb of the gut (Fig. 36A).

The gonads are elongated, one on each side. The left gonad is totally included inside the gut loop, against the rectum (Fig. 36A,E). The right gonad lies in the middle of the right side of the body (Fig. 36A,E). Each gonad has a long, sinuous ovary ending in a short wide oviduct whose opening is surrounded by a large collar-like membrane (Fig. 36C), well figured by Savigny. The testis almost entirely covers the ovary; it has many lobes placed edge-to-edge and opens by short, simple papillae on the ovary's internal surface (Fig. 36B). In young specimens it appears that a single sinuous sperm duct receives minor ducts from several testis lobes (Fig. 36F), and this common sperm duct then opens on the ovary surface by numerous papillae distributed along its length. In old specimens, with bulky gonads, the sperm ducts do not remain visible and even the papillae are scarcely apparent (Fig. 36B), for they are only small sessile holes along the ovary surface.

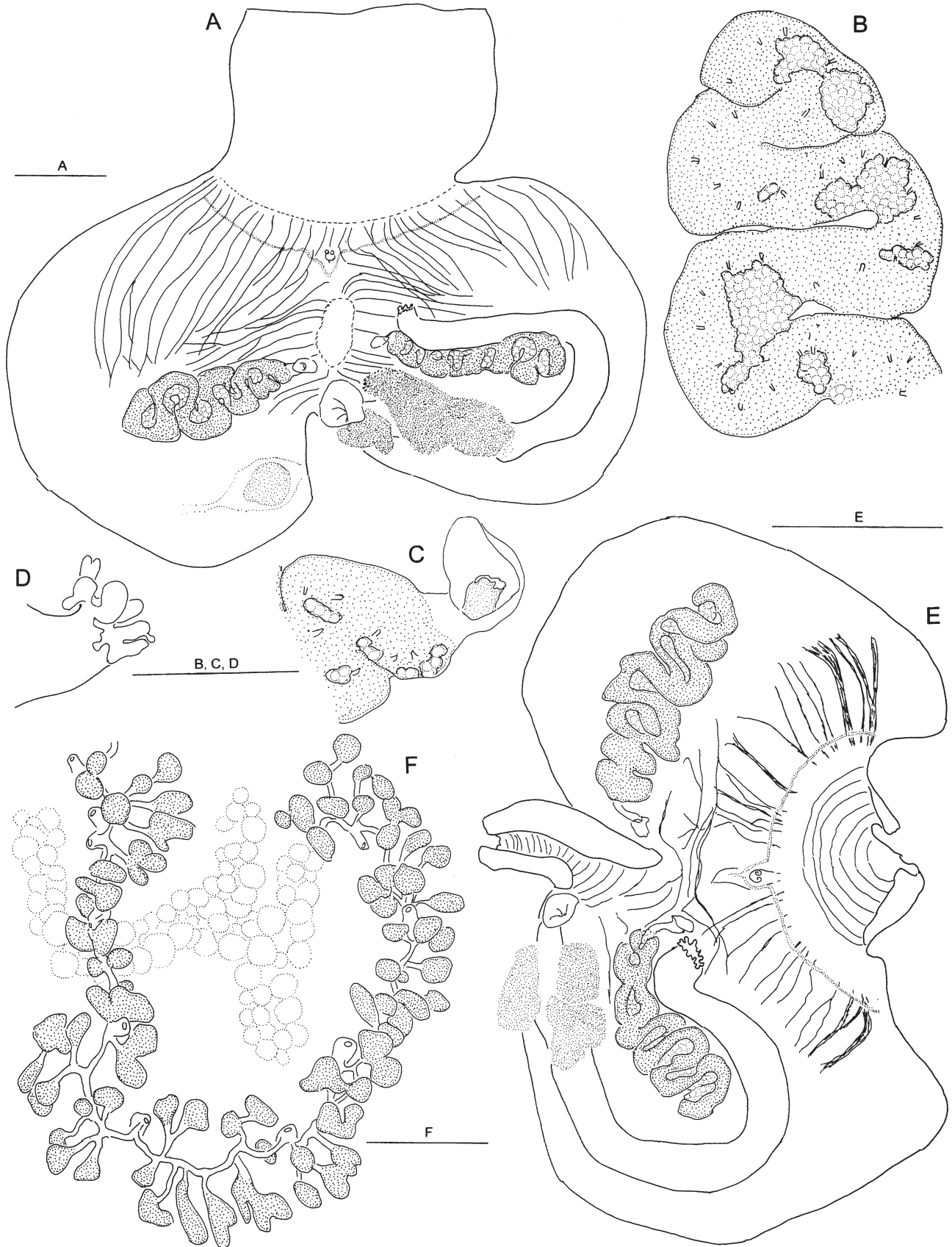
The cloacal velum is scalloped.

