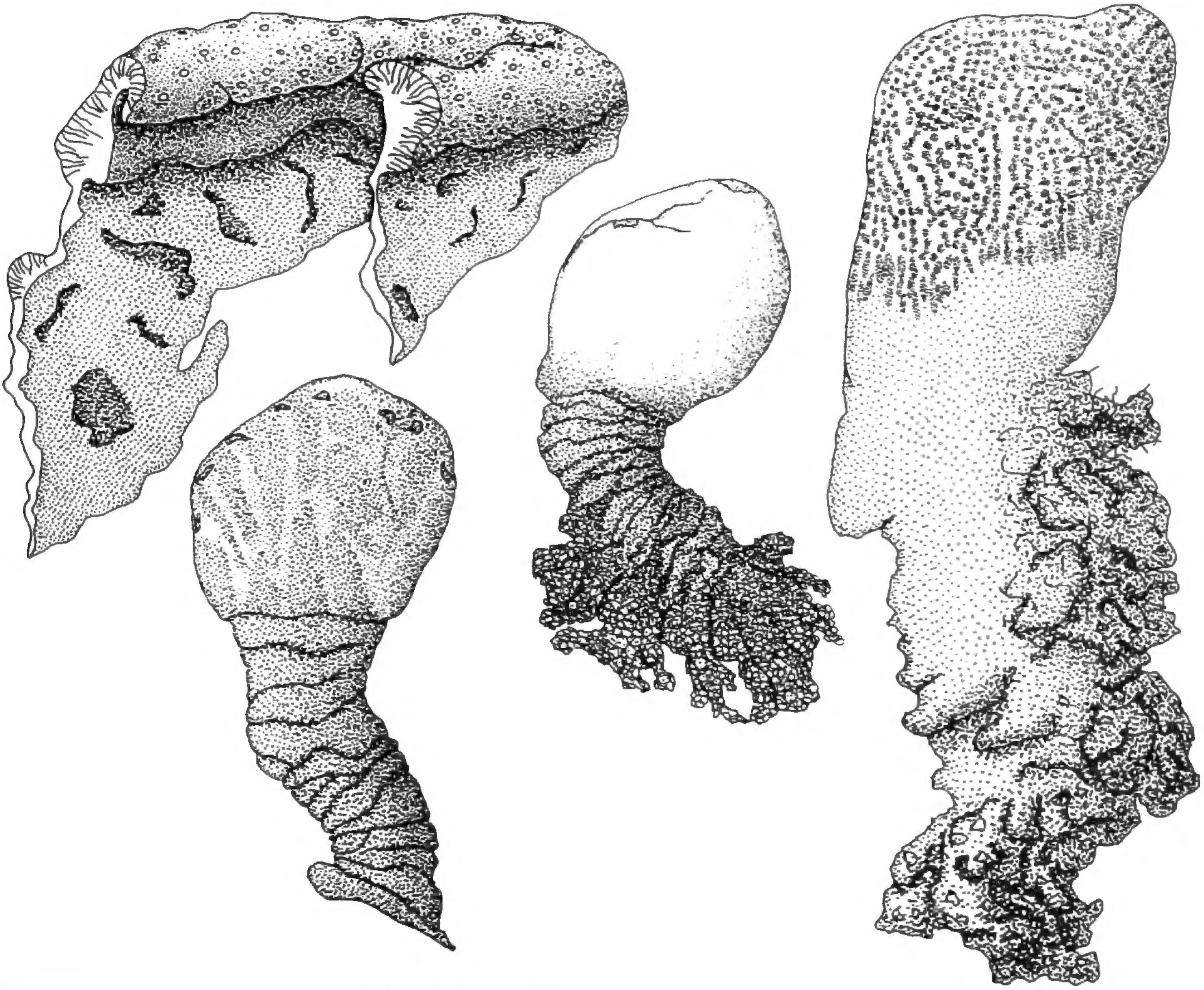
MEMOIRS

OF THE

QUEENSLAND MUSEUM



BRISBANE
1 OCTOBER, 1992

VOLUME 32
PART 2

From the President's Desk

The XII International Congress of Arachnology was held at the Queensland Museum, Brisbane, from 12th to 18th July, 1992 under the joint auspices of the Trustees of the Queensland Museum and the Centre International de Documentation Arachnologique. More than 122 registrants from 32 countries and 37 accompanying persons participated.

The 114 presented papers covered nearly all fields of arachnological research, reflecting the progress in our knowledge of arachnids. This progress may encounter some scepticism from particularly the older, loyal participants since every president in each presidential report underlines the 'progress made during the last three years'. A congress program does not reflect the actual research level, but only the fields of interests of participants whose attendance at congress depends on economic or other factors. Real progress can be emphasised in the fields of biology, ecology, bio-indication and phylogeny. However, we might be regressing in taxonomy because the number of taxonomists remains stable while the numbers of identifications requested by ecological and other studies (raising new taxonomical problems) are increasing. Some arachnid groups will perhaps be 'orphaned' in the near future as specialists retire from active study.

Arachnids are fascinating animals of great biological importance. Is there any reason not to tell this more frequently to 'the public'? Ecologists should allow a reasonable fee for identification of their material when submitting grant applications.

At the meeting of CIDA members held during the Congress, Dr R. Jocqué was elected the new CIDA president.

The congress excursion was held mid-week at O'Reilly's, Lamington Plateau, where participants could discover the rich bird and arthropod fauna of the forest, stroll through the botanical garden or have an exciting canopy walk.

Brisbane was a marvellous occasion to meet friends and colleagues, but also (at least for me) a wonderful time to discover a fascinating continent and its plants and animals, and I am sure that we will come again. Thanks to all of the organising staff and the people we had the chance to meet for their friendliness and helpfulness.

'Le Roi est mort, vive le Roi'. Hopefully we will meet in Geneva in 1995.

Volker Mahnert

President, Centre International de Documentation Arachnologique 1989-1992

MEMOIRS OF THE QUEENSLAND MUSEUM, VOLUME 32

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PART 1 (Issued 29 June, 1992)

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PART 2 (Issued 1 October, 1992)

THE AUSTRALIAN ASCIDIACEA PART 3, APLOUSOBRANCHIA (2)

PATRICIA KOTT

Kott, P. 1992 10 01: The Australian Ascidiacea Part 3, Aplousobranchia (2). *Memoirs of the Queensland Museum* **32**(2): 375–620. Brisbane. ISSN 0079-8835.

In this continuing systematic revision of the taxonomy of the class Ascidiacea (subphylum Tunicata) taxa in the formerly polyphyletic family Polyclinidae Milne Edwards are treated. Included are all species recorded from Australian waters with a posterior abdomen containing the gonads, and usually the heart. New families are erected to accommodate the genera formerly grouped in the polyphyletic Euherdmaniinae, viz. Placentelidae (*Placentela*), Protopolyclinidae (*Protopolyclinum*, *Monniotus*, *Condominium* n.gen.), Ritterellidae (*Ritterella*, *Dumus*, *Pharyngodicyton*), Euherdmaniidae (*Euherdmania*) and Pseudodistomidae (*Pseudodistoma*, *Anadistoma* n.gen., *Citorclinum*). The family Polyclinidae is redefined and restricted to the genera formerly comprising the nominal subfamily Polyclininae, viz. *Polyclinum*, *Aplidiopsis*, *Sidneioides*, *Synoicum*, *Morchellium* and *Aplidium*.

Larvae, observed for the majority of species, have characters significant at species, genus and family levels, and constitute valuable evidence of phylogenetic affinities. Embryos are incubated to tailed larvae internally in all taxa, usually being fertilised and beginning their development in the distal part of the oviduct, sometimes in a brood pouch constricted off from the zooid and sometimes at the base of the oviduct.

Colony development is significant in this group of aplousobranch taxa in which replication is prolific. Zooids are arranged in various colonial, including cloacal, systems. In taxa with extensive cloacal spaces (*Aplidium*), and in those with a soft test (e.g. *Polyclinum*), intracolonial hydrostatic pressure appears to contribute to colony turgidity. Sand and other inclusions in the test add strength and contribute to diversity in colony size and shape.

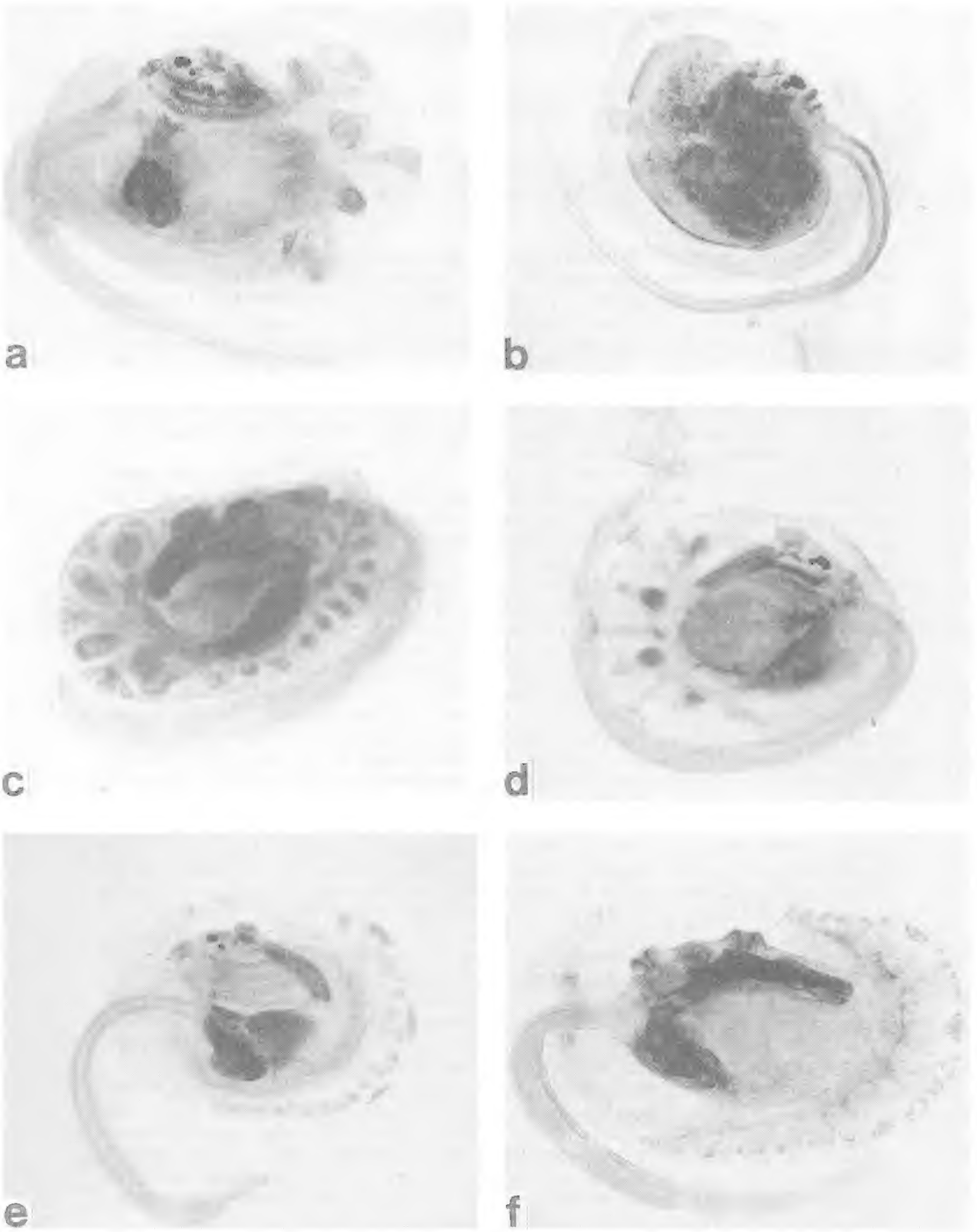
Parallel reduction in the size of zooids often results in convergent evolution, especially in size (number of rows of stigmata and number per row) of the branchial sac and size of larvae. Some taxa (*Pseudodistoma*, *Polyclinum*) have zooids and larvae with conservative morphology, and differences in colonial systems and colony shape and texture often determine species-level taxa. Zooid and larval morphology are more diverse in *Ritterella*, *Synoicum*, *Aplidiopsis* and *Aplidium*, with differences in the atrial aperture, stigmata, stomach wall and arrangement of larval ampullae and vesicles, as well as features of the colony and its systems, providing characters for species determination. Other characters, such as the nature of the larval adhesive apparatus, presence of branchial papillae, length of the oesophagus, nature of the stomach wall, and shape of the posterior abdomen and arrangement of male follicles in it, are significant indicators of relationships at higher (genus or family) taxon levels.

Sixty-two of the total of 110 species treated in this work are new. Many may be indigenous, but these families are not always well sampled, not often being found intertidally. Collection by SCUBA diving enables a diversity of habitats to be sampled and the range of forms treated in this work is largely the result of efforts of these divers. Other difficulties in studying this group, which have resulted in synonymy and misidentification, are colour variation and its post mortem change and loss, loss of colony and zooid turgor obscuring their shape and arrangement, and contractibility of zooids obscuring their morphology.

The most diverse genera in these waters are in the Polyclinidae, in which zooids are organised around well developed cloacal cavities. *Aplidium* is the most diverse genus, and is well represented in both tropical and temperate waters by species with large and conspicuous colonies. Of the families with independently opening zooids without cloacal systems, Pseudodistomidae and Ritterellidae are well represented, especially in certain temperate locations. Euherdmaniidae and Protopolyclinidae are less diverse although each contains some species with wide temperate geographic ranges common in certain locations.

☐ *Indo-West Pacific, Ascidiacea, Aplousobranchia, Placentelidae, Protopolyclinidae, Ritterellidae, Euherdmaniidae, Pseudodistomidae, Polyclinidae.*

Patricia Kott, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; 1 April, 1992.



Frontispiece: larvae of Aplousobranchia — **a**, *Pseudodistoma australe* (see Fig. 17g); **b**, *Euherdmania digitata* (see Fig. 13f); **c**, *Polyclinum fungosum* n.sp. (see Fig. 25d); **d**, *Aplidium inflorescens* n.sp. (see Fig. 82c); **e**, *Aplidium altarium* (see Fig. 62e); **f**, *Aplidium filiforme* n.sp. (see Fig. 75e).

CONTENTS

INTRODUCTION

Ascidians of the suborders Phlebobranchia (one of the 2 suborders of the order Enterogona) and Stolidobranchia (the only suborder of the order Pleurogona) were reported on in part 1 of the present work (Kott 1985); and 7 families of Aplousobranchia (the other suborder of the Enterogona) were dealt with in part 2 (Kott 1990). The following account (part 3) continues the review of the Aplousobranchia, dealing with genera formerly contained in the family Polyclinidae Milne Edwards, 1842. These genera are here assigned to 6 different families, 5 of them new (Table 1).

Didemnidae (Aplousobranchia), the only family not yet treated, will comprise part 4 of this monographic treatment of the Ascidiacea in Australia.

The collections on which the work is based are those set out in parts 1 and 2 (Kott 1985, 1990). Museums housing the material examined are referred to by the following abbreviations: AM, Australian Museum, Sydney, New South Wales; BM, British Museum (Natural History), London, UK; QM, Queensland Museum, Brisbane, Queensland; SAM, South Australian Museum, Adelaide, South Australia; TM, Tasmanian Museum, Hobart, Tasmania; MV, Museum of Victoria, Melbourne, Victoria; NTM, Northern Territory Museum, Darwin, Northern Territory; WAM, Western Australian Museum, Perth, Western Australia; USNM, US National Museum of Natural History, Smithsonian Institution, Washington DC, USA; ZMA, Zoological Museum of Amsterdam, Amsterdam, Netherlands; ZMC, Zoological Museum, University of Copenhagen, Copenhagen, Denmark. AMPI refers to the Australian Marine Photographic Index (Neville Coleman).

All specimens referred to by a museum registration number have been examined in the course of the present study. A registration number in italics refers to a sampled portion of the preceding colony.

Throughout this work, the characters of species are summarised to provide a general overview of the diversity of each genus. Dichotomous keys are presented as aids to the identification of taxa at all levels. They have been prepared, as far as possible, to reflect phylogeny. This type of key is generally used for biological material in preference to tabular keys such as those in Monniot (1987). The latter provide too rigid a framework for the analysis of diverse biological material, communicate only a limited amount of information, lack the flexibility to distinguish between convergent and phylogenetic relationships, are open to subjective interpretation, and are unnecessarily unwieldly and ambiguous to use.

Procedures for collection and examination of species are set out in Kott (1990). Examination of specimens is by stereoscopic and compound light microscopy. All larvae are described from stained and mounted specimens taken from adult colonies as indicated.

ACKNOWLEDGEMENTS

I am grateful to those of my collegues, as set out in parts 1 and 2, who, in various material ways, have contributed to the preparation and presentation of these volumes; and to those who have made less tangible, but equally significant contributions by their support and encouragement.

The black and white figures were prepared from camera lucida and other sketches of the specimens by Stephen Cook (Figs 1a–d, 2–6, 7b–d, 8a, 9a–f, 11a–f, 13a–e, 14, 17b–3, 18a–c, 19, 21a, 24, 27, 28a, 35a,b–e); Lucille Crevola Gillespie (Figs. 7a, 17a, 22a); and John Kennedy (all other figures including the larvae of all taxa). Peta Woodgate typed the manuscript. I am grateful to them all. Sue Boyd with Christine Mateira in the Museum of Victoria; Penny Berents in the Australian Museum, Loisette Marsh with Jean Thipthorp in the Western Australian Museum, and Wolfgang Zeidler with Karen Gowlett Holmes in the South Australian Museum have been co-op-

gut loop behind pharynx	colonial, and/or gut loop vertical	no internal longitudinal vessels or forked vestiges	branchial apertures 6 lobed	replicates generated by division of zooids	replicates not by oesophageal budding	gonads in posterior abdomen	stigmata in more than 3 rows	stomach halfway down short abdomen	heart in posterior abdomen	cloacal systems absent	posterior abdomen not constricted		RITTERELLIDAE n. fam.	APLOUSOBRANCHIA
											posterior abdomen constricted		PROTOPOLYCLINIDAE n. fam.	
										cloacal systems present			POLYCLINIDAE emend.	
									heart in abdomen				PLACENTELIDAE n. fam.	
								stomach at posterior end of long abdomen					EUHERDMANIIDAE	
							stigmata in 3 rows						PSEUDODISTOMIDAE n. fam.	
						gonads in abdomen							POLYCITORIDAE	
					replicates by oesophageal budding								DIDEMNIDAE	
				replicates generated in vegetative stolens	lobes of apertures smooth								HOLOZOIDAE	
					lobes of apertures denticulate								STOMOZOIDAE	
			branchial apertures not lobed	abdomen more than twice length of thorax; embryos fertilised at base of oviduct; larval adhesive organs inverted tubes									PYCNOCLAVELLIDAE	
				abdomen not more than twice length of thorax; embryos fertilised at top of oviduct; larval adhesive organs with axial cone									CLAVELINIDAE	
		internal longitudinal branchial vessels or forked vestiges											DIAZONIDAE	
	solitary, and gut loop horizontal												CIONIDAE	
gut loop at side of pharynx	gut on right side of pharynx	stigmata straight										RHODOSOMATINAE	CORELLIDAE	PHLEBOBRANCHIA
		stigmata coiled										CORELLINAE		
	gut on left side of pharynx	internal longitudinal branchial vessels represented by papillae											AGNESIIDAE	
		internal longitudinal branchial vessels entire	pharynx flat; gonads on left side only	gonads not embedded in the test	solitary								ASCIDIIDAE	
					colonial								PEROPHORIDAE	
				gonads embedded in the test									PLURELLIDAE	
			pharynx folded; gonads on both sides	simple branchial tentacles	solitary							STYELINAE	STYELIDAE	STOLIDOBRANCHIA
					colonial	cloacal systems absent						POLYZOINAE		
						cloacal systems present						BOTRYLLINAE		
				branched branchial tentacles	rectangular stigmata; no renal vesicle								PYURIDAE	
					stigmata not rectangular; renal vesicle present	pharynx whole body length perforated by spiral or irregular stigmata							MOLGULIDAE	
						pharynx short anterior band, perforated by circular stigmata							HEXACROBYLIDAE	

TABLE 1. Ascidiacea – Graphic Key to families

erative and prompt in response to my many requests for large specimen loans.

During 1991 large collections from all around Australia also became available to me from the Australian Institute of Marine Science (AIMS), Townsville, through Dr Peter Murphy. This important collection was made by Rob McCauley and his colleagues (AIMS Bioactivity Group), by SCUBA, as part of their Shallow Water Marine Organism Collection Program for the National Cancer Institute (1992-1996). This collection includes photographs of the living colonies *in situ*. The voucher specimens are now registered in the collection of the Queensland Museum.

Grants from ABRS (1980–82) and MST (83/1320) supported the author's field programme. The work was also supported by the ARC (A19031140).

ANNOTATED GLOSSARY

A discussion of the morphology of aplousobranch ascidians and their larvae in the Australian Ascidiacea Part 2 (Kott 1990) refers particularly, although not exclusively, to families reviewed therein. Morphological features, and their variations and functional implications that have not been discussed previously, are reviewed in the glossary that follows. It should be used in conjunction with the glossaries in parts 1 and 2 (Kott 1985, 1990) to appreciate the full range of functional adaptations and other morphological variations in ascidians, (with the exception of the Didemnidae).

adhesive organs: Each of the 4 types of adhesive organs present in the families discussed below, occurs also in other possibly related aplousobranch families.

1. Deeply invaginated tubular adhesive organs, as in Pycnoclavellidae, are in Euherdmaniidae. They are arranged in a triangle when 3, or in the median line when only 2. They suggest a relationship with Pycnoclavellidae.
2. The 3 median adhesive organs in Pseudodistomidae have a hollow, completely eversible axial protrusion in a deep epidermal cup and are either sessile or stalked. The axial protrusion is flat-topped or conical, and apparently lacks the columnar cells found in the axial cones of Holozoidae (*Distaplia*: see Cloney 1977). When everted it is thin-walled and balloon-like, and may have closer affinities with the adhesive organs of Pycnoclavellidae than any others.
3. The 3 median adhesive organs in Protopolyclinidae are stalked, and have an axial cone composed of long columnar cells in a deep epidermal cup. They resemble the adhesive organs of Holozoidae (see Cloney 1977) and Didemnidae (see Turon 1991).
4. The 3 stalked adhesive organs in the anterior mid-line in Ritterellidae and Polyclinidae have a shallow, wide axial cone in a tight epidermal cup. These resemble the adhesive organs of Polycitoridae, although they are smaller. Their relationship to the adhesive organs of Clavelinidae, and Holozoidae awaits investigation.

Epidermal ampullae may also have an accessory adhesive function. (See also **larvae, ampullae, vesicles**).

ampullae, epidermal —, larval —: Outgrowths of the anterior larval epidermis, possibly accessory adhesive organs. In Aplousobranchia they are absent from *Pycnoclavella*, *Euherdmania* and a few other species level taxa in other genera in which size reduction appears to have resulted in simplification.

Ampullae project from the base of triradial adhesive organs (Clavelinidae, Holozoidae). Ampullae arise from lateral ridges along each side of median adhesive organs and also from the median line alternating with them (Polycitoridae, Protopolyclinidae n.fam., Ritterellidae n.fam., Pseudodistomidae n.fam., Polyclinidae). In the new families Protopolyclinidae (*Monniotus*) and Ritterellidae (*Dumus*), and in Polyclinidae (*Polyclinum*, *Aplidiopsis* and some *Aplidium* spp.) the terminal ends of the ampullae have a cap of modified, possibly secretory cells. (See **larvae, vesicles**).

ampullary vesicles: see **vesicles**

anal opening, anus: The rectum continues anteriorly, embedded in the body wall along the dorsal border of the pharynx. Its opening into the atrial cavity is invariably bilabiate in the present aplousobranch families. Its position relative to the atrial apertures (which are normally antero-dorsal) appears determined by selective pressures affecting the position of gonoducal openings. Faecal pellets are found in the rectum but never in the atrial cavity. Presumably, when necessary, the anus is brought into a position near the base of the atrial siphon by muscular action, so that the faecal pellets can be ejected directly to the exterior. Although the oviduct is sometimes diverted into a brood pouch, or is turned ventrally, the opening of the vas deferens is usually associated closely with the anus, the advantage possibly being that sperm also can be expelled directly to the exterior with the excurrent water.

In Placentelidae n.fam., in which numerous embryos are incubated in what probably is an elaborate brood pouch in the distal part of the oviduct (where it lies in the atrial cavity), the anus is in a primitive position in the anterior part of the atrial cavity, opposite the second or third row of stigmata. This is in a position comparable with most Diazonidae, in which the gonoducal openings, at the base of the atrial aperture, are associated with the release of gametes directly to the exterior for external fertilisation.

The anus and gonoducal openings are at mid-thoracic level in most other genera discussed below. In all these families fertilisation and incubation is either in the atrial cavity or in the distal part of the oviduct. Only in Euherdmaniidae and the (probably) related Pycnoclavellidae, both with characteristically long abdomina, are anal and gonoducal openings at the base of the atrial cavity; and in both fertilisation is at the base of the oviduct — at the posterior end of the long abdomen.

apertures: In most aplousobranch ascidians, irrespective of the form of their systems, branchial apertures are 6-lobed. Exceptions in which the branchial apertures are 8-lobed are in some *Ritterella* spp. (viz. *R. pedunculata*), *Aplidium* spp. (e.g. *A. amorphatum*, *A. protectans*) and *Morchellium*. Apparent subdivision of branchial lobes in some species *Aplidium* (e.g. *A. macrolobatum* n.sp. and *A. incubatum* n.sp.) results from contraction of a band of muscles that extends up the centre to the tip of each lobe.

Separately opening 6-lobed atrial, as well as branchial, apertures interrupt the surface test of colonies in the new families Placentelidae, Protopolyclinidae, Ritterellidae, Euherdmaniidae, and Pseudodistomidae. None of these contain genera with true cloacal systems although other colonial systems, or rudimentary cloacal systems, sometimes occur. Some narrow, stalked Ritterellidae n.fam. (*R. asymmetrica*, *R. pedunculata*) have the zooids in colonial systems with atrial apertures in a row along one side of the flattened, terminal edge of each stalk, and branchial apertures in a row on the opposite side. In other species (*R. papillata* n.sp., *R. cornuta* n.sp., *R. compacta* n.sp.) the atrial apertures are in the centre of the terminal end of lobes of the colony surrounded by the branchial apertures to form rudimentary cloacal systems in which excurrent water from all zooids is ejected in a single stream from the centre of the circular system. Similar rudimentary cloacal systems occur in Polycitoridae (see Kott 1989, 1990). At least in *R. cornuta* n.sp., *in situ* photographs show the flat terminal end of the colony lobe directed away from the oncoming current; and the excurrent stream of water from the centre of each end is entrained by the current as it passes the colony. The arrangement of the apertures of the separate zooids of *Monniotus* spp. is similar to *Ritterella asymmetrica* and *R. pedunculata*, with atrial apertures on the convex side of the spoon-shaped head, and branchial openings on the concave side. A large flap of test along their upper margin directs the branchial apertures downwards (Kott 1989). Also in Protopolyclinidae n.fam., colonial systems of *Condominium* n.gen. have zooids arranged in single lines along flat fan-shaped lamellae. Atrial apertures open in a line on the convex side of the lamella, near and parallel to the top of the colony, on the opposite side to the groove in which the branchial apertures are concealed. The row of atrial apertures are also concealed in a groove when zooids contract.

Very likely the linear arrangement of zooids and their apertures in the hard, sandy, often rigid test is a result of the pressures to direct and separate the respective incurrent and excurrent ciliary streams in these species with separately opening zooids. The compression of the atrial aperture into a transverse opening or slit and the division of its rim into an anterior and a posterior lip usually with 6 lobes on each (e.g. *Monniotus*, *Condominium* gen. nov. and some sandy *Ritterella* spp.) further controls and directs the incurrent and excurrent streams of water.

The relatively large, usually gelatinous, separate zooids in Euherdmaniidae often have large external lobes around the apertures (e.g. *E. dentatosiphonis*, *E. translucida* n.sp.) that resemble those of Stomozoidae (see Kott 1990), although in the latter family the zooids are not separate, being embedded in common test. The function of these enlarged lobes around the apertures, which involve the test as well as the body wall of the zooids, is not established. It is possible that they help to direct the ciliary current, and, to some extent may act as sense organs through the pigment spots at their base which, like similar pigment spots in *Ciona*, Diazonidae and some Phlebobranchia (see Kott 1985, 1990), may be light sensitive. Generally, the lobes around the apertures have musculature associated with the longitudinal muscle bands of the thorax, and the sphincter muscle that surrounds each aperture behind the lobes.

Zooids in stalked colonies of Pseudodistomidae are arranged in the colony like those of some species of Clavelinidae (*Nephtheis*), and Holozoidae (*Sigillina*), all with atrial apertures uppermost and branchial apertures directed toward the stalk so that each stalked head forms a single colonial (but not cloacal) system as discussed by Kott (1989, 1990).

In Polyclinidae, the zooids are arranged in cloacal systems, either around cloacal cavities, or along each side of canals that converge to common cloacal apertures. The atrial apertures open into the sides or base of these cloacal cavities or canals. The openings either are relatively large, exposing part of the branchial sac to the cloacal cavity (as in *Sycozoa* or *Distaplia*); or there is a short, narrow protuberant siphon with a distinct sphincter muscle and a small terminal aperture. Each opening has a flattened atrial lip (or tongue) projecting from its upper rim or from the body wall anterior to the opening. This projection is strap- or leaf-like, triangular or subdivided into 2 or 3, and its tip is straight edged, pointed, bi- or tri-dentate or serrated. Sometimes the circular muscle around the opening continues through the base of the lip, and muscle fibres from the sphincter extend out into the lip (e.g. *Aplidium uteute*, *A. altarium* and the majority of *Synoicum* spp.). Other species, usually with protuberant siphons, have the sphincter muscle (and the aperture) independent of the atrial lip (*Aplidium crateriferum* and related species, and *Polyclinum* spp.).

The size of the atrial lip varies according to its role in effecting the closure of cloacal apertures and contraction of the cloacal canals. An example can be seen in *Polyclinum vasculosum* in which the anteriorly oriented atrial aperture is in the base of the cloacal canals, while the large atrial lip stretches along the top of the canal, and in some cases reaches and is inserted into the test around the cloacal aperture.

ascending limb of gut loop: see gut, gut loop.

atrial aperture, — lip, — tongue: see apertures

atrial cavity: In taxa in which it opens directly to the exterior through a 6-lobed atrial aperture, the atrial cavity, its size varying with the size of the thorax, is a relatively contained chamber in which (often large) numbers of embryos complete their development to tailed larvae. Only in some *Pseudodistoma* is a special incubatory pouch constricted off from the atrial cavity.

In Polyclinidae the atrial cavity is a similarly contained chamber in those species in which the atrial aperture is a small anteriorly directed circular opening separate from the atrial tongue (viz. many *Polyclinum*, *Sydnerioides*, and *Aplidium* species, and some *Synoicum* species). In the species in which the atrial tongue is part of the rim of the aperture and the circular muscles of the aperture diverge out into the atrial lip, the aperture itself is less restricted, and when relaxed is a large opening exposing the atrial cavity directly to the cloacal cavity. Both types of atrial aperture are present in *Aplidium* and *Synoicum*. No apparent correlation exists between the size and form of the atrial aperture and cavity and the size and number of embryos being incubated in the chamber. Only in *Polyclinum*, in which small circular atrial apertures prevail, are the embryos and larvae consistently small (trunk appreciably less than 1 mm long). In this genus embryos also are relatively numerous (usually more than 5 being incubated at a time). Although large atrial cavities result from the relatively narrow branchial sacs in the wide thoraces, the embryos seldom fill the atrial cavity, and in many species they are removed entirely from it, being incubated in a brood pouch separate from the atrial cavity. Under these circumstances, the atrial cavity is not occluded by embryos, and possibly remains functional during the period of their development.

The atrial cavities of small *Aplidium* zooids with short, narrow branchial sacs, are relatively small and are subject to further constriction by longitudinal muscles which extend the length of the zooids.

Other variations in the configuration of the atrial cavity occur as a result of the connectives which conduct transverse muscle fibres from the transverse branchial vessels across the atrial cavity to the parietal body wall. In the large zooids of *Synoicum castellatum* n.sp. a row of these connectives appears to divide the atrial cavity into dorsal and ventral chambers (see *S. castellatum* n.sp. below). It is possible that these chambers are present also in smaller zooids, but not so readily observed.

In the taxa reviewed below, the ventral pouches in the atrial cavity observed in *Sycozoa* and *Distaplia* (see Kott 1990) are not present. These are formed where the cavity extends ventrally over the perforated area of pharyngeal wall but does not penetrate over the triangular areas of imperforate pharynx between the ventral ends of the rows of stigmata. (See also **incubation of embryos**)

branchial papillae: possible vestiges of the branchial papillae which support the internal longitudinal branchial vessels in Phlebobranchia, and some aplousobranch families (Cionidae, Diazonidae), occur in Protopolyclinidae n.fam. (*Protopolyclinum*, *Monniotus*), Ritterellidae n.fam. (*Ritterella compacta* n.sp., *R. coronata* n.sp., *R. multistigmata* n.sp., *R. papillata* n.sp.) and Polyclinidae (*Polyclinum*). These branchial papillae are flat, rounded to short tongue-like projections from the transverse vessels.

Nothing is known of their function and their status as vestiges of phlebobranch branchial papillae is speculative.

branchial sac: In the present group of families the branchial sac becomes progressively smaller, with fewer stigmata and fewer rows of stigmata, in parallel with the reductions in zooid size. Similar trends can be observed in Polycitoridae (*Polycitor* to *Eudistoma*) and Holozoidae (*Sigillina* to *Sycozoa* and *Distaplia*). Placentelidae n.fam. have a large broad pharynx with many rows of numerous stigmata. In Protopolyclinidae n.fam. the number of rows of stigmata as well as the length of each row are as great or greater (up to 20 rows of up to 50 stigmata in *Condominium* n.gen.) than in Placentelidae n.fam. In Ritterellidae n.fam. the zooids are reduced in size and although stigmata are in up to 16 rows, often there are only 5, and in *Dumus* only 4. The number of stigmata in each row are similarly reduced from a maximum of 35 to 12.

The branchial sacs (together with the solitary zooids) of *Euherdmania*, which does not replicate as freely as other taxa, remain relatively large with numerous rows of up to 100 stigmata per row.

Pseudodistomidae n.fam. have 3 long rows of stigmata, in a wide pharynx.

The greatest size reduction in zooids can be observed in the polyclinid genus *Aplidium* in which prolific replication occurs, and zooids are arranged in cloacal systems. In this genus the stigmata occasionally are in only 5 rows. Although the length of the stigmata often is reduced, the number of rows is not, and most species have from 12 to 20 rows of stigmata. *Synoicum* species have similar reductions in size of the branchial sac. The most conspicuous difference between these genera and other polyclinid genera is their reduction in the size of the perforated pharynx. *Polyclinium* and *Aplidiopsis* have relatively large branchial sacs.

Internal longitudinal branchial vessels are present only in Cionidae and Diazonidae; and the only vessels in the branchial sac of all other aplousobranch taxa are transverse. The primary transverse vessels are the unperforated expanses of the pharyngeal wall between the rows of stigmata. On their mesial side, the walls of these vessels are ciliated endoderm projecting into the lumen of the pharynx. On the parietal side the epithelium is ectodermal and not ciliated. Transverse muscle fibres are in the transverse vessels and these join the muscles of the parietal body wall through connectives that cross the atrial cavity (see **atrial cavity**; *Synoicum castellatum* n.sp., below)

Parastigmatic vessels, extending across the stigmata halfway between the primary transverse vessels, sometimes subdivide the stigmata along their length creating additional rows. More often they occur in species with long stigmata and persist as inconspicuous strands which hold the delicate interstigmatal bars in place, and prevent distortion of the stigmata. Parastigmatic vessels occur in Protopolyclinidae n.fam. (*Monniotus* spp. and *Condominium* n.gen.) and Ritterellidae n.fam. (e.g. *Ritterella asymmetrica*, *R. multistigmata* n.sp.). Despite the large size of *Euherdmania* zooids, the stigmata are relatively short and disposed in numerous rows. Parastigmatic vessels are not known in this genus nor are they known in the short branchial sacs of Pseudodistomidae n.fam. In Polyclinidae they are known in some species of *Aplidium* with relatively large branchial sacs (e.g. *Aplidium amorphatum*, *A. parastigmaticum* n.sp.).

branchial tentacles: although these are not specifically counted in the descriptions that follow, a ring of short, relatively stumpy tentacles of various sizes is always present at the base of the branchial siphon, protecting the incurrent aperture. Intrageneric variations in the tentacles do not appear significant taxonomically.

branchial vessels: see **branchial sac**.

brooding, brood pouch: see **incubation**.

budding: see **replication**.

cloacal cavities, — systems: As in Polycitoridae (see Kott 1990) some other taxa with independently opening atrial apertures and embedded zooids have their zooids arranged in incipient or rudimentary cloacal systems. Thus, in Ritterellidae n.fam., *R. papillata* n.sp. and *R. cornuta* n.sp. have zooids arranged in circles with their atrial apertures in a depression in the centre of the circle and their branchial apertures around the periphery; and in *R. compacta* n.sp. the excurrent apertures open into a circular chamber lined with sand which appears to be an invagination in the surface of the colony.

In Polyclinidae a high degree of organisation into cloacal systems is achieved. These systems range from simple circles of zooids around circular chambers with a central cloacal aperture to rows of zooids arranged along each side of branching canals which converge to a cloacal aperture. Sometimes partitions of zooid-free test occur between adjacent systems, or between parts of the same system (i.e. between converging canals); but in other species the systems are crowded together. In preserved or contracted colonies, zooid-free areas of test, being solid and without cloacal cavities or chambers containing zooids, are prominent and usually protrude from the surface. This is an artefact, for in living, extended specimens, the cavities and zooids are expanded and the surface over them is not depressed.

In Polyclinidae there are relatively few taxa (compared with Holozoidae) in which the colony is a single system (e.g. *Aplidium australiense*, *Polyclinum orbitum* n.sp.). More often colonies, even those with large, regular, circular systems are relatively irregular, and contain a number of cloacal systems, each with a conspicuous cloacal aperture. The systems have the capacity to subdivide forming relatively large, bulky colonies. Despite the capacity of Polyclinidae to form large colonies of one or more systems, the cloacal cavities themselves are relatively narrow canals and small, rounded chambers rather than the extensive 3-dimensional cavities of Didemnidae.

The strength and rigidity of the test, especially when this is firm and gelatinous, or contains embedded sand and/or calcareous particles contributes to the maintenance of colony shape including surface features such as ridges and grooves that affect the organisms' interactions with the environment (such as direction of current flow: Kott 1989). The pressure of excurrent water in the common cloacal cavity (when one is present) also contributes to maintenance of the shape and the configuration of the surface, of the colony. Thus, both factors contributing to the strength and rigidity of the test (such as embedded sand), and also to the turgidity of a large, 3-dimensional cloacal cavity (such as efficient replication increasing the number of zooids contributing to the internal pressure within the cloacal cavities), constitute adaptive advantages favoring the evolution of large, 3-dimensional colonies.

In some species of *Polyclinum*, the surface test has a thin, brittle layer of sand but the internal test is soft. In this case their round colony shape may be maintained by the water pressure in the large pharynges of the crowded zooids rather than the brittleness of the surface layer of test. (See also **apertures**, **colonial systems**, **colonies**).

colonial systems: In other taxa with independently opening atrial apertures, the zooids are not embedded in common test; or are arranged in colonial systems other than cloacal ones; or, rarely, do not have any obvious systematic arrangement in the colony. *Monniotus* and *Euherdmania* zooids either are solitary; or separate from one another, attached to common test or stolons only at their posterior end, and, like separate Diazonidae, Clavelinidae, and Pycnoclavellidae, function as solitary individuals and do not form systems of any kind. As with cloacal systems, other sorts of systems have zooids so arranged to ensure that the functioning of the whole colony exceeds the efficiency of the sum of its component zooids.

Although zooids of *Ritterella compacta* n.sp, *R. cornuta* n.sp. and *R. papillata* n.sp. are in circular rudimentary cloacal systems with their atrial apertures in the centre, *R. asymmetrica*, *R. pedunculata*, *R. multistigmata* n.sp. and *Condominium* gen. nov. have their zooids arranged around fan-shaped stalked colonies, with the branchial and atrial apertures on opposite sides of the colony margin. Incurrent and excurrent streams, respectively, reinforce one another, and are kept apart; and the long narrow stalks enable the colony to change its orientation with the prevailing currents.

Stalked *Pseudodistoma* with all atrial apertures directed to the top of the colony and the branchial apertures directed downwards towards the point of attachment are equally flexible with regard to changes in current flow. Other benefits from this uniform arrangement of apertures include protection of the open incurrent apertures from falling sediments (Kott 1989; see also **apertures**, **cloacal systems**).

colonies: The size and form of colonies reflects their phylogeny, toughness of test and amount and type of embedded material. More primitive families such as Diazonidae, Clavelinidae and Pycnoclavellidae, do not usually form particularly large self-supporting colonies. However, generally other aplousobranch families have firm and gelatinous test, resembling the test of phlebobranch families in consistency; or it is strengthened externally or throughout with sand or other hard (including calcareous) particles. When strengthened, large often complex self-supporting colonies are formed. Occasionally species such as *Pseudodistoma fragile* and *P. gracilum* with particularly soft almost fluid test also have relatively large colonies, possibly occupying sheltered habitats.

The complexity of colonies of the Ascidiacea is most evident in colonies in which the embedded sand makes the test hard, brittle and allows it to form massive 3-dimensional branching colonies (e.g. *A. solidum*); or in intricate colonial systems (e.g. *A. crateriferum*, *Condominum areolatum* n.gen., n.sp.). However, although complexity in shape appears to require sand or other inclusions in the test, the size of colonies *per se* is not related to sand inclusions (e.g. gelatinous colonies of *Polycitor* and *Aplidium* become as large as some of the sand-strengthened colonies in these genera).

As well as affecting the size and form of the colonies, the consistency of the test, which is directly affected by the type and quantity of material embedded in it affects the configuration of the surface test, which, in turn, can modify the currents flowing over the colony and influence its interactions with the environment. In many *Ritterella* spp. and in *Monniotus* a layer of brittle sand-embedded surface test protects the incurrent and excurrent apertures and separates the currents flowing through them. In Polyclinidae the operation of the colony is enhanced by its ability to sort sand and to determine precisely its distribution. For instance, in *Aplidium tabascum* n.sp. a single line of fine sand particles outlines the margins of the firm zooid free areas that protect the branchial apertures; and in *A. caelestis* and *A. macrolobatum* n.sp. fine sand particles are embedded in the thin, flexible test over cloacal cavities, while coarser grains are in the rigid test between the systems.

Colony size and shape does not appear affected by the development of cloacal systems, except that colonies consisting of a single system are a finite size and shape (e.g. *Aplidium altarium* n.sp.) and generally are smaller and more regular than those with multiple systems.

Environmental pressures such as substrate and current flow probably have most influence on the size and shape of the colonies found in any habitat. Thus stalked species appear to occupy habitats where surge alternates the direction of water flow past the zooids; and large spherical, oval, or irregular colonies occupy sea floor habitats at depths where strong currents are not likely to dislodge them from substrates.

Extensive areas of sandy substrate favour large mixed populations of *Monniotus radiatus* n.sp., *Dumus areniferus*, *Ritterella pedunculata*, *R. asymmetrica*, and *R. papillata* n.sp., which all have similar fine, sandy, finger-like colonies embedded in sand — the individuals being more or less held together and stabilised by the sand that accumulates around them (see Kott 1989); and, at the same time, they stabilise the sand. As well as these narrow stalked colonies with hair-like test projections and basal stolons that form sandy aggregates and mats in and over the substrate (e.g. *Pycnoclavella* spp.: Kott 1990, *Ritterella* spp., *Monniotus* spp.), there are other types of colonies that stabilise sandy substrates and protect them from erosion. These are colonies with basal test forming root-like projections that hold them firmly in the substrate (e.g. *Aplidium geminatum* n.sp.), and colonies embedded in the substrate and forming 3-dimensional reticula and branching lamellae (e.g. *Aplidium acroporum* n.sp., *A. petrosum* n.sp., *A. solidum*, and *Polyclinum terranum* n.sp.). (See also **cloacal cavities, colonial systems**).

descending limb (of gut loop): see **gut**.

dorsal lamina, — languets: No continuous fold occurs along the mid-dorsal line of the pharynx in Aplousobranchia as in some Stolidobranchia and Phlebobranchia. Instead pointed languets arise from the transverse vessels to the left of the mid-line, and curve over to the right. These channel the mucous food cord (gathered from the sheets moving dorsally over each side of the pharynx) as it moves posteriorly to the oesophagus.

duodenum: see **gut**.

epidermal ampullae: see **ampullae**.

epidermal vesicles: see **vesicles**.

excurrent aperture: see **apertures**.

fertilisation: About half the extant Ascidiacea are solitary species which, with few exceptions (see below), are externally fertilised. The other half are colonial, and these, with the exception of the Diazonidae, are fertilised internally. The colonial species are predominantly Aplousobranchia, although taxa of Phlebobranchia (Perophoridae) and Stolidobranchia (Botryllinae and Polyzoinae) are included. Solitary species are predominantly Stolidobranchia and Phlebobranchia, only 2 genera of Aplousobranchia (*Ciona* and *Rhopalaea*) being included.

With the exception of *Polycarpa* and some Molgulidae and Agnesiidae, solitary Ascidiacea have long and relatively few male and female gonads, and their ducts open together near the anus, at the base of the atrial siphon. Released gametes thus are ejected, and presumably dispersed with the excurrent ciliary stream. Gametes also are released in the excurrent water as the animal rythmically squirts to irrigate the atrial and branchial cavities. In both cases waste products and gametes are projected well away from the animal where they are not likely to contaminate the incurrent stream (see Hoshino *et al.* 1986, Kott 1989b).

If both male and female gametes of the same mature individual are released together there would be opportunities for self-fertilisation. However there is growing evidence that individuals are generally self-sterile (Santis and Pinto 1991, Fuke 1983, Kawamura *et al.* 1987, Cloney 1990, Litscher and

Honegger 1991). Further, species are not necessarily functional hermaphrodites, and may be either protandrous or protogynous. Other mechanisms may exist to prevent self-fertilisation, one being the possibility that ejected sperm are dispersed further away than ova.

The stimulus for release of gametes is not understood, although their are obvious advantages for one to exist. Under certain conditions light is known to trigger gamete release. Carlisle (1951) proposed that *Ciona intestinalis* released gametes and stopped secreting mucus from the endostyle in response to the presence of a gamete of the same species in the incurrent feeding stream. Although it is an apparent advantage for mucus secretion to stop when fertilisation is internal, it is not for externally fertilised species.

In *Polycarpa*, short gonads and their ducts are scattered over the body wall, and the openings of the ducts are removed from the atrial aperture. Presumably this results in longer retention of gametes of both sexes in the atrial cavity than would be the case if they were released at the base of the atrial siphon. In certain species (*P. intonata*, *P. tinctor*, *P. tinctorella*: see Kott 1985) even longer retention results from the ventral orientation of the short gonoducts, and indeed these species are internally fertilised and embryos are brooded in the atrial cavity. Certain molgulid species are analgous to *Polycarpa* in respect to the arrangement of their male and female gonoducts, and also are internally fertilised, brooding, species. They all have the oviducal apertures turned ventrally, and the openings of the vas deferens distant from the atrial aperture. *Molgula calvata* and *M. manhattensis* (see Kott 1985) have short, multiple openings of the sperm duct along the length of the ovary; and *M. ellistoni*, *M. sabulosa* and *Eugyra* spp. (see Kott 1985) have a short vas deferens, at the proximal end of the ovary, turned ventrally. Although the reproductive strategy of *Adagnesia* spp. is not known, both gonoducts are turned ventrally (see Kott 1985) and probably embryos are brooded internally. Only one species of the Pyuridae, *Pyura littoralis* (see Kott 1985), has short female ducts while retaining a long vas deferens. This may be an adaptation for internal fertilisation, although embryos have not yet been found in the atrial cavity.

It is not known if these internally fertilised solitary species are self-sterile or not. If they are, the reasons for the adaptations found in the majority of these species, which apparently ensure the retention of sperm as well as ova in the atrial cavity, are difficult to understand. Further, if they are self-sterile, it is possible that mucus secretion is interrupted to allow sperm for cross fertilisation to reach the atrial cavity through the pharynx. In *Ecteinascidia turbinata*, at least, it appears not to be drawn in through the atrial aperture with relaxation of body muscles following contraction and squirting (Ryland *pers. comm.*).

Whereas only relatively few solitary species have evolved devices for internal fertilisation, this strategy is universal in colonial species, and once it has evolved it appears never to be lost. The family Diazonidae, which contains some genera retaining a solitary habit, and the related and supposedly primitive solitary Cionidae are the only aplousobranch taxa externally fertilised.

In colonial internally fertilised species (as in solitary ones) the position of each gonoduct relative to the others and to the atrial aperture probably is related to patterns of gamete release and fertilisation. Although the oviduct is often displaced when it acts as a brood pouch, the vas deferens and anus of colonial species open together, usually part of the way up the thorax, and not necessarily close to the atrial aperture. The atrial cavity, although it is often distended with embryos, never contains faeces outside the rectum, and presumably faecal pellets are released by the contraction of the body wall muscles, which irrigates the atrial cavity and brings the anus close to the atrial aperture. Since the opening of the vas deferens is associated with the anus it is possible that gametes are also released in this way. In holozoid genera with cloacal systems, and in the Didemnidae, large atrial apertures often expose anal and gonoducal openings directly to the cloacal cavity. This also happens in some Polyclinidae (*Aplidium*, *Synoicum* and a few *Polyclinum*). Thus, the opening of the male duct of colonial, internally fertilised species (as in solitary externally fertilised ones) is usually positioned where sperm released from it are most likely to be expelled to the exterior, either directly or through the cloacal cavity, rather than being retained in the atrial cavity for self-fertilisation. It is not known whether or not embedded colonial zooids have a pattern of rythmic squirting, like solitary and independent colonial ones, to increase means by which sperm might be released.

Further, colonial, like solitary, species have been shown to be self-sterile (e.g. *Diplosoma listerianum*: Ryland and Bishop 1990; *Botryllus schlosseri*: Sabbadin 1979). In addition to the growing evidence of cytological and chemical mechanisms for self-sterility, the existence of functionally gonochoric colonies in the genus *Sycozoa* (see Kott 1990), and of sequentially hermaphroditic colonies in many other taxa, support the view that colonial, as well as solitary, ascidians are not generally self-fertilised. Sabbadin (1979) reports a protogynous condition for *Botryllus*. Further evidence of protandry or protogyny exists when embryos but not mature male gonads are present and when there are mature male gonads but no embryos suggesting that the male gonads mature either before or after the female ones (see below).

If, as the evidence suggests, internally fertilised colonial species are not self-fertilised, sufficient concentrations of sperm must reach the atrial cavity from outside the zooid for some to enter the oviduct, and move to the fertilisation chamber (the brood pouch, or the proximal end or top of the oviduct, or the atrial cavity) at the time that oocytes reach maturity. Thus it is probable that advantages associated with the synchronous release of gametes are as great in internally fertilised colonial species as they are in externally fertilised solitary ones, especially as colonial zooids are small, with relatively small ovaries, few ova and often ephemeral gonads. Again, little is known of mechanisms triggering such a synchronous release. Further it is not known how sperm enters the atrial cavity. Ryland (*pers. comm.*) found that external material was not drawn into the atrial cavity of *Ecteinascidia turbinata* following its partial evacuation by squirting. It is not kown whether or not embedded zooids do squirt, however even if they do it seems unlikely that sperm could enter zooids through common cloacal chambers against the direction of the ciliary current. Even in independently opening zooids it is unlikely that it would enter directly through the atrial aperture. The alternative hypothesis is that the process reported by Carlisle (1951) for *Ciona intestinalis* is present in colonial species viz. that mucus secretion is interrupted so that sperm entering the pharynx can pass through the stigmata into the atrial cavity, thence into the oviduct

The only colonial, internally fertilised families which seem to be analogous with *Polycarpa, Molgula, Eugyra* and *Adagnesia* species (with short, and ventrally directed vas deferens suggesting retention of sperm in the atrial cavity) are Pycnoclavellidae and Euherdmaniidae, with the gonoducal and anal openings at the base of the atrial cavity. Possibly these families also have mechanisms to prevent self-fertilisation.

The relatively large size of the testis in relation to the ovaries in most colonial species indirectly supports the view that generally cross- rather than self-fertilisation is likely. Otherwise the production of a large amount of sperm for the fertilisation of few oocytes within the same zooid in colonial species would not be economic. Further, it is difficult to entertain an hypothesis that the well established mechanisms ensuring self-sterility reported in Cionidae (see Kawamura *et al.* 1987, Cloney 1990, de Santis and Pinto 1991), Ascidiidae (Litscher and Honegger 1991) and Pyuridae (Fuke 1983) are exceptions from a general condition; especially when selection for short-lived free-swimming, viviparous larvae occurring simultaneously (see Kott 1974, 1982) results in the maintenance of crowded populations with maximal opportunities for gene exchange. (See also **incubation of embryos**).

gastric folds: see **gut**.

gastro-intestinal gland: see **gut**.

gonads: unlike the families discussed in Part 2 (Kott 1990) in which they are in the gut loop, the testis follicles and small ovary of most of the families discussed below are in a posterior abdomen behind the gut loop. The exceptions are some *Euherdmania* (*E. digitata, E. dentatosiphonis, E. translucida* n.sp.) in which they sometimes are in the gut loop, and *Sidneioides* in which the ovary is in the thorax. In Protopolyclinidae n.fam., *Polyclinum* and *Aplidiopsis* the testis follicles are bunched together in a sac-like posterior abdomen separated from the abdomen by a narrow neck with the small ovary surrounded by the testis follicles. In *Sidneioides* a similar sac-like posterior abdomen contains the male follicles, but the ovary is halfway up the thorax, with a short oviduct opening directly into the atrial cavity.

In other taxa (*Euherdmania, Ritterella, Aplidium, Synoicum, Morchellium*) there is no constriction between abdomen and posterior abdomen. The testis follicles in these taxa either are bunched together in a short, thick posterior abdomen, or arranged in one or two longitudinal series in a sometimes thread-like posterior abdomen which is many times the length of the rest of the zooid. In many species of Pseudodistomidae n.fam. gonads seem intermediate between those with testis follicles bunched behind the ovary, and those with testis follicles in a longitudinal series in the posterior abdomen. In most known species of this family the male follicles are bunched together around the ovary in a small part of a long thread-like posterior abdomen. In specimens of *Pseudodistoma candens* n.sp., the vas deferens, distended with sperm, is seen to originate at a point level with the ovary, about halfway down the cluster of male follicles, as if the gonads had turned onto their side to fit into the thin posterior abdomen. *Pseudodistoma gracilum* n.sp. and *Synoicum atopogaster* have a similar arrangement of male follicles.

In genera with male follicles in longitudinal series the ovary is invariably anterior to them and the vas deferens is joined by short vasa efferentia as it extends up the side of the posterior abdomen. When 2 series of testis follicles are present the vasa efferentia alternate between the rows. Male follicles are in a single series when a second is not developed. This appears to be an ephemeral condition and does not constitute a genetic difference. Male follicles arranged in longitudinal series can appear bunched when they are drawn together with contraction of the long posterior abdomina. However, in certain species (*Aplidium altarium, Aplidium uteute*) the testis follicles are actually bunched, with short vasa efferentia joining them to a relatively short vas deferens, in a short posterior abdomen.

The ovary is always small in these families, producing relatively few eggs for internal fertilisation and brooding. Testes, however, are relatively large, but always composed of numerous separate follicles rather than a large single one, as in most taxa of the Ascidiacea. Large, undivided testes are present only in some *Perophora* spp., and in some Polyzoinae (see Kott 1985; see also **fertilisation**).

gonoducal openings, gonoducts: see **fertilisation**

gut, gut loop: Distal to the large pharynx, the gut of aplousobranch ascidians always forms a simple, narrow and usually vertical U-shaped loop, which occupies the length of the abdomen. In the present group of families (characterised by the presence of the gonads behind the gut loop in a posterior abdomen), the range of variations resembles those found in those aplousobranch families in which the gonads are enclosed in the gut loop (see Kott 1990). These variations are:

1. The length of the oesophagus. In Euherdmaniidae this is long, as it is in Pycnoclavellidae and Polycitoridae and to some extent in Clavelinidae, with the stomach in the posterior end of a long abdomen. The oesophagus is relatively short, with the stomach halfway down the abdomen, in Protopolyclinidae n.fam., Ritterellidae n.fam. and Polyclinidae (as it is in Holozoidae and some Clavelinidae). In Pseudodistomidae n.fam. (as in Diazonidae) the oesophagus is of various lengths, sometimes being moderately long. It is almost twice the length of the post-pyloric part of the gut loop in *Pseudodistoma aureum* and even longer in *Anadistoma* n.gen. Occasionally a prestomach enlargement is in the oesophagus, as in *Aplidium altarium*. The only other genus in which this is known is *Clavelina* (*C. moluccensis*, *C. cylindrica*: Kott 1990).
2. The orientation of the stomach. This usually is oblique to the long axis of the zooid, with the oesophagus curving ventrally to enter the cardiac end of an asymmetrical stomach with a short dorsal border and a long curved ventral border. Only in *Aplidium*, *Morchellium*, and in some species of *Ritterella* is the oesophagus straight, entering the cardiac end of a more or less radially symmetrical, vertical barrel-shaped stomach.

   In *Polyclinum* and *Sidneioides* the gut loop usually is horizontal, and slightly twisted, the right or descending limb moving around to lie above the ascending limb, and the posterior end of the loop curving dorsally. The horizontal orientation of the gut loop is reminiscent of Cionidae, and Holozoidae (*Sycozoa*, *Distaplia*).
3. Post-pyloric subdivisions of the gut. These consist of a wide duodenum immediately behind the stomach, and a narrow mid-intestine that expands into a large oval, posterior stomach about halfway along its length. There is thus a proximal (post-pyloric) part of the mid-intestine, as well as a distal (pre-rectal part). This arrangment is found in most other aplousobranch families (see Kott 1990). Only very rarely is there a departure from this pattern — viz. in Pseudodistomidae n.fam. the proximal part of the mid-intestine is wider than usual and is more or less continuous with the duodenum, an external crease marking their junction.

   Pockets in the proximal end of the rectum on each side of its junction with the distal section of the mid-intestine form a rectal valve in many species of aplousobranch, especially *Ritterella*, *Aplidium*, *Aplidiopsis*, *Synoicum*, *Polyclinum*.

   It is possible there are some intraspecific variations in the development of this valve and its appearance is affected by artefacts of preservation and gut contents. It is associated with the long, straight, vertical ascending limb of the gut loop in these families of the Aplousobranchia.
4. The stomach wall is either smooth, both inside and out, interrupted only by a typhlosole (or suture line) along the dorsal border; or it is folded; or, as in *Synoicum*, *Morchellium* and *Aplidiopsis*, its internal lining is raised into circular or irregular glandular areas, and the external surface may also be raised into mulberry-like swellings.

   In *Pseudodistoma* the short, wide stomach is partially divided into 4 shallow, longitudinal compartments. *Aplidium* species, with relatively small zooids and narrow short stomachs, have a relatively large glandular area achieved by longitudinal folding of the stomach wall into from 5 to 30 often deep folds. *Euherdmania*, *Monniotus* and *Ritterella* have similar, though not so numerous longitudinal folds in the stomach wall.
5. A gastro-intestinal gland, with a duct from the pyloric end of the stomach breaking into branches around the ascending limb of the gut, probably always is present in all families of Aplousobranchia, although it is usually conspicuous only in Polycitoridae, and has a storage vesicle only in some Holozoidae.

head: The expanded terminal free end of stalked solitary and colonial ascidians is termed the head. It accommodates the thoraces, which, when expanded, are the widest part of the zooid or individual, and colony and zooid openings are on its surface. The narrow abdomina and posterior abdomina are in the stalk.

heart: The heart is a delicate curved tube in the posterior end of the posterior abdomen in most of the genera discussed below. The exception is *Placentela*, the monotypic genus from the north-western Pacific, which has its heart in the abdomen, presumably retained there in a primitive position while the gonads spill back behind the gut loop (see Nishikawa 1984b).

incubation of embryos: all families discussed in the present work are internally fertilised and embryos, brooded internally by the parental zooids, are released as tailed larvae. The process of replication is well developed. Zooids as a consequence are small and simplified, but numerous (see Kott 1990). Thus, despite the fact that in most cases the embryos are relatively small (< 1 mm) and yolky, few are produced and incubated at a time by any one zooid. The number of larvae being produced by the whole colony is maintained by the large numbers of zooids producing few embryos, rather than few zooids producing a large number.

Larger embryos are found in *Euherdmania*. In this genus eggs are fertilised at the base of the oviduct and are incubated in the oviduct as they move up the long abdomen, as in the possibly related Pycnoclavellidae (see Kott 1990). Relatively large embryos are also produced in *Pseudodistoma* in which the eggs of some species appear to be fertilised and incubated, usually one at a time, in a brood pouch constricted off from the posterodorsal corner of the thorax.

In most of the other taxa discussed below, eggs are fertilised, and the relatively small embryos are incubated in the atrial cavity. Only in *Polyclinum*, which has zooids with large roomy atrial cavities, do the

Adhesive organs (arrangement)		Triradial	Median linear			
Vesicles		No vesicles	No vesicles	With vesicles (except in some simplified Polyclinidae)		
Ampullae	Adhesive organs (type)			Vesicles separate from paired postero-ventral, dorsal, and sometimes anterior epidermal strands	Vesicles separate from paired ventral and dorsal epidermal strands	Vesicles separate directly from epidermis along lateral, and sometimes, median lines
No ampullae	Thin-walled everting tubes	Pycnoclavellidae *Sigillina mjöbergi* Euherdmaniidae				
With ampullae (except some simplified Polyclinidae)	Thin-walled everting cylinders or spheres		Pseudodistomidae			
	Axial cones or platforms large: wider than deep	Clavelinidae	*Sigillina* *Hypodistoma* *Eudistoma* *Polycitorella*			
	Axial cones moderate to large: deeper than wide	Holozoidae (except: *Sigillina* *Hypodistoma*)	*Polycitor* *Cystodytes*	Protopolyclinidae		
	Axial cones small: wider than deep			Ritterellidae (not aequalisiphonis group) *Polyclinum* *Synoicum* spp.	*Synoicum* spp. *Aplidium lunacratum* *Aplidium multilineatum* *Aplidium ornatum* *Aplidium protectans* *Aplidium robustum* *Aplidium tabascum*	*Ritterella* spp. (? aequalisiphonis group) *Synoicum* spp. *Aplidium* spp.

TABLE 2. Summary of epidermal elements at anterior end of larval trunk in aplousobranch families.

particularly small embryos (larval trunk seldom more than 0.6 mm long) appear not to occlude the pharynx, even when relatively large numbers are present at a time (up to 12 embryos: *P. fungosum*). Nevertheless, it is in this genus that a brood pouch sometimes is present (*P. marsupiale*, *P. tsutsuii*, *P. terranum* n.sp.) constricted off from the body wall in a unique position, about halfway along the dorsum of the thorax at the level of the anus. It is most probable that fertilisation as well as incubation of embryos, takes place in it; or in the atrial cavity.

Only very few *Aplidium* species (*A. uteute*, *A. altarium*) have a brood pouch, at the postero-dorsal corner of the atrial cavity, in which embryos are incubated. In this genus, fertilisation generally appears to be in the top of the oviduct or in the atrial cavity.

incurrent aperture: see **apertures**.

larvae: The larvae of the taxa formerly grouped in the single family Polyclinidae, as originally defined, demonstrate its polyphyletic nature. The larvae of the new families proposed below can be characterised by their size, adhesive organs, ectodermal vesicles and ectodermal ampullae (see Table 2). The Euherdmaniidae have adhesive organs that are invaginated tubes that evaginate on settlement, as in the family Pycnoclavellidae; the relatively large larvae of Pseudodistomidae n.fam., as do Polycitoridae, have large adhesive organs and ectodermal ampullae between and lateral to the median adhesive organs; the generally smaller larvae of Polyclinidae *emend.*, Protopolyclinidae n.fam., and Ritterellidae n.fam. usually have ectodermal vesicles which separate off from the larval epidermis into the test between and alongside the median adhesive organs. There are also differences between genera in the origin of the ectodermal vesicles (see **vesicles** below).

All the larvae of the families discussed below have a discrete mass of yolk cells in the middle of the trunk. Larval ocellus and otolith are present in all genera. Although *Euherdmania* has similar adhesive organs to *Pycnoclavella*, the larvae do not appear to have a tendency to loss of the ocellus as do those of *Pycnoclavella*.

With the exception only of *Euherdmania* in which the invaginated tubes are triradially arranged, the 3 adhesive organs are in the anterior median line. Only *Aplidium triggsense* (with 12), and *A. multipapillatum* Millar, 1975 (with 8), have a different number of adhesive organs, all in the median line.

muscles: With the exception of sphincter muscles around the apertures, the body musculature in the parietal body wall is usually longitudinal, although fibres are exchanged with adjacent bundles. Transverse fibres are present, forming a network with the longitudinal ones, only in *Ritterella multistigmata* n.sp. and *Anadistoma* n.gen. These transverse fibres may originate as branches from the longitudinal muscle bands. Also in *Ritterella*, oblique muscles similar to those in the Clavelinidae cross the thorax from the endostyle to the postero-dorsal corner of the thorax. Longitudinal and oblique muscles extend in a band along each side of the abdomen and posterior abdomen, as they do in most of the genera. Only some *Aplidiopsis* species, *Polyclinum* and *Sidneioides* are exceptions with short longitudinal muscles confined to the anterior part of the thorax.

In some Pseudodistomidae n.fam. (*P. oriens* n.sp., *P. candens* n.sp) at least some fibres of the longitudinal muscles extend along a vascular stolon posterior to the posterior abdomen and heart. The presence of these muscles on the long, distinct vascular stolon is reminiscent of *Sigillina* (Holozoidae, see Kott 1990). The presence of both a gonad-containing posterior abdomen, and a vascular stolon with muscles (apparently homologous with a similar organ in *Sigillina*) in certain *Pseudodistoma* species suggests that the vascular stolon of Holozoidae is a separate structure rather than being homologous with the posterior abdomen of Polyclinidae, Ritterellidae n.fam., Pseudodistomidae n.fam. and Protopolyclinidae n.fam.

In all taxa, transverse fibres are present in the transverse vessels. These are fibres that derive from longitudinal muscle bands. These muscles are seen clearly in the large zooids of *Synoicum castellatum* n.sp., branching off longitudinal muscles and entering the transverse vessels through connectives from the parietal body wall about one-third of their length from the dorsal mid-line. Ventrally they divide into branches each side of the endostyle.

The large atrial lips of *Polyclinum* and species of other genera in Polyclinidae are also muscular. Branches from the ventral thoracic longitudinal muscles extend out into these tongues, and circular muscles from around the atrial apertures also are diverted out along them. These large atrial lips insert into the test to protect the atrial openings into the cloacal cavities, and in some cases, insert into the rim of common cloacal apertures and exert some control over these excurrent openings.

Anteriorly, the longitudinal muscle bands extend onto the siphons, where there is exchange of fibres with circular (including sphincter) muscles, longitudinal fibres are then organised into bands, one extending into the each lobe around the rim of the aperture. When these muscles are concentrated into the tip of each lobe they depress it and divide the tip of the lobe into 2 (e.g. *Ritterella dispar*, *Aplidium macrolobatum* n.sp.).

parastigmatic vessels: see **branchial sac**.

posterior abdomen: see **gonads**.

replication: In these well developed aplousobranch families replication takes place by horizontal division of the posterior abdomen and/or the abdomen, and usually is prolific. The process has not been specifically studied in Australian species. However the process is similar in the range of polyclinid species studied by Berrill (see 1935 for review), Nakauchi (1966–1987), and Nakauchi and Kawamura (1974a–1986). The process is the same in *Ritterella* (see Nakauchi 1977).

Generally reserve food cells (trophocytes) pack the abdomen and posterior abdomen. Sometimes the thorax and abdominal organs are resorbed but in other species they remain functional during the budding process (see *Ritterella pulchra*: Nakauchi, 1977). The abdomen and/or posterior abdomen are then divided, by constriction of the epidermis, into numerous buds. A segment of epicardial tube is contained in each, and is the regenerative tissue for the new vegetative zooid which develops from each bud.

In *Polyclinum* vegetative zooids with relatively long strap-like vegetative posterior abdomina (as opposed to the short sac-like posterior abdomen of sexual zooids) are found crowded in the growing margins of colonies (see *P. vasculosum*).

Although moderately long, sometimes branched, vascular appendices are present in Ritterellidae, and shorter ones are present in most of the other families, these seem not to be involved in the process of replication as they are in Holozoidae.

Pseudodistomidae n.fam. have a long vascular stolon with longitudinal body muscles extending along it as in *Sigillina* (Holozoidae). This supports the view that this family is related to *Sigillina* (Holