Ascidians from Northern Australia

by

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ASCIDIANS FROM NORTHERN AUSTRALIA

Introduction

The twenty-six species of the class Ascidiacea as discussed hereunder were collected from the Darwin area of the Northern Territory by Miss Elizabeth Pope of the Australian Museum, and from the Hervey Bay area of Queensland by Mrs. G. McKeon of Hervey Bay.

Examination of collections confirms the strong relationship of the fauna of the Dampierian and Banksian (Hedley, 1904) marine faunal regions of Australia (Fig. 1) with that of Indonesia, the Philippines, and Japan. Only two species, Polycarpa moebii and Styela stolonifera have a distribution confined to Australia. There is no evidence here of relationship between the Indian fauna and that of Indonesia, although some species of Didemnidae do extend as far as the east coast of Africa and some continuity must be assumed on the Indian and Malayan peninsulas. The lack of records is therefore responsible for apparent discontinuity of the ascidian fauna from Indonesia into the Indian Ocean (Table 1).
TABLE 1  
(Showing Species Distribution)

<table>
<thead>
<tr>
<th>Species</th>
<th>West Indian Ocean</th>
<th>Red Sea</th>
<th>Ceylon</th>
<th>Indonesia</th>
<th>Dampierian</th>
<th>Banksian</th>
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*Also circum Australia.
† and/or Palau I., Caroline Group.
Previous collecting relevant to this area is indicated by the following reports:
Herdman: 1882, 1886 – Indonesia, Arafura Sea ('Challenger' Expedition)
Sluiter: 1885, 1887, 1890 – Indonesia
Sluiter: 1895 – Northern Australia and Malaysia
Sluiter: 1904, 1909 – Indonesia ('Siboga' Expedition)
Sluiter: 1913 – Aru I., Arafura Sea
Hartmeyer: 1919 – Northwestern Australia
Van Name: 1918 – Philippines
Tokioka: 1942, 1950, 1955 – Palau I., Caroline Group
Tokioka: 1952 – Arafura Sea
Millar: 1963 – Australia

Considerable progress has been achieved in the taxonomy of the group, especially in the family Didemnidae where the existence of larvae in colonies from Darwin has clarified and confirmed relationships suggested by the structure of the zooid and the development of the cloacal system. The use of the cloacal system as a specific character in certain groups of the Didemnidae has been shown to be particularly useful (Kott, 1962).

It has been necessary, in many cases, to describe some of the morphological features of the present specimens, in order to clarify and amplify their relationships with others of the same and of related species. Descriptions are not necessarily intended as full descriptions of the species.

Suborder APLOUSOBRANCHIATA Lahille
Family CLAVELINIDAE Forbes and Hanly
Subfamily POLYCITORINAE Michaelsen
Genus POLYCITOR Renier
POLYCITOR CIRCES Michaelsen

Polycitor circes Michaelsen, 1930, p. 495; Kott, 1957, p. 84; Millar, 1963, p. 710.
Records. 35–37 fm, Cape Inscription, Western Australia (Kott, 1957); Cape Boileau, Broome, northwestern Australia (Millar, 1963); Shark Bay and Fremantle, Western Australia (Michaelsen, 1930); East Point, Darwin, Northern Territory, Australia (“L.W.M. Spring tide fauna”, coll. E. Pope, present collection, single specimen).

Description. Gelatinous, firm; smooth surface, whitish with brown markings. Eighteen muscle bands extend from thorax along either side of abdomen. Twelve long rows of stigmata but number of stigmata obscured by accumulation of brown pigment in thorax. Long posterior abdominal vascular extension present. In this specimen the zooids are in a condition of active vegetative reproduction; the structure of the alimentary canal is obscured by resorption and accumulation in the abdomen of masses of trophozooites.

Remarks. Although the numbers of rows of stigmata are not as great as previously reported and the structure of the stomach is not discernible, there is considerable variation of these characters in the specimens previously described (Millar, 1963). The present specimens do agree with others in the gelatinous but opaque nature of the test, the smooth surface of the colony, the width of the thorax, and the numbers of longitudinal muscle bands. The records suggest a distribution in the Dampierian marine faunal region.

Genus EUDISTOMA Caullery

EUDISTOMA LORICATUM (Sluiter)


Records. Kaniungan and Timor (Sluiter, 1909); Cape Don, Northern Territory, Australia (coll. E. Pope, 7.x.65, present collection, single specimen).

Description. Basal plate 3 cm diameter bearing numerous upright lobes 0.5 cm diameter; total height 1 cm. Basal plate grey with enclosed mud and foeces balls. Lobes semitransparent, basal half wrinkled transversely (stalk), head delicate, slightly expanded. Abdomen about 3 times length of thorax. Fine circular and longitudinal muscles on thorax, forming a continuous sheet. Muscles not particularly developed in region of siphons. Branchial sac with 12 long stigmata in 3 rows. Stomach at posterior end of abdomen, large spherical and smooth, although in present contracted zooids collapsed into transverse folds. Gonads in loop of gut; only very short posterior abdominal extension present.

Remarks. The present specimens conform exactly with those described by Sluiter (1909). Recorded range from Indonesia to northern Australia.

Family POLYCLINIDAE Verrill

Subfamily POLYCLININAE Adams

Genus APLIDIUM Savigny

APLIDIUM ALTARIA M (Sluiter)

Amaroucium altarium Sluiter, 1909, p. 105.


Records. South of Ceram, Indonesia (Sluiter, 1909); Zanzibar (Michaelsen, 1919); Mozambique (Millar, 1956); Cape Boileau, northwestern Australia (Millar, 1963); Fannie Bay, Darwin, Northern Territory, Australia (coll. E. Pope, 12/x/65, 3 colonies, present collection).

non Aplidium altarium; Kott, 1963, p. 93.

*The position of the atrial opening is here described in error; the true relative character is more than 30 stomach folds.
Description. Rounded colonies 1.2 to 2.0 cm diameter, each colony 0.5 cm thick around periphery, 0.7 cm thick in centre. Colonies fixed by large part of flattened base; no stalk. Three to four common cloacal openings present on upper surface. Test clear, gelatinous. Zooids parallel to one another, more or less vertical to surface, arranged in double rows on either side of canals radiating from common cloacal cavities beneath apertures. Due to crowding of zooids double row arrangement of zooids not always evident.

Zooids short, thorax, abdomen each 3 mm, posterior abdomen 2.5 mm. A marked constriction present between abdomen and posterior abdomen. Branchial siphon short with 6 lobes. Atrial opening small, placed well towards anterior end of dorsal surface, protected by short muscles on each side of opening and by a very short pointed atrial lip from body wall anterior to opening (Fig. 2). Nine rows of about 25 (total from right and left) very long rectangular stigmata. Testes lobes in “sac-like” posterior abdomen, not arranged in double rows. Ovary anterior to testes lobes. Short stomach, rather wide with 30 fine longitudinal folds, posterior stomach enlargement, oval midintestinal enlargement in loop of gut (Fig. 3).

Larvae (Fig. 4). Three developing embryos in distal end of oviduct in peribranchial cavity. Well-differentiated embryo 0.6 mm long. Tail extends only three-quarters of way around body. Otocyst and otolith present. Three suckers present anteriorly, 10 ectodermal ampullae develop from lateral ridge on either side of base of suckers: single pair ampullae dorsal to suckers, 3 pair of ampullae between successive suckers, 3 pairs ventral to suckers. There are also 2 ampullae placed postero-ventrally. Ampullae spherical, at end of slender stalks.

Remarks. The most distinctive characters of this species are the parallel arrangement of the zooids in the test, the large number of stomach folds, the constriction between the abdomen and posterior abdomen, and the sac-like abdomen.

The colonies, zooids, and larvae closely resemble A. phortax (Michaelsen) and A. multiplicatum Sluiter in the sac-like posterior abdomen with bunched arrangement of the testes lobes and the epidermal vesicles of the larvae. However, although A. phortax has zooids parallel to one another in the test as does the present species, it has only a single developing embryo in a real brood pouch at the posterior corner of the thorax. Aplidium altarium has up to three developing embryos in an expanded oviduct in the peribranchial cavity. This expanded oviduct is not a true brood pouch. It represents a condition half way between the true brood pouch of A. phortax and the situation in most of the species of this genus where the embryos, sometimes in great numbers, develop freely in the peribranchial cavity. Aplidium multiplicatum, like A. altarium has up to three developing embryos in the peribranchial cavity; these may still be enclosed in the oviduct; however the zooids of the former species are not arranged parallel to one another in the test.

The larva of A. multiplicatum; Kott 1963, although similar, is smaller. The larva of A. multiplicatum; Millar 1963, however, is unusual in the retention of the unmodified paired lateral ampullae – a condition rarely seen in Aplidium spp. – in particular in neither A. altarium; Millar 1956 nor A. multiplicatum; Kott 1963. The adult zooids of these colonies are all identical.

The larva of A. altarium is the same size and of the same structure as that described for this species by Millar (1956) except that the latter has only “four rounded . . . vesicles detached from the body of the larva” while the present species has 10 pairs of vesicles. There is some variation in the number of vesicles in the larva from different locations (Kott, 1963) in A. phortax, so it is
Fig. 2.—Diagram showing atrial aperture musculature of Aplidium altarium. Fig. 3.—Abdomen and posterior abdomen of Aplidium altarium. Fig. 4.—Larva of Aplidium altarium. Fig. 5.—Spicules of Trididemnum cyclops. Fig. 6.—Diagram showing common cloacal system and arrangement of zooids in test, Didemnum ternatanum. Fig. 7.—Larva of Leptoclinum (Lissoclinum) molle. Fig. 8.—Larva of Leptoclinum virens. Fig. 9.—Diagram showing branchial tentacles projected down into branchial sac by contraction of circular sphincter muscle at base of siphon, Pyura lepidoderma. Fig. 10.—Dorsal tubercle Pyura lepidoderma. Fig. 11.—Gonad, Pyura lepidoderma. Fig. 12.—Pyura vittata with inverted siphons. Fig. 13.—Pyura vittata with everted siphons.
most probable that this is the case here. Millar does not make it quite clear whether the vesicles in his specimens of *A. altarium*; Millar 1956 are paired or not.

The present specimens are not pigmented – but otherwise seem to be identifiable with those described from Cape Boileau, northwestern Australia (Millar, 1963). Distribution of the species is from the west Indian Ocean to the East Indies and the Dampierian marine faunal region of Australia.

**Family DIDEMNIDAE Giard**

**Genus TRIDIDEMNUM Della Valle**

**TRIDIDEMNUM SAVIGNII** (Herdman)

subspecies SAVIGNII Herdman

*Didemnum savignii* Herdman, 1886, p. 261.


*Trididemnum savignii*; Hastings, 1931, p. 91; Tokioka, 1962, p. 3.

*? Polyclinum pullum* Sluiter, 1898, p. 23.


*? Trididemnum pullum*; Millar, 1961, p. 4.

non *Didemnum savignii*; Van Name, 1902, p. 358 = *T. savignii atrocanum*.

non *Trididemnum savignii*; Van Name, 1945, p. 100 = *T. savignii atrocanum*.

**Records.** Southern and eastern Africa (Michaelsen, 1920; Herdman, 1886); Japan (Tokioka, 1962); Indonesia and Timor (Sluiter, 1909); Great Barrier Reef, Australia (Hastings, 1931; Kott, 1962); Queensland, Australia (Millar, 1963); Stokes Hill Power Station, Darwin, Northern Territory, Australia (on intake screens, coll. E. Pope, present collection, single specimen).

**Description.** Large fleshy lobe, 6 cm long; 2 cm wide; 1.5 cm diameter, fixed along its length. Common cloacal apertures marginal on rounded border of colony sometimes as close as 4 mm.

Surface layer bladder cells above layer of spicules, fairly sparse and uneven. Sprinkling of spicules in floor of cloacal cavities and sparse again in basal test. Thin layer of spicules where colony adheres. Spicules stellate, 0.015 to 0.03 mm with up to 12 rays in optical section. Common cloacal canals thoracic and oesophageal. Zooids with brown pigment especially along either side of endostyle. However pigment not accumulated in cap on anterior end of endostyle. Thorax with usual 3 rows of stigmata; oesophagus long; short posteriorly directed atrial siphon from mid-thoracic level. Gonads not developed in this specimen, no vas deferens detected.

**Remarks.** In the present specimen the atrial siphon, cloacal system, and the distribution of spicules and bladder cells are identical with previously described forms; the absence of an accumulation of pigment at the anterior end of the endostyle is unusual but specimens of this species have been recorded without it (Kott, 1963). The spicules have generally the same number of rays in optical section as those from other localities but are smaller (0.015 to 0.03 mm diameter, all previous descriptions 0.03 to 0.08 mm diameter).

In discussing *Trididemnum savignii* (Herdman) from Cape of Good Hope (?), Van Name (1945), due to the indicated doubt on Herdman’s station and similarity of the type with West Indian and east coast American specimens, has suggested that in fact the ‘Challenger’ Station was off Bermuda and not off the Cape of Good Hope. He consequently synonymized all the American species under Herdman’s *Trididemnum savignii*; Van Name 1945, Kott 1962. If indeed the type *T. savignii* was collected off Cape of Good Hope, *T. planum* and its synonyms (above) are synonyms of *T. savignii* (Herdman). While the new world forms
are united as *Trididemnum savignii* subsp. *atrocanum* Van Name (Van Name, 1902, 1945).

The only difference between the subspecies seems to be the number of vas deferens coils – as many as 10 to 12 in the new world forms and a maximum of 7½ in the old world forms. Herdman’s colony has only 4½ to 5 which would indicate a similarity with the old world form.

In any case it would seem that the similarities are too great for separation of the species, and it is proposed here that they be known as geographic subspecies of the species: viz. *T. savignii* (Herdman), subsp. *savignii* and *T. savignii* (Herdman) subsp. *atrocanum* respectively.

Millar (1955, 1962) has described numerous specimens both convoluted and simple colonies as *T. cerebriforme*. He has not described the conditions of the common cloacal systems. In the specimens of *Lissoclinum molle* and *Didemnum ternatanum* (see below) in the present collection even very young colonies have the posterior abdominal cloacal cavity characteristic of the species. Possibly the cloacal cavity of *Trididemnum cerebriforme* is developed differently and the hypoabdominal cavity is present only in very large and convoluted colonies, in which case the synonymy of *T. cerebriforme* and *T. savignii* as suggested by Millar (1961) would be valid. In specimens of the former species from Australia (Kott, 1962), there is a gradation in colonies from flat investing membranes to highly convoluted forms, but in all cases there is a great development of the posterior abdominal cavity. Also the larvae of *T. cerebriforme* are smaller (0.5 to 0.8 mm) while those of *T. savignii* are variable and 0.8 to 1.6 mm long (Kott, 1962; Tokioka, 1962). There is therefore no conclusive evidence that the two species are synonymous, and though the zooids, pigmentation, and distribution are similar they are distinguished by the very much greater development of the common cloacal system in the former. *Trididemnum pullum* (Sluiter) is a small specimen in which the cloacal system has not been described – the zooid differs in having a greater number of stigmata than has been recorded for either of the above species with which Millar (1961) has suggested its synonymy.

*Didemnum areolatum* Herdman (1906) is probably not a synonym of the present species as suggested by Hastings (1931) as Herdman describes extensive vacuolations in the basal test which indicates synonymy with closely related *T. cerebriforme* Hartmeyer (Kott, 1962).

Distributed from northern Australia, through Indonesia to Japan, eastern and southern Africa.

**TRIDIDEMNUM CYCLOPS** Michaelsen


*Records.* West Indian Ocean (Michaelsen, 1921); Great Barrier Reef, Queensland (Hastings, 1931; Kott, 1962); Dudley Point, Darwin, Northern Territory, Australia (coll. E. Pope, present collection, numerous colonies).

*Description.* Small oval specimens. Colonies with shallow thoracic common cloacal cavities. Superficial layer of test with bladder cells, surface smooth, slippery. Spicules in layer beneath superficial test; in single rows around lobes of branchial openings; in test sheath around thoraces; in a layer between thorax and abdomen beneath common cloacal space; only very sparse at abdominal level and in basal test. Thorax with about 5 stigmata in 3 rows; atrial opening mid-thoracic, no siphon. Pigment particles accumulated on the abdomen, obscuring gonads; a pigment cap on anterior end of endostyle (endostylar eye). Spicules 0.015 to 0.08 mm in diameter, stellate with pointed rays, about 12 in optical cross section (Fig. 5).
Remarks. The specimens agree in all aspects with other specimens of this species. The species is distinguished from *T. savignii* (Herdman) mainly by the lack of an atrial siphon, by the smaller number of stigmata in each row of the branchial sac, by a shallower common cloacal system confined to the thoracic region, by a thicker layer of spicules beneath the cloacal canals, and by the smaller zooids. These differences are constant and despite the similarities in other ways (coils of vas deferens, pigmentation) the species does not appear to be identical with *T. savignii* as suggested by Millar (1961).

Distribution from the west Indian Ocean, across northern Australia to the Great Barrier Reef.

Genus *DIDEMNUM* Savigny

*DIDEMNUM TERNATANUM* (Gottschaldt)

Didemnoides ternatanum Gottschaldt, 1898, p. 648.
Didemnum ternatanum; Van Name, 1918, p. 152; Tokioka, 1955, p. 47.
Leptoclinum bistratum (nom. nud.) Sluiter, 1905, p. 103; 1905a, p. 18.
Didemnum sycon Michaelsen, 1920, p. 137 (part).

Records. Red Sea (Michaelsen, 1920; Kott. 1957); west Indian Ocean (Sluiter, 1905; Michaelsen, 1920); Indonesia (Gottschaldt, 1898; Sluiter, 1909); Palau I., Caroline Group (Tokioka, 1955); Philippines (Van Name, 1918). Dudley Point, reef and East Point, Darwin, Northern Territory, Australia (coll. E. Pope, present collection, numerous colonies).

Description. Spreading colonies up to 1.6 cm in diameter, 5 mm thick. Single common cloacal opening in centre of highest part of colony, conspicuous with spicule filled lip surrounding opening. In one colony only 3 common cloacal apertures. Spicules 0.01 to 0.015 mm diameter with very numerous blunt rays, absent from test surrounding zooids, sparse in surface test but very thick in basal test. Common cloacal cavities extensive (Fig. 6), both at level of zooids and posterior to zooids: strands of test from base of colony traverse posterior abdominal cavities and divide to support groups of zooids at surface. In each group of zooids, test material again divides to support each individual in its own strand of test. Basal test sometimes increased in thickness in centre, giving colony its maximum thickness there; occasionally basal test so increased to form a central test core, thus forming lobe-like colony with terminal cloacal opening. Generally, due to extensive cloacal system, colony very delicate, collapsed when fixed. Cloacal spaces filled with green zooxanthellae, giving when viewed from above grey green colour to colonies. These zooxanthellae are held in cavities by mucous (Tokioka, 1955), very evident in some of present colonies.

Zooids with 8 stigmata per row; 4½ spirals of vas deferens around single testis lobe.

Larvae. 0.6 mm long with 3 anterior papillae, 2 pairs of ectodermal ampullae or lobes developed from the corners of lateral ridge which in this case appears to be developed into a frontal plate; 2 precocious buds and an oozooid.

Remarks. The species shows the maximum development of the cloacal system (Kott, 1962, p. 271, Fig. 3, a2). However the thoracic canals are better developed than in *D. lambitum* etc., and have expanded to envelop the whole zooid.

The colonies, spicules, zooids, and larvae are identical with those previously described for this species although previous descriptions indicate more stigmata and more coils of the vas deferens.
In the group of species closely related, all with developed posterior abdominal cloacal canals (Kott, 1962, p. 321):

*Didemnum lambitum* (Sluiter) has a colony of entirely different consistency and larvae without precocious buds.

*Didemnum spongioides* Sluiter, *D. turritum* Michaelsen, *D. roberti* Michaelsen, *D. pantherium* Sluiter, *D. jedanese* Sluiter, and *D. velans* Michaelsen have the secondary cloacal canals developed only at the thoracic level, have larger spicules, and, where the larval form is known, do not have precocious buds.

*Didemnum sycon* Michaelsen with a well-developed test core and single terminal cloacal aperture and *D. bistratum* (Sluiter) a spreading, investing colony with several cloacal openings and not much development of the basal test are similar to *D. ternatanum* in both the development of the secondary cloacal canals and in the form of the spicules.

The present colonies represent a stage between the "bistratum" and "sycon" condition where the basal test is developed under the cloacal openings to produce mounds and occasionally lobes. Tokioka (1955) and Van Name (1918) describe specimens roughly dome-shaped and Michaelsen's type of *D. sycon* was cone-shaped. *Didemnum sycon* and *D. ternatanum* are therefore synonyms, completely lacking in any distinguishing characters and *D. bistratum* is also synonymous, representing young colonies of *D. ternatanum* as described by Van Name (1918, pl. 28, Fig. 16), and as present in this collection, before the development of basal test to produce a lobed colony. *Didemnum ternatanum* with larvae showing precocious buds are now recorded from Palau I. and northern Australia, so it is unlikely that representatives of the species from the East Indies, the Philippines, and the west Indian Ocean (Table 2), will differ in any way. *Didemnum, bistratum, D. sycon, and D. ternatanum* have all been described with zooxanthellae. Records of this species therefore, as for other species of *Didemnidae*, indicate a wide range, in this case from the west Indian Ocean, via the East Indies and northern Australia to the Philippines and the Caroline Group – i.e. similar to the range found for *T. savignii* above.

<table>
<thead>
<tr>
<th></th>
<th>Philippines</th>
<th>Caroline Group</th>
<th>Northern Australia</th>
<th>East Indies</th>
<th>West Indian Ocean</th>
<th>Red Sea</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>D. ternatanum</em></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>D. bistratum</em></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>xx</td>
</tr>
<tr>
<td><em>D. sycon</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 2**

(Showing Overlapping in the Range of *D. ternatanum* and its Synonymous Species)

*Didemnum candidum* Savigny?

*Didemnum candidum* Savigny, 1816, p. 194.

For further synonymy see Van Name, 1945, p. 83; Kott, 1962, p. 327.

*Records.* Mediterranean; Red Sea; Indian Ocean; Malaya; Great Barrier Reef, Queensland; Western Australia; Stokes Hill Power House, Darwin, Northern
Territory, Australia (on intake filters, coll. E. Pope, present collection, single specimen).

**Description.** Investing colony, packed with spicules. Common cloacal cavity thoracic. Spicules almost globular, up to 0.02 mm, stellate but with almost 20 rays in cross-section, so that under smaller magnification they appear almost globular. Thoraces crossing cloacal cavity in their own discrete spicule filled sheath of test. Abdomina in clumps sometimes projecting into base of cloacal cavity. Gonads not distinguished.

**Remarks.** This specimen has been identified by the form of the spicules and the well-developed thoracic cloacal cavity.

**Genus LEPTOCLINUM Milne Edwards**

Subgenus LISSOCLINUM Verrill

**LEPTOCLINUM (LISSOCLINUM) MOLLE (Herdman)**

*Diplosomoides molle* Herdman, 1886, p. 310; Sluiter, 1909, p. 85; 1913, p. 78.

*Didemnum voeltzkowi* Michaelsen, 1920, p. 54; Hastings, 1931, p. 97.

*Didemnum gottschtalidi*; Tokioka, 1950, p. 118.


*Leptoclinum molle*; Kott, 1962, p. 309.


**Records.** Madagascar (Michaelsen, 1920); Palau I., Caroline Group (Tokioka, 1950); Aru I., southwestern New Guinea (Herdman, 1886); Japan (Tokioka, 1954); “N.E. Coast”, Australia (Millar, 1963); Great Barrier Reef, Queensland (Hastings, 1931; Kott, 1962); Dudley Point reef, Darwin, Northern Territory, Australia (coll. E. Pope, “very common indeed inshore”, present collection).

**Description.** Flattened oval to round colonies about 1.0 cm diameter. Central, single common cloacal opening; cloacal cavities largely posterior abdominal, traversed by strands of tissue anchoring clumps of zooids; secondary cloacal canals at thoracic level. Spicules dense in base and walls of colonies – distribution varies from sparse to moderate in surface and very sparse in remainder of test. Spicules spherical, composed of radiating rods, small, from 0.005 mm to 0.015 mm. Zooids small, thorax with 4 rows of 7 stigmata; single testis lobe with uncoiled but hooked vas deferens. Zooxanthellae present in cloacal cavity giving to colony its green-grey colour.

**Larvae.** (Fig. 7). Present in test strands crossing posterior abdominal cloacal spaces. 0.8 mm long, 8 pairs epidermal ampullae from lateral ridges either side of the 3 suckers; oozooid and 2 blastozooids.

**Remarks.** *Leptoclinum patella* Gottschaldt, a species from the same general geographic area, with posterior abdominal cloacal canal, spherical spicules, a single testis lobe and uncoiled vas deferens, has been confused with the present species (Millar, 1963). It is however distinguished by a specialized branchial aperture (Kott, 1962), by considerable elaboration of the surface of the colony, by considerably more stigmata in each row of the branchial sac, and by larger spicules which are generally 5 to 7 μ while the largest spicules recorded for the present species are 3 to 6 μ (Michaelsen) but are generally smaller than this; the larvae are also quite distinct in size and form (Kott, 1962). *Leptoclinum patella* could not be confused with *L. voeltzkowi*, while *L. molle* differs from the latter species only in the slightly larger spicules, and as variation in these does occur even within the recorded Australian forms it is not considered significant. The branchial lobes of *L. molle* are variable in their definition according to their con-
traction and provide no distinguishing character between L. molle and L. voeltzkowi.

*Leptoclinum notti* Brewin which Millar (1963) has suggested may be identified with the present species does not have a posterior abdominal cloacal system (Kott, 1962).

*Leptoclinum patella* as well as *Leptoclinum molle* (see Kott, 1962, p. 306) may be considered intermediate between *Leptoclinum* and *Didemnum* for, while typically *Leptoclinum* in the straight vas deferens and larval buds, they are related to *Didemnum ternatanum* Gottschaldt and a large group of *Didemnum* spp. by the particular development of the posterior abdominal cloacal system which otherwise does not occur in the genus *Leptoclinum*. Precocious budding in larvae also occurs in *D. ternatanum* but not generally in other *Didemnum* species. *Leptoclinum patella* may be considered more closely related to the *Didemnum* spp., *L. molle* has closer similarities with *Leptoclinum* spp. (Tokioka, 1955, p. 48; Kott, 1962, p. 306).

*Leptoclinum molle* therefore extends from the west Indian Ocean, southern Japan, through the Caroline Group to western New Guinea, northern Australia, and the Great Barrier Reef. *Leptoclinum patella* has more limited range from the Caroline Group in the north but has been taken from further to the south on the Western Australian coast, and so far has not been recorded from the west Indian area.

Subgenus LEPTOCLINUM Milne Edwards

**LEPTOCLINUM (LEPTOCLINUM) RAYNERI** (Macdonald)


*Diplosoma macdonaldi* Herdman, 1886, p. 315; Van Name, 1945, p. 109; Brewin, 1946, p. 100.


*Leptoclinum takeharai* Tokioka, 1951, p. 21.

*Leptoclinum macrolobium* Tokioka, 1949, p. 44.


For further synonymy see Van Name, 1945, p. 109, and Tokioka, 1953, p. 201.

**Records.** East Coast U.S.A., West Indies (Van Name, 1945; Herdman, 1886, etc.); Philippines (Van Name, 1918); Indonesia (Gottschaldt, 1898); Japan (Tokioka, 1949, 1951, 1953, 1962); Port Jackson, New South Wales (Macdonald, 1859; Kott, 1962); Western Australia (Kott, 1962); Queensland (Kott, 1962); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, single specimen).

**Description.** Thin investing sheet, 2 cm diameter. Common cloacal openings plentiful. Zooids supported by discrete strands of test between basal and surface test, arranged in circular groups of about 6 zooids with endostyles directed to centre of each group. Common cloacal cavity extends from behind zooid to surface test. No spicules, but numerous oval to spherical cells in test throughout, giving white colour to colony. Brown pigment on abdomen, branchial lobes, and endostyle. Abdomen at right angles to thorax. Thorax large but delicate with large atrial aperture, 4 rows of long rectangular stigmata. Two testes lobes with simple hooked vas deferens. Basal test with numerous developing embryos. Six distinct branchial lobes with pigment at base of deep cleft between lobes.

**Larvae.** As described (Kott, 1962) with distinctive single large blastozooid same size as ooozyoid. The large oval cells in adult test are also present in larval test.
Remarks. Most of the above synonyms have been separated on geographic grounds alone. However, numerous species from this area have been shown to have a similar geographic range (T. savignii, A. sydneiensis, P. vittata) and continued separation on this ground alone seems unjustified. Leptoclinum takeharai Tokioka has been distinguished by an enlargement in the proximal part of vas deferens; however this occurs in many species when distended with sperm and does not provide adequate grounds for separation as Tokioka (1953) has already suggested. The deep cleft between branchial lobes which has been used to distinguish L. macrolobium has been apparently exaggerated by the distribution of dark pigment at the base of the cleft, as in the present specimens. Leptoclinum macrolobium and the present specimens only have this deep cleft between branchial lobes but as other characters including the larvae are the same it may be a character which varies with the age of the colonies. It does not in any case appear to be a sufficient ground for specific separation. The firm texture of the colony mentioned by many authors is not due so much to a limited common cloaca but is due to the accumulation of zooids in circular clumps and the lateral orientation of the abdomen. Leptoclinum listerianum Milne Edwards, as described from the North Sea, Irish Sea, English Channel, and Mediterranean seems indistinguishable from the present species and they may be synonymous (Kott, 1962, p. 304), in which case the name L. listerianum holds priority over L. rayneri. The species is very similar to L. ostrearium (Michaelsen) 1930 in the form of colony, presence of spherical to oval cells, delicate branchial sac with rectangular stigmata and zooids in groups. However, the present species has no spicules and the larva form has a blastozooid (Kott, 1962, for larva of L. ostrearium).

LEPTOCLINUM VIRENS Hartmeyer

Leptoclinum virens Hartmeyer, 1909, p. 1456; Tokioka, 1942, p. 500.
Diplosoma viride Herdman, 1906, p. 341.
Diplosoma virens; Hastings, 1931, p. 102.

Records. Ceylon (Herdman, 1906); Palau I., Caroline Group (Tokioka, 1942); Queensland (Hastings, 1931); East Point, Darwin, Northern Territory, Australia (coll. E. Pope, present collection, numerous colonies).

Description. Small oval, or long, colonies on Eunicid worm tube. Central cloacal opening. Cloacal cavity surrounds zooids supported by test sheath between surface and basal test. Zoochlorellae in cloacal cavity. Zooids very small, thorax half size of abdomen. Stomach more or less rectangular. Two testes lobes, simple hooked vas deferens. Test tough and zooids and larvae isolated from it with difficulty. Zooids bud prolifically from oesophageal region.

Larvae (Fig. 8). Present in test strands behind zooids. Distinctive, as although the oozooid otolith and otocyst are present the oozooid itself appears to have been resorbed, replaced by large cells; 2 small blastozooids anteriorly behind frontal plate. Usual 3 suckers and 2 pairs of ectodermal ampullae.

Remarks. In addition to the zoochlorellae in the cloacal cavities (which does not provide a specific distinction), the zooids and particularly the thorax are distinctive. The present specimens share with those from other areas a tendency to prolific oesophageal budding. Colonies with a single central cloacal opening are also distinctive.

Distribution Ceylon and northern Australia and Palau I. in the Caroline Group north of Indonesia. This insignificant species may therefore be expected to occur in Indonesia.
**ECTEINASCIDIA NEXA** Sluiter

_Ecteinascidia nexa_ Sluiter, 1904, p. 11.

**Records.** Indonesia (Sluiter, 1904); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, single clump of 10 zooids).

**Description.** Small, pale green, transparent zooids maximum length 4 mm. Each zooid fixed to a basal stolon by the whole of ventral side or posteriorly without development of stalk. Branchial aperture terminal, atrial aperture from mid-dorsal surface. Both apertures sessile. Body musculature transverse bands across dorsal surface, extending no further than halfway down sides of zooid. Muscle bands best developed on right. Dorsal lamina a series of pointed languets. Seventeen rows of stigmata, 19 longitudinal vessels on each side of branchial sac supported by papillae at junctions with transverse vessels, only about 1 stigma per mesh. Alimentary canal a transverse loop at posterior end of body, rectum not extending very far anteriorly due to mid-dorsal position of atrial aperture. Stomach oval, without spiral folds. Mid-intestinal region differentiated.

**Remarks.** This species resembles _E. multiclathrata_ Sluiter 1913 and _E. jacarens_ Tokioka 1954 in its method of sessile fixation; however, both the latter species have a smaller number of rows of stigmata. _Ecteinascidia tortugensis_ Plough & Jones (Van Name, 1945) from Florida is also similar in colour, fixation, position of apertures, course of alimentary canal, number of rows of stigmata, and can be distinguished only by the greater development of external siphons and the distribution on the east coast of America. _Ecteinascidia tokarensis_ Tokioka 1954 has a more pronounced double loop of the alimentary canal although the atrial siphon is well posterior; the development of transverse muscles is similar.

**ECTEINASCIDIA HATAII** Tokioka


**Records.** Palau I., Caroline Group (Tokioka, 1950); Great Barrier Reef, Queensland (Kott, 1964); Fannie Bay, Darwin, Northern Territory, Australia (on rocks, coll. E. Pope, present collection, single clump of specimens with 25 zooids).

**Description.** Single clump of 25 zooids joined to basal plate by which colony was fixed to substrate. Zooids 1 cm long with very short stalk posteriorly. Apertures sessile, yellow pigment spots line siphons internally. Transverse muscle bands on anterior part of body interrupted dorsally over rectum and ventrally over endostyle. Anterior muscle bands continuous over dorsal surface behind atrial siphon. Dorsal tubercle egg-shaped with transverse slit anteriorly on widest part of tubercle. Branchial sac with 16 internal longitudinal vessels supported by papillae. Stomach with 5 spiral ridges. Gonads in loop of gut – a circle of radiating testes lobes around central ovary.

**Remarks.** These specimens conform with previous descriptions and in particular all zooids have the 5 spiral ridges on the rectangular stomach. This apparently distinguishes the species from others closely related (Kott, 1964).

The species has been recorded from the Caroline Group north of Indonesia and on the Great Barrier Reef of Queensland and therefore may be expected to occur elsewhere in Indonesia.
Subfamily ASCIDIINAE Herdman
Genus PHALLUSIA Savigny

PHALLUSIA DEPRESSIUSCULA Heller

Ascidia depressiuscula Heller, 1878, p. 5; Herdman, 1906, p. 305.
Phallusia depressiuscula; Van Name, 1918, p. 116; Hastings, 1931, p. 80; Tokioka, 1952, p. 111.
Pachychlaena oblonga Herdman, 1880, p. 461; 1882, p. 222; 1891, p. 596; 1898, p. 446; 1899, p. 15.
Pachychlaena obesa Herdman, 1880, p. 462; 1882, p. 223; 1891, p. 596; 1898, p. 446; 1899, p. 15.
Phallusia oblonga × obesa; Traustedt, 1885, p. 16; Hartmeyer, 1909, p. 1403.
Phallusia obesa; Michaelsen & Hartmeyer, 1928, p. 308; Millar, 1963, p. 723.
Ascidia obesa; Kott, 1952, p. 303.
Ascidia phallusioideis Herdman, 1899, p. 12.

Records. Ceylon (Heller, 1878; Herdman, 1906); Philippines (Van Name, 1918); Indonesia, Arafura Sea (Sluiter, 1919; Tokioka, 1952); northwestern Australia (Hartmeyer, 1909; Michaelsen & Hartmeyer, 1928; Millar, 1963); eastern Australia (Hastings, 1931; Kott, 1952; Herdman, 1880, 1882, 1899); Northwest I., Capricorn group (coll. Ward and Boardman, 1929, Aust. Museum collection, 3 specimens).

Description. Smoky grey, stiff gelatinous test without foreign bodies attached. Dark brown pigment cells in test, especially plentiful in anterior part of body, in test vessels, especially in plentiful terminal ampullae of test vessels. Specimens 7 to 10 cm long. Smallest specimen with sessile siphons, medium specimen with branchial siphon recurved to right in characteristic manner; short atrial siphon. Largest specimen with apertures opening towards dorsal surface, no appreciable siphons externally. Two specimens with broad, rounded posterior end, other specimen posteriorly produced into stalk for fixation. Internally atrial siphon short, from anterior half of dorsal surface. Mantle with irregular muscles on right. Prebranchial area papillated. Dorsal tubercle small, shallow U- or deeper E-shaped slit, directed anteriorly; very numerous secondary openings into peribran chial cavity. Branchial sac with 5 to 6 stigmata per mesh, longitudinal vessels carried halfway up broad papillae with several rounded expansions from papillae just above longitudinal vessel. Alimentary canal filled with mud from distal end intestine, around second loop and in proximal part of rectum. 17 – 20 finger-like anal lobes, their length and breadth depending on the expansion of the anus. Base of atrial siphon well anterior to pole of first alimentary loop.

Remarks. After a careful survey of the literature it has been found impossible to separate species listed as synonyms above (Table 3). The condition and position of the siphons is variable (present specimens, Van Name, 1918, and Herdman, 1880, 1882); fixation of the animal to its substrate varies from whole of left side (Van Name, 1918), part of left side and posterior, to production of posterior part of body into stalk (Tokioka, 1952, present specimen, Herdman P. oblonga); mud content of the gut varies and mud may or may not be present: and any combination of these characters may exist. Similarly the number of branchial vessels, tentacles, and secondary tubercles vary. The form and size of the dorsal tubercle vary although generally it is small and horns, although they may be turned in, are reported as spiralling inwards only in specimens from Ceylon. Generally specimens have been described as smoky, earthy, or even darker brown. Pigment in the terminal ampullae of the test vessels may be yellow (Herdman P. obesa), purplish black (Hastings), or darker than the rest of the test (Herdman P. oblonga). Tokioka had whitish semitransparent specimens; however specimens
observed from the Gulf of Carpentaria (Kott, unpublished), although whitish and semitransparent without pigment cells in the general test, do have dark cells in the blood vessels, in the very ramified test vessels, and in their terminal ampullae. Millar (1963), Kott (1952), and Herdman (1899) had specimens with black spots, or "little black areas scattered over the surface" with lighter brown spots and papillae representing enlarged knobs of blood vessels (Herdman, 1899, p. 14). Tokioka (1950, 1961) and Kott (1964), both working with probably reasonably fresh material, describe for P. julinea brown pigment cells distributed generally through the test, interrupted by yellow areas where blood vessels proliferate into the surface test in limited areas or on surface papillae. The situation is therefore the same for P. depressiuscula and P. julinea and variations in pigmentation may be explained as the effects of metabolism or artefacts of preservation on the blood pigmentation together with variations in the distribution of pigment cells in the matrix of the test; either absent or apparently

### TABLE 3

**P. depressiuscula, P. obesa, P. julinea**

<table>
<thead>
<tr>
<th>Author</th>
<th>Size (mm)</th>
<th>Colour</th>
<th>Atrial Siphon</th>
<th>Branchial Siphon</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. julinea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hartmeyer 1911</td>
<td>76-88</td>
<td>yellowish grey</td>
<td>mid-dorsal</td>
<td>not recurved</td>
</tr>
<tr>
<td>Tokioka 1950</td>
<td>75</td>
<td>yellow in test ampullae</td>
<td>mid-dorsal</td>
<td>not recurved</td>
</tr>
<tr>
<td>Tokioka 1952</td>
<td>80-94</td>
<td>white opaque</td>
<td>varies</td>
<td>not recurved</td>
</tr>
<tr>
<td>Kott 1952</td>
<td>-</td>
<td>whitish yellow</td>
<td>anterior 1/3</td>
<td>not recurved</td>
</tr>
<tr>
<td>Kott 1964</td>
<td>45-50</td>
<td>Smoky brown to white, yellow in test ampullae</td>
<td>mid-dorsal</td>
<td>not recurved</td>
</tr>
<tr>
<td>Tokioka 1961</td>
<td>51</td>
<td>Milky white</td>
<td>anterior 1/3</td>
<td>not recurved</td>
</tr>
<tr>
<td>P. obesa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herdman 1882</td>
<td>80-100</td>
<td>brown with darker brown or yellow in test ampullae</td>
<td>-</td>
<td>not recurved</td>
</tr>
<tr>
<td>Kott 1952</td>
<td>-</td>
<td>yellowish brown with black spots</td>
<td>anterior 1/3</td>
<td>recurved</td>
</tr>
<tr>
<td>Millar 1963</td>
<td>-</td>
<td>black spots</td>
<td>anterior 1/3</td>
<td>recurved</td>
</tr>
<tr>
<td>P. depressiuscula</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Van Name 1918</td>
<td>102-112</td>
<td>smoky brown</td>
<td>mid-dorsal</td>
<td>not recurved</td>
</tr>
<tr>
<td>Hastings 1931</td>
<td>60</td>
<td>dark brown to purplish black</td>
<td>anterior 1/3</td>
<td>not recurved</td>
</tr>
<tr>
<td>Tokioka 1952</td>
<td>90</td>
<td>whitish</td>
<td>anterior 1/3</td>
<td>recurved</td>
</tr>
<tr>
<td>Present collection and Gulf of Capricornia</td>
<td>70-100</td>
<td>smoky brown or translucent white</td>
<td>anterior 1/3</td>
<td>varies</td>
</tr>
</tbody>
</table>
absent (Tokioka, 1952), limited to small areas or spots over the test (P. obesa; Millar, Kott, and Herdm an), concentrated mainly in the anterior part of the body, or evenly throughout. Variations described in the pigmentation of preserved animals therefore cannot be explained merely in terms of the effects of preservation.

Phallusia depressiuscula therefore may be characterized by: stiff, thick gelatinous test with proliferation of test vessels into numerous ampullae in the surface; pigment cells in test matrix, in test vessels and ampullae; muscles on right side of body only; longitudinal branchial vessels carried on papillae: simple dorsal tubercle and secondary openings into peri-branchial cavity; alimentary canal a double loop, with or without mud in the region of the second loop: anus fringed by about 20 finger-like lobes: fixation to substrate by whole or part of left side, by posterior, or stalked: apertures sessile, or on siphons turned dorsally or to the right.

Phallusia julinea Sluiter as originally described was a larger specimen than generally designated to this species and is indistinguishable from P. depressiuscula as defined above. Since then Sluiter’s species have accommodated specimens that are generally smaller (P. julinea: 4.5 to 9.4 cm; P. depressiuscula: 6.0 to 11.2 cm), more yellow, with atrial siphon often more posterior and its base posterior to the pole of the first alimentary loop (but not always); and specimens more often fixed by the whole of the left side (but not always). Secondary tubercular openings are also less numerous than in the present species although this may be explained by this size difference of the animals concerned. The range of variation therefore in both P. depressiuscula and P. julinea indicates an overlapping of characters and if distinctions exist they may be found to be due to size of the individuals.

As variations of pigmentation are so great is it possible that P. nigra (from Australia, Kott, 1952), P. melanostoma Sluiter (from Indonesia) may represent variations of the present species where the proportion of black pigment cells in the test is increased. Phallusia depressiuscula; Hastings 1931 certainly represents an approach to this condition. This would explain the extraordinary occurrence of a new world form (P. nigra) in Australia (Kott, 1952).

The species is distributed from Ceylon, via Indonesia to the Philippines, northern Australia, western and southeastern Australia. This distribution covers the same geographic area as P. julinea, and the Australian records of P. nigra; Kott are within the range. Therefore the suggested synonymy of the latter two species would not be at all inconsistent with the distribution.

Phallusia julinea Sluiter


Records. Indonesia (Sluiter, 1919); Palau I. (Caroline Group), Noumea (Tokioka, 1950, 1961); northwestern Australia (Hartmeyer, 1919; Kott, 1952); Cottesloe, Western Australia (Millar, 1963); Great Barrier Reef, Queensland (Kott, 1964); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, 2 specimens).

Description. Narrow, fairly small zooids, dark colour around siphons and in stripes internally in siphons or completely black all over. Terminal branchial siphon, atrial siphon halfway down dorsum. Fixed along whole of left ventral surface. Minute pointed papillae on surface. Two to three accessory dorsal tubercle openings in line between ganglion and tubercle. Dorsal lamina ribbed with ribs continuous with membranous languets bordering lamina. Branchial sac
with about 5 stigmata per mesh, papillae at junctions of vessels, with some intermediate papillae associated with accessory transverse vessels. Alimentary canal a double loop with both loops closed, occupying the posterior two-thirds of body length. Pole of primary loop anterior to atrial siphon.

Remarks. These specimens conform with previous descriptions of the species. Distribution indicated around the north coast of Australia and in Indonesia. The close relationship of the species with *P. depressiuscula* (Heller) is discussed above.

Genus ASCIDIA Linnaeus

**ASCIDIA GEMMATA Sluiter**


**Records.** Indonesia (Sluiter, 1895); eastern Australia (Herdman, 1899); western Australia (Michaelsen & Hartmeyer, 1928; Hartmeyer, 1919; Noumea, 1952); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, 1 specimen).

**Description.** Small, glassy, transparent test; 4 cm long, of which half is tubular branchial siphon; 1.5 cm wide. Short atrial siphon from posterior one-third of body (excluding branchial siphon). Alimentary canal primary loop extends anterior to rectum, halfway up body. Second loop swollen with mud.

**Remarks.** Distribution circum-Australian, Indo-Malayan, and from Noumea.

**ASCIDIA SYDNEIENSIS Stimpson**

*Ascidia sydneiensis* Stimpson, 1855, p. 387.


**Records.** West Indies; Indonesia; Malaya; Japan, Pacific, South Africa; circum-Australia; Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, 1 specimen).

**Description.** This specimen conforms with previous descriptions of the species.

**Remarks.** This species has a particularly wide distribution extending from Tasmania, and the southern tip of South Africa to Japan. It occurs also in the West Indies.

**ASCIDIA AUSTERA Sluiter**


**Records.** Indonesia (Sluiter, 1904); Queensland (Kott, 1964); Fannie Bay, Darwin, Northern Territory, Australia (on rocks, coll. E. Pope, present collection, single specimen).

**Description.** Apertures sessile, atrial aperture one-third distance down dorsal surface. Test clear, transparent, minute tubercles on surface but no hairs; fixed by most of left side. Simple U-shaped dorsal tubercle, prebranchial zone with minute papillae; 4 to 5 stigmata per mesh, spatulate papillae at junction of vessels, no intermediate papillae. Double-looped intestine.

**Remarks.** Confirms previous descriptions. Range from East Indies to northern Australia and the Great Barrier Reef.
Suborder STOLIDOBRANCHIATA Lahille
Family STYELIDAE Sluiter
Subfamily BOTRYLLINAE Adams
Genus BOTRYLLOIDES Edwards

BOTRYLLOIDES LEECHII (Savigny)

*Botryllus lechii* Savigny, 1816, p. 199.

For further synonymy see Kott, 1952, p. 258; Millar, 1962, p. 177.

**Records.** Western Europe; Mediterranean; Australia; New Zealand; South Africa; Fannie Bay, Darwin, Northern Territory, Australia (on rocks, coll. E. Pope “Just below Oyster Zone on an overhang”, present collection, single colony).

**Description.** Purple investing colony, zooids in long systems, purple pigment especially along both sides of endostyle. Wide atrial opening and long upper lip. Pear-shaped stomach with short caecum, 10 stomach folds, Gonads not evident.

**Remarks.** A similar distribution to *Ascidia sydneiensis* except that *B. lechii* has been taken from western Europe and not from the West Indies.

Subfamily STYELINAE Herdman
Genus STYELA Fleming
Subgenus CNEMIDOCARPA Huntsman

**STYELA (CNEMIDOCARPA) AREOLATA** Heller

*Styela areolata* Heller, 1878, p. 26; Herdman, 1906, p. 316; Van Name, 1918, p. 87; Tokioka, 1950, p. 145.


*Styela (CNEMIDOCARPA) AREOLATA*; Kott, 1964, p. 138.

*CNEMIDOCARPA VALBORGI* Hartmeyer, 1919, p. 35.


*Styela (CNEMIDOCARPA) IRMA*; Kott, 1952, p. 217.

**Records.** Ceylon (Heller, 1878; Herdman, 1906); Japan (Tokioka, 1953–1954); Palau I., Caroline Group (Tokioka, 1950); Noumea (Tokioka, 1961); Philippines (Van Name, 1918); Western Australia (Michaelsen & Hartmeyer, 1928; Kott, 1952); northeastern Australia (Hastings, 1931; Kott, 1964); Fannie Bay, Darwin, Northern Territory, Australia (on rocks, coll. E. Pope, present collection, single specimen).

**Description.** White, thin, leathery test with purple pigment anteriorly around siphons. Twelve stigmata per mesh; 2 to 5 longitudinal vessels between, and 7 to 9 on the folds. Dorsal tubercle with U-shaped slit directed anteriorly, both horns turned in. Alimentary canal usual long double loop, although in this case no endocarp enclosed in primary loop; short plicated stomach. Two long gonads on right converging to atrial opening; single gonad on left curving around anterior to pole of primary gut loop. Anal border fringed with lobes.

**Remarks.** Although this species usually has numerous endocarps in the gut loop they are absent here. This may represent an abnormality of this particular individual but is not considered significant taxonomically as otherwise the specimen agrees with previous descriptions, in the condition of the test, purple colouration anteriorly, body musculature, branchial sac, gut, and gonads. It is one of the few species which have been recorded from Ceylon as well as Indonesia, has a wide range on the coast of Western Australia, and otherwise has a distribution through the Philippines and Japan similar to that of other species from this area.
**Styela (Cnemidocarpa) stolonifera** Herdman


*Records.* Port Jackson, New South Wales (Millar, 1963); Moreton Bay, Queensland (Herdman, 1899; Kott, 1952); northern Queensland, Tasmania, Western Australia (Kott, 1952); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, single specimen).

*Description.* Characteristic external appearance with white furrowed test and both apertures on siphons anteriorly. Posteriorly the test produced into a short stalk. Body musculature a continuous layer of circular muscles externally, internally a layer of very numerous wide longitudinal bands. Some purple pigment anteriorly on test extending into siphons. Alimentary canal partly behind branchial sac, forming narrow primary loop enclosing 4 to 5 large endocarp, secondary gut loop not very deep. Stomach long, narrow, pleated. Anus fringed by 14 irregular but rounded lobes. Gonads tubular, branched, 4 on right, 2 on left, some branches on left projecting down into second gut loop, some extending anteriorly to pole of first loop.

*Remarks.* Millar (1963) has proposed the synonymy of this species with *S. areolata* Heller (see above). However, although there are certain similarities in the branchial sac, nature of the test, and purple pigmentation, *S. stolonifera* may be distinguished in the following ways: the body form of the present species is constant and characteristic, long, with siphons anteriorly produced and adjacent; the body musculature is distinguished by the continuous coat of outer circular muscle which in *S. areolata* is limited only to the anterior part of the body; the stomach is longer in the present species, the gut loop narrower and the endocarps though variable in number are never more than 5 while 8 to 11 have been recorded for *S. areolata*; the endocarps of the latter species are always narrow while those of *S. stolonifera* are thicker and often flat topped. While *S. areolata* has been recorded from north Australia, Indonesia, Ceylon, and Japan, the records of *S. stolonifera* are from Rottnest I., Western Australia, across the south coast and up the east coast to northern Queensland. Therefore although it is possible that there is a circum-Australian distribution for the present species, and that across the north of Australia it would coincide with the range of *S. areolata*, records of the two species at this stage merely overlap in northern Queensland.

**Genus POLYCARPA** Heller

**POLYCARPA longiformis** Tokioka


*Records.* Arafura Sea (Tokioka, 1952); Thursday I. and Sarina, Queensland (Kott, 1952, 1964); East Point, Darwin, Northern Territory, Australia (“L.W.M. Spring tide fauna”, coll. E. Pope, present collection, single specimen); Moreton Bay, Queensland (present collection, 2 specimens).

*Description.* Upright specimen, both apertures on siphons, atrial siphon slightly posterior to branchial siphon. Test leathery, quite thick and externally wrinkled. Body wall very thin and closely adherent to test. Dorsal tubercle with U-shaped slit, right horn turned in, opening directed slightly to right. About 14 longitudinal vessels on folds, 4 between. Alimentary canal forms horizontal loop in posterior part of body almost behind branchial sac. Rectum turns at right angles to loop running anteriorly to terminate at base of atrial siphon. Anal border with dendritic lobes. Tall endocarps in loop of gut. Long oval polycarps more
or less in about 5 rows, about 16 on each side of the body, lying on their sides and directed to base of atrial siphon.

Remarks. This species has been recorded only from the Banksian and Dampierian marine faunal regions.

**Polycarpa moebii** Michaelsen


Records. Southeastern, southern, and southwestern Australia (Michaelsen, 1905; Michaelsen & Hartmeyer, 1928; Kott, 1952); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, 3 specimens).

Description. Thick test, smooth externally. Apertures sessile, branchial aperture terminal, atrial aperture halfway down dorsum. Body wall very muscular, inner body wall with spongy appearance and polycarps embedded in body wall. Dorsal tubercle U-shaped, directed anteriorly with both horns spiralled outwards. Branchial sac with widely separated folds not overlapping, not very high, about 2 longitudinal vessels between folds and 7 on folds. Most ventral folds represented by only a few longitudinal vessels. Transversely lengthened meshes with about 10 stigmata between folds. Large circular endocarp in loop of gut, anal border with about 6 rather shallow lobes, sometimes bidentate at tip.

Remarks. These specimens are distinguished by characteristically thick spongy body wall and embedded polycarps, distinctive gut loop, endocarp and branchial sac. *Polycarpa obtecta*; Kott 1952 undoubtedly refers to individual variants of the present species. The species is recorded mainly from the West Indies and there is no indication of its extension out of that general area. *Polycarpa moebii* recorded from around the coast of Australia from west, south to northeast.

Family **PYURIDAE** Hartmeyer

Genus **PYURA** Molina


Records. Japan (Tokioka, as above); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, 3 specimens).

Description. Small, from spreading base, maximum diameter 2.5 cm, 1.5 cm high. Siphons from opposite ends of upper surface, only slightly protruding. Test tough, thick, surface differentiated into polygonal plates which cover surface extending onto siphons, absent only from basal surface fixed to substrate. Basal test very thin. Body wall muscular with strong band of circular muscle internally at base of siphon. Externally circular muscle only on anterior part of body; longitudinal bands internally radiating from base of siphons converging posteriorly on basal surface where those in the antero-postero plane are continuous and bands from right and left sides fade out. Internal muscle bands at base of siphons associated with tentacles and in contracted specimens projecting into lumen of branchial sac bearing tentacles on its free edge (Fig. 9). Dorsal tubercle (Fig. 10) a long slit with posterior end bent to left. Peritubercular area very long extending almost to mid-dorsum. About 12 well-branched branchial tentacles. Branchial sac with 6 high folds on each side of the body with about 16 to 20 internal longitudinal vessels on folds, 2 between; 3 to 4 stigmata per mesh. Gut loop simple,
narrow, ending in lobed anus. Single long gonad on each side of body consisting of long duct, separate sacs along its length; one young specimen with only three gonad sacs (Fig. 11) but in better developed forms 4 to 5 either side of central duct. Arrangement of sacs along duct apparently quite random, their situation either side of duct not suggesting pairing.

Remarks. The species is very similar to Pyura tessellata (Forbes) from western Europe (Berrill, 1950) and Pyura squamata Hartmeyer from the Antarctic (Hartmeyer, 1911, p. 439). It is distinguished from the former by the branchial sac; however the species from the Antarctic can be distinguished at present only by its thinner test and greater number of gonad sacs. The distinctions between Pyura squamata and Pyura lepidoderma are therefore most unsatisfactory although a distribution from Japan through to the Antarctic continent is difficult to imagine. The species is small, however, and closely adherent to rocks, etc., which may explain the lack of records at least between Japan and northern Australia.

PYURA VITTATA (Stimpson)

Cynthia vittata Stimpson, 1852, p. 142.


Records. East coast, U.S.A. (Van Name, 1945); Japan (Tokioka, 1952); Palau I., Caroline Group (Tokioka, 1950); Arafura Sea (Tokioka, 1952); circum Australia (Kott, 1952, 1964) Kerguelen I. and Macquarie I. (Kott, 1954); south Indian and Atlantic Oceans (Millar, 1960); Fannie Bay, Darwin, Northern Territory, Australia (coll. E. Pope, present collection, single specimen); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, single specimen).

Description. Small leathery specimens, test tough uneven. Both apertures sessile on upper surface, fairly close together, in one specimen depressed into surface of test, in other specimen protruding slightly from test (Figs. 12, 13). Inner lining of siphons extending out over outer surface of openings, covered with same long spines, directed away from opening as found lining siphons. Colour of siphon lining in Australian specimens green, although Japanese, Antarctic, American specimens pigmented red in siphon linings. Pigmentation of siphon linings in stripes corresponding to lobes of apertures. Spines lining siphon 0.175 mm long. Dorsal tubercle a simple U with horns rolled in, directed anteriorly. Dorsal lamina a series of fine languets. About 12 tentacles of moderate size, smaller and rudimentary tentacles alternating between. Six folds per side, 10 to 20 longitudinal vessels per fold, about 2 to 5 between successive folds. Alimentary canal narrow simple loop enclosing left gonad. Anal border plain. Gonads a tubular duct on each side of body with a double row of numerous gonad sacs along both sides of each duct.

Remarks. There has been considerable confusion concerning this species. Pyura jacatrensis; Kott 1952, 1954, is identical with the present specimens and certainly not with P. jacatrensis Sluiter (Hartmeyer 1919), as, although specimens from Western Australia (Kott, 1952) are almost colonial and have wart-like siphons (as described for Sluiter's species), the siphonal spines in the latter are only 0.03 mm long and the animals are laterally flattened while the spines of the present rounded or dorso-ventrally flattened species are more than 0.1 mm. Pyura albanensis Michaeelsen & Hartmeyer 1928 has even longer siphonal spines (0.26 mm) and lacks a dorsal lamina; these distinctions cannot
be explained by the size of Michaelsen & Hartmeyer's specimen which was only 3 cm. long. *Pyura vittata* is characterized by a leathery test, short siphons lined with spines more than 0.1 mm long, with 6 branchial folds per side and a simple alimentary loop enclosing a double row of gonad sacs along each side of a duct on the left, with a similar gonad on the right. There is some variation in the width of the alimentary loop – but this may vary with the development of the gonads; there is also some variation in the anal border (Millar, 1960) and the siphonal lining may be red or green. The extension of siphonal lining and spines onto the external surface of the siphons has been noted particularly for the specimens from Japan and Australia, but it does occur in specimens from sub-Antarctica.

There is therefore, as Millar (1960) has indicated no character known at present which could distinguish more than one species from these populations extending over a tremendously wide geographic area – i.e. circum Australia, Indonesia, and Japan extending across the southern oceans (the Indian and Atlantic and Pacific) to the east coast of U.S.A.

Genus *HERDMANIA* Lahille

**HERDMANIA MOMUS** (Savigny)

*f. grandis* Heller

*Cynthia momus* Savigny, 1816, p. 143.
*Cynthia grandis* Heller, 1878, p. 97.
*Pyura momus* Savigny f. grandis; Michaelsen & Hartmeyer, 1928, p. 441.


**Records.** Southern Australia (Kott, 1925; Millar, 1960); Western Australia (Michaelsen & Hartmeyer, 1928; Kott, 1952); eastern Australia (Heller, 1878; Herdman, 1899; Kott, 1952, 1964; Millar, 1963); Japan (Tokioka, 1953); Hervey Bay, Queensland, (coll. Mrs. G. McKeon, present collection, single specimen).

**Description.** Laterally compressed, 2 cm wide, 2 cm high, soft white gelatinous test. Thirteen branchial folds on each side of body. Complicated dorsal tubercle. Gonads not developed. Distinctly lobed anal opening.

**Remarks.** There has been considerable confusion concerning the relationships of specimens in this species. Michaelsen distinguished certain forms which have been found to accommodate Australian specimens (Michaelsen & Hartmeyer, 1928; Kott, 1952, 1964). However, Tokioka (1953), Van Name (1945), and Millar (1960, 1964) suggest the distinguishing characters may be merely an indication of maturity, etc.

The present specimen, although immature and in the size range of *H. momus* f. *momus* Savigny (syn. *H. momus* var. *curvata* Kott 1952, 1964), has the dorsal tubercle, branchial sac, and anal lobes of *H. momus* f. *grandis*.

The combination of characters distinguishing these two Australian forms from one another and from others is so constant that true species may be indicated. Distributional records indicate a more or less sympatric range for many of the forms. *H. momus* f. *momus* is recorded from the Queensland coast and from the Red Sea; *H. momus* f. *grandis* from western, southern, and eastern Australia and from Japan; *H. momus* f. *pallida* (Heller), with unlobed anus, has confusing records from western Australia, the Philippines, the Indian Ocean, Malaya, and the West Indies and is not sufficiently distinguished from f. *galei* Michaelsen, recorded from eastern and western Australia (Michaelsen & Hartmeyer, 1928).

Records of distribution are therefore, at present, most unsatisfactory.
Genus MICROCOSMUS Heller

MICROCOSMUS AUSTRALIS Herdman


For further synonymy see Kott, 1952, p. 288; Millar, 1963, p. 741.

Records. Circum Australia (Herdman, 1899; Millar, 1963; Kott, 1952); New Zealand (Brewin, 1948); Darwin, Northern Territory, Australia (coll. E. Pope, present collection, numerous specimens); Hervey Bay, Queensland (coll. Mrs. G. McKeon, present collection, numerous specimens).

Description. Usual variable leathery test, pinkish colour, siphons variable length.

Remarks. Externally this species is extremely variable; however, the branchial sac always has a large number of folds, spines present in the siphon lining, and a double-looped alimentary canal.

References

ASCIDIANS FROM NORTHERN AUSTRALIA