Spicules are abundant in all organs. Some of them reach 1 cm in length. They are made of annular rings of about 40 spines for the largest (Fig. 35C).

#### Remarks

The above account applies as much to specimens in very old collections stored in the MNHN as it does to others collected more recently. It corresponds exactly to the detailed description provided by Savigny, and to a specimen collected in 1801 that I believe is the type.

The distribution of this species covers the eastern Mediterranean Sea, the Red Sea, and the western





Indian Ocean down to Mozambique. Many other specimens of *Herdmania* collected worldwide have been attributed to the species *Herdmania momus*, based on the presence of acicular barbed spicules in their tissues and the general disposition of their gut and gonads. But in the process, several species have been confused as one. They differ in the distribution of the musculature, the shape of the gut and the hepatic gland, and the shape of the gonads and their ducts. The shape of the dorsal tubercle and the number of branchial folds also have to be considered, even when these traits are more variable, more dependent on body size and consequently more difficult to assess.

*HERDMANIA PALLIDA* (HELLER, 1878) (Figs 35D,37)

*Cynthia pallida* Heller, 1878: 96, pl. III, figs 17,18 – Mauritius, Jamaica, western Pacific; Herdman, 1882: 143 – Fiji.

*Cynthia pallida billitonensis* Sluiter, 1885: 183 – Indonesia.

*Cynthia rosea* Sluiter, 1887: 264 – Indonesia.

*Herdmania momus*: Monniot C., 1992: 16, fig. 6A – New Caledonia.

*Herdmania pallida*: Monniot F. & Monniot C., 2001: 341 – western Pacific.

#### Material

Types of *Cynthia rosea*, ZMA TU 400 and *Cynthia pallida billitonensis*, ZMA TU 895.

Pacific Ocean: Guam, Honolulu, New Caledonia, Hawaii, Vietnam.

Atlantic Ocean: Guadeloupe, Martinique, Brazil, Panama.

Indian Ocean: Djibouti, Zanzibar, Mozambique.

Australia: Sharks Bay.

#### Description

Heller's original description does not define a type specimen, but instead blends observations of individuals collected in the three oceans. My identification of specimens as *Herdmania pallida* is based on later descriptions and especially that of Michaelsen (1919).

Specimens from different sources measure 1–6 cm across, with a tunic that is always soft, wrinkled, and more-or-less covered with epibionts or sometimes sediment. The red colour of the tunic is variable in inten-

sity and extension. It disappears when the animals are fixed in formalin or alcohol. The internal lining of the tunic is gelatinous.

Extracted from the tunic, the body is laterally flattened. The body wall, as all other tissues, contains abundant spindle-like spicules (Fig. 35D). They are very similar in size and shape to those in *H. momus*. The musculature is strong in the dorsal half of the body, with a thick sphincter around the siphons and radiating, well-separated bundles, extending down to the level of the middle of the gut loop on the left side, and reaching the gonad on the right (Fig. 37A). The ventral side of the body is devoid of muscular ribbons.

The oral tentacles are generally large and secondarily ramified, but some individuals from the same stations have thin, poorly branched tentacles.

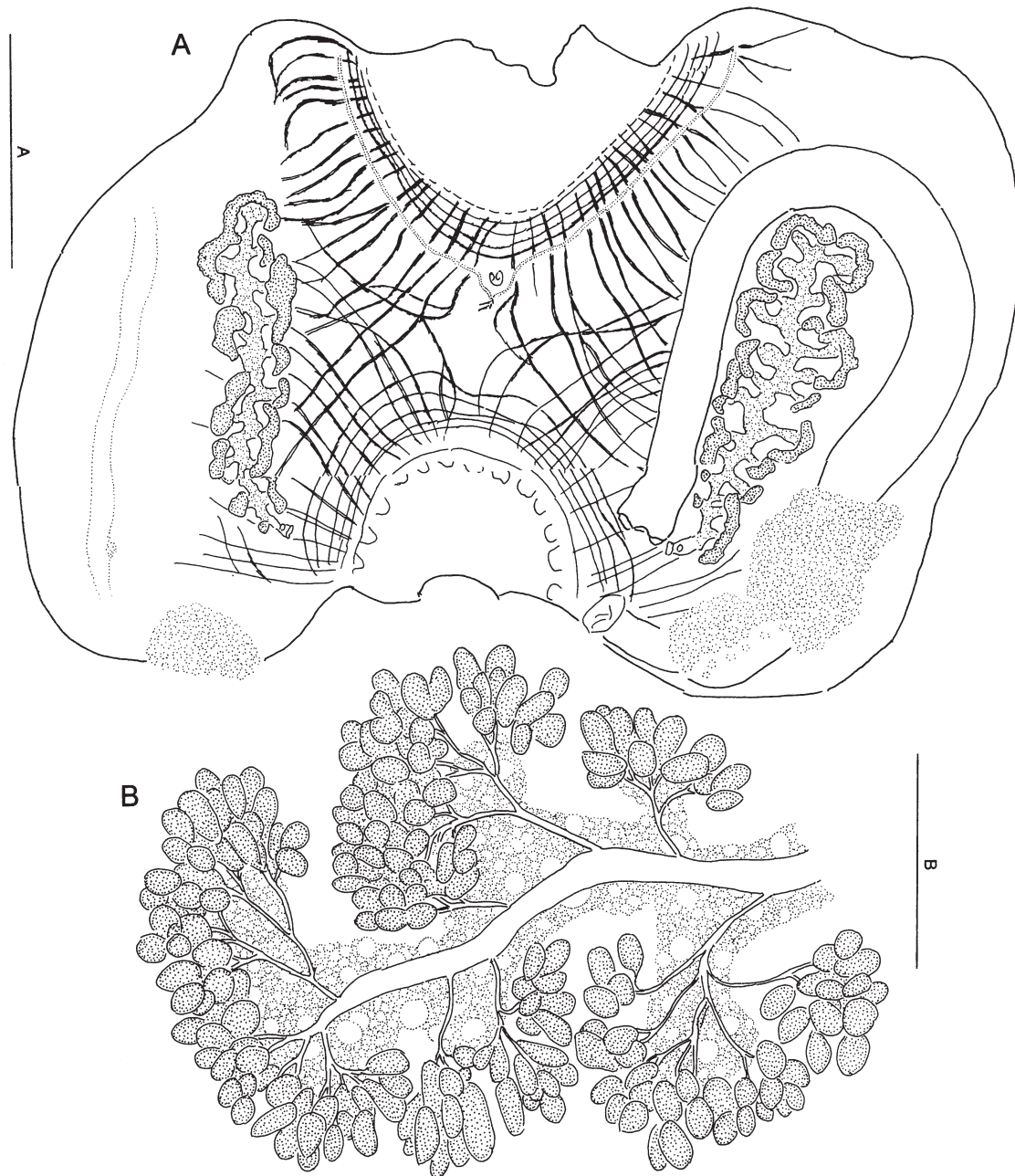
The prepharyngeal band is indented into a deep V. The slit of the dorsal tubercle is U-shaped, anteriorly opened with its ends rolled inward in several turns that protrude.

The dorsal lamina has numerous sharp languets. The branchial sac has 8–9 folds on each side, often eight folds on the left side and nine on the right side according to the body size. The folds are high, overlapping each other, with 8–14 longitudinal vessels each. The stigmata are cut with parastigmatic vessels. The endostyle is very long, attached to the stomach wall in its terminal part.

The gut makes a long, simple, and open loop (Fig. 37A); the top does not reach the anterior limit of the branchial sac. The short oesophagus leads to a poorly defined stomach. The intestine has a constant diameter and ends in a plain-edged anus; it is not linked to the dorsal lamina. The hepatic gland comprises one lobe on the right side of the ventral line and a larger lobe on the stomach, of irregular outline, covering less than half of the ascending limb of the gut (Fig. 37A). The hepatic papillae are dense, thin, with round tips.

There is one long gonad on each side (Fig. 37A). The left gonad lies along the whole descending limb of the gut, inside the digestive loop. The right gonad occupies the middle of that side. In each gonad the ovary is sinuous, central, surrounded by a widely developed testis (Fig. 37B) that often almost entirely covers the ovary when fully mature. The oviduct is short, attached to the body wall. When they are visible, the male ducts can be seen to converge to join an axial sperm duct that follows the ovary (Fig. 37B) and opens

**Figure 36.** *Herdmania momus*: A,B,C,D, specimen from Cyprus. A, body ventrally opened. B, proximal part of a gonad. C, female papilla. D, anus. E,F, young specimen from Mozambique. E, body ventrally opened. F, part of the gonad showing multiple male papillae. Scale bars: A = 1 cm, B,C,D,E = 5 mm, F = 0.2 mm.



**Figure 37.** *Herdmania pallida*: A, specimen from Israel ventrally opened. B, apical part of a gonad. Scale bars: A = 5 mm, B = 1 mm.

by a simple hole against the female papilla. In very large individuals the course of the gonoducts cannot be seen.

The heart extends in a long tube parallel to the endostyle and contains a round concretion.

A scalloped membrane fringes the base of the cloacal siphon.

#### Remarks

The deep V of the prepharyngeal band around the dorsal tubercle is remarkable, and so is the shape of the dorsal tubercle's opening: the ends of both horns closely rolled and protruding. The straight, long gonads with short, simple genital papillae are also characteristic of this species.

*Herdmania pallida* has a worldwide distribution in warm, shallow waters. It settles easily on artificial substrates, even in polluted areas. The species sometimes lives in very dense populations.

FAMILY MOLGULIDAE LACAZE-DUTHIERS,  
1877

*MOLGULA DIONE* (SAVIGNY, 1816) (Fig. 38)

*Cynthia dione* Savigny, 1816: 93, 153, pl. 7, fig. 1, – Red Sea.

*Ctenicella dione*: Harant, 1927: 366, – Suez.

*Molgula dione*: Van Name, 1952: 218, – Aqaba Gulf.

*Molgula somaliensis* Millar, 1988: 845, figs 10,30m, – Somalia.

*Material*

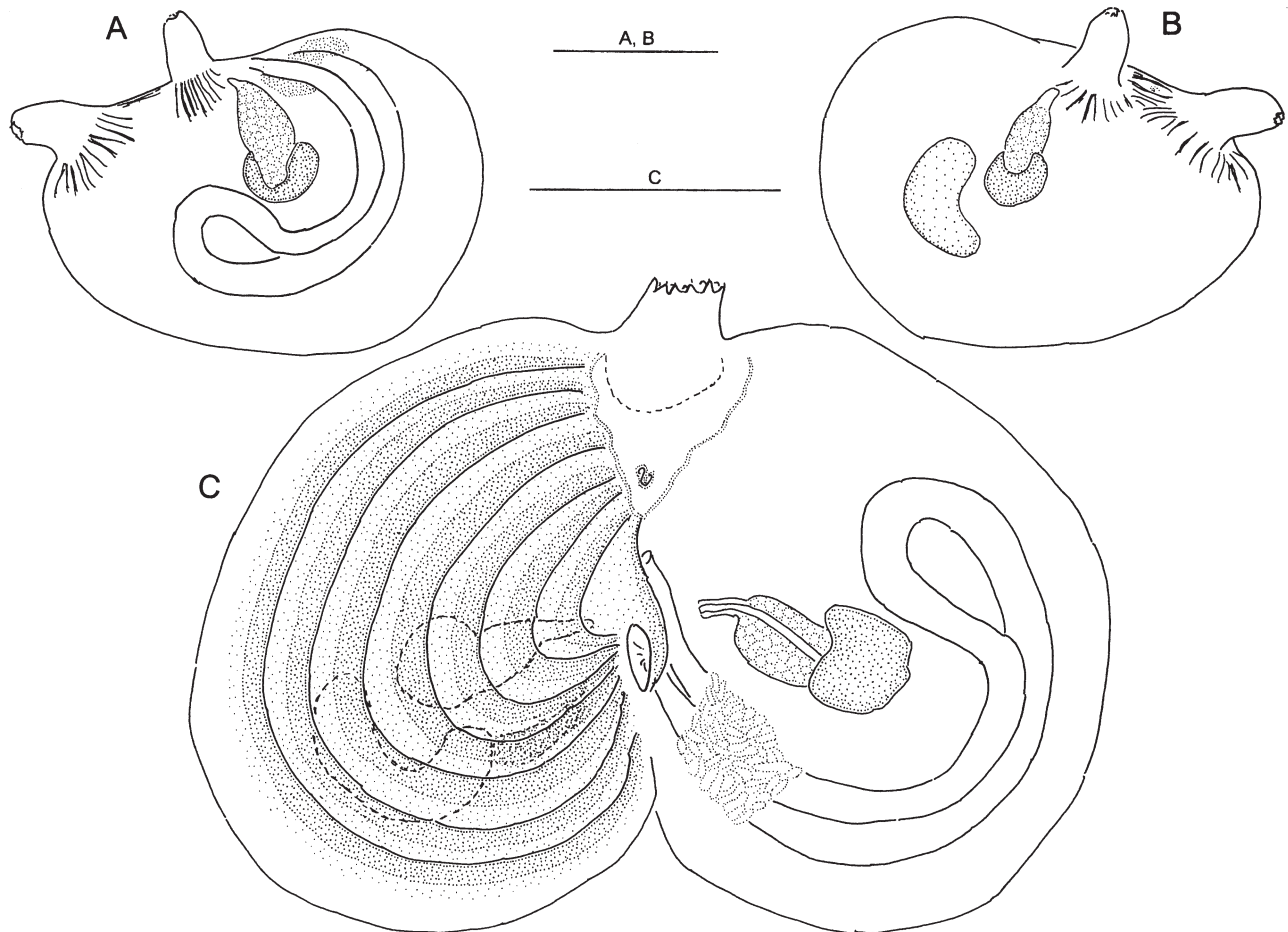
Yemen, Socotra Island, coll. C. Monniot, 1997.

*Description*

The single specimen collected is spherical, 26 mm in diameter, entirely embedded with sand and broken shells, making the thin tunic brittle. The siphons are short, close to each other, not protruding.

The body wall is thin. The musculature is limited to the siphonal sphincters and to strong but short longitudinal fibres that do not extend beyond the siphonal bases (Fig. 38A,B). The thick oral tentacles arise at the base of a velum and have two orders of ramifications. The prepharyngeal band forms a wide and deep dorsal V. The slit in the dorsal tubercle is in shape of a C opening anteriorly, with the end of the left horn curved in and the end of the right horn curved out (Fig. 38C).

The short dorsal lamina increases in height posteriorly. The branchial sac has seven folds on each side. The infundibula are constituted of two spiral stigmata wound in opposite ways. The formula on the right side is:



**Figure 38.** *Molgula dione*: A,B, external sides of the body. C, specimen ventrally opened. Scale bars = 1 cm.

E (9) 3 (12) 3 (13) 2 (13) 3 (15) 3 (12) 2 (11) 3 DL

The longitudinal vessels are often incomplete between the folds and sometimes join into just a single vessel.

The gut is long, in a closed loop, both limbs touching each other along almost all their length (Fig. 38A,C). The intestine is narrow compared to its length. The hepatic gland covers the stomach in a single lobe (Fig. 38C). The rectum is attached to the dorsal lamina. The anus has a smooth edge with two inconspicuous lobes.

On each side the gonad is made of a male part at the end of a slightly elongated ovary (Fig. 38A–C). Both ducts are long, joined together, and attached to the body wall until they open side by side in male and female papillae (Fig. 38C). The right gonad lies in the middle of the body (Fig. 38B); the left one lies in the secondary intestinal loop, but it does not touch the intestine (Fig. 38A,C).

The voluminous renal vesicle bulges in a crescent (Fig. 38B). It is prolonged by a long vesicle filled with dark pigment.

There is no cloacal velum, nor any cloacal tentacles.

#### Remarks

The specimen collected at Socotra corresponds in all points to Savigny's description. The species was collected again by Harant (1927) in the Gulf of Suez and by Van Name (1952) in the Gulf of Aqaba, but these authors did not give descriptions. The type specimen has not been found.

#### *MOLGULA LONGITUBIS* SP. NOV. (Fig. 39)

##### Material

Holotype: On microscopic slide, MNHN S3801  
Mozambique: Bela Vista, coll. Darteville, 1947.

Other specimens examined: same origin: MNHN S3  
MOL A 335.

##### Description

The specimens are spherical, the biggest 7 mm in diameter. They are entirely covered with siliceous sand. The siphons are sessile and close to each other; the oral siphon has six pointed lobes in the shape of a star. In some specimens hair-like short filaments arise from the ventral side of the body. The tunic is transparent, very thin but extremely resistant.

The thin body wall has a musculature made of well-separated ribbons (Fig. 39C). There are sphincters around the siphons and radiating muscular bundles that reach halfway down each side. The body also has a ventral belt of short transverse fibres (Fig. 39C).

The eight oral tentacles are bushy, with numerous ramifications, and they totally occlude the oral aperture. The prepharyngeal band does not form a dorsal V. The dorsal tubercle is a circular button opened posteriorly in a C-shaped slit with its horns rolled inward (Fig. 39C). The dorsal lamina is a short, plain edged, low membrane.

The branchial tissue is flat. There are six very low folds on each side, each with only two longitudinal vessels. There are six rows of coiled stigmata. Each infundibulum has two imbricated stigmata wound in opposite directions (Fig. 39D). At the endostylar end of the stigmata rows, the infundibula are doubled (Fig. 39D). At each extremity of a row of six infundibula crossed by the longitudinal vessels is an additional infundibulum.

The gut is particularly long (Fig. 39A,C). A short oesophagus leads to a wide and long stomach, which has a thin wall on which appears a mosaic pattern (Fig. 39C). No hepatic gland is individualized. The long and narrow intestine describes a primary loop to finally curve anteriorly and attach to the dorsal lamina (Fig. 39C). The edge of the anus is finely toothed. The gut is voluminous and occupies most of the left side (Fig. 39A).

A single massive and elongated hermaphroditic gonad lies in the middle of the right side (Fig. 39B,C). The testis covers a central ovary. The genital papillae are short; the female papilla is distal, and the male papilla opens a little behind it (Fig. 39C). The voluminous renal vesicle is applied to the whole posterior length of the gonad (Fig. 39B,C).

The gut, the gonad and the kidney are very loosely attached to the body wall.

##### Remarks

This new species has several uncommon characters: branchial folds made of only two longitudinal vessels, a particularly long intestine folded in a double loop, and a single gonad on the right side.

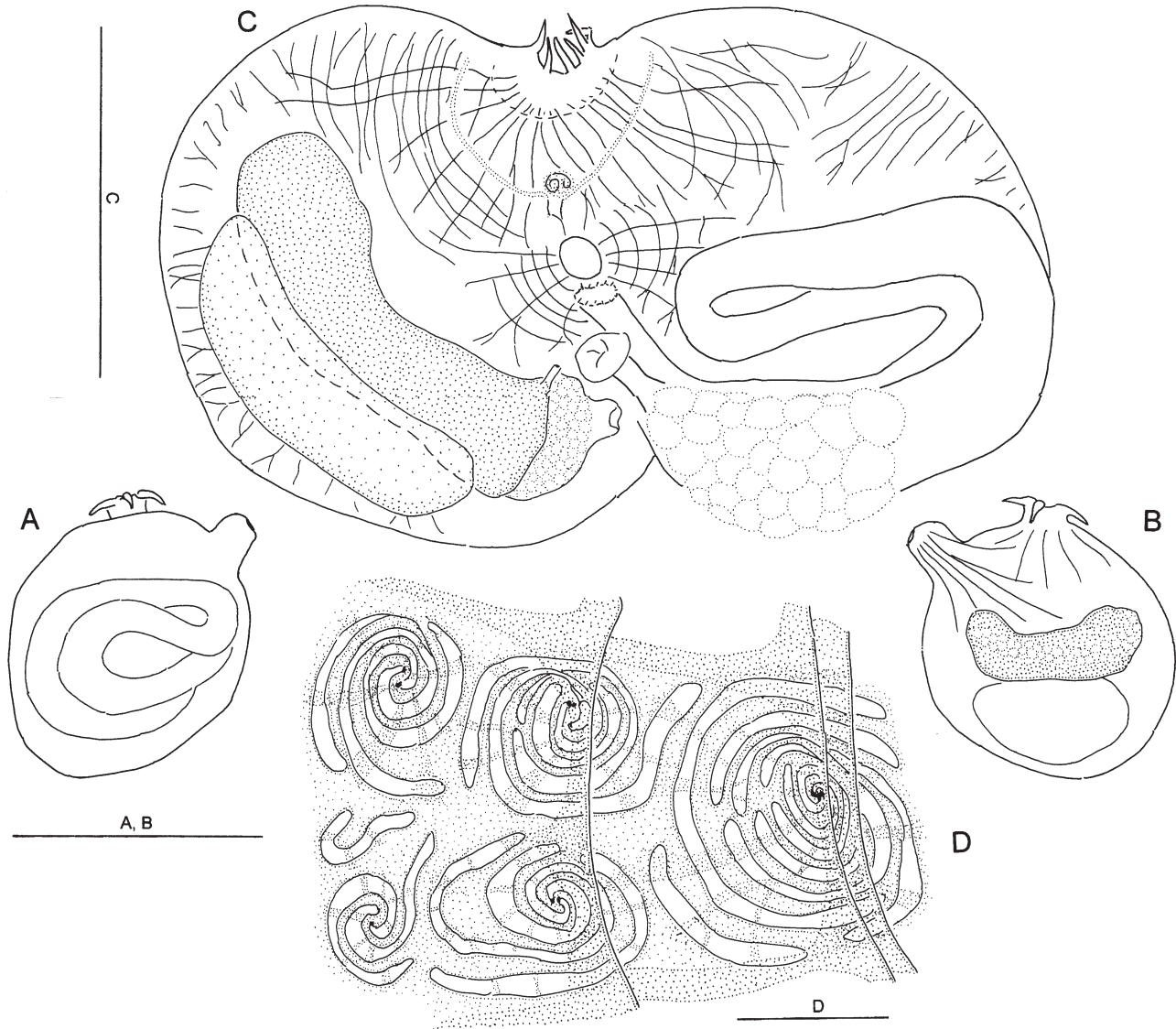
In the Mozambican region, two other *Molgula* species with two longitudinal branchial vessel per fold have been recorded: *Molgula brieni* Monniot C. & Monniot F., 1976 and *Molgula dicosta* Millar, 1988. Both have one gonad on each side of the body.

##### Etymology

The species name recalls the particularly long intestine.

#### ACKNOWLEDGEMENTS

I am very grateful to Madeleine Martin for her help in the preparation of the manuscript. I am much indebted to Professor Todd Newberry who carefully



**Figure 39.** *Molgula longitubis* sp. nov.: A,B, both sides in external view. C, body ventrally opened. D, part of the branchial tissue close to the endostyle. Scale bars: A,B,C = 5 mm, D = 0.5 mm.

corrected my English. Thanks also to the different Museums for the loan of specimens and to all persons having collected ascidians for the MNHN.

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## APPENDIX

## INDEX OF SPECIES (NEW SPECIES IN BOLD)

- Botryllus gregalis* (Sluiter, 1895)  
*Botryllus maeandrius* Monniot C., 2001  
*Botryllus tuberatus* Ritter & Forsyth, 1917  
*Symplegma bahraini* Monniot C. & Monniot F., 1997  
*Symplegma rubra* Monniot C., 1972

***Symplegma zebra****Metandrocarpa manina* Monniot C. & Monniot F., 1987*Metandrocarpa reducta* Monniot C., 1988*Amphicarpa inhacae* (Millar, 1956)*Amphicarpa prolifera* (Sluiter, 1905)*Eusynstyela hartmeyeri* Michaelsen, 1904*Eusynstyela miniata* (Sluiter, 1905)*Stolonica multitestis* Monniot C., 2001*Stolonica laevis**Polycarpa anguinea* (Sluiter, 1898)*Polycarpa argentata* (Sluiter, 1890)*Polycarpa arnoldi* (Michaelsen, 1914)***Polycarpa gradata****Polycarpa madagascariensis* Michaelsen, 1912*Polycarpa mytiligera* (Savigny, 1816)*Polycarpa nigricans* Heller, 1878***Polycarpa plantei******Polycarpa pori****Polycarpa stirpes* Kott, 1985*Polycarpa suesana* Michaelsen, 1919***Cnemidocarpa concha****Cnemidocarpa hemprichi* Hartmeyer, 1916*Cnemidocarpa irene* (Hartmeyer, 1906)*Cnemidocarpa margaritifera* Michaelsen, 1919***Cnemidocarpa schumacheri****Styela canopus* (Savigny, 1816)***Styela meteoris****Styela plicata* (Lesueur, 1823)*Pyura gangelion* (Savigny, 1816)***Pyura mozambica****Pyura scortea* Kott, 1985*Pyura tongaea* Monniot C. & Monniot F., 1976*Microcosmus exasperatus* Heller, 1878*Microcosmus madagascariensis* Michaelsen, 1918*Microcosmus pupa* Savigny, 1816*Microcosmus squamiger* Michaelsen, 1927*Halocynthia spinosa* Sluiter, 1905***Herdmania coutieri****Herdmania momus* (Savigny, 1816)*Herdmania pallida* (Heller, 1878)*Molgula dione* (Savigny, 1816)***Molgula longitubis***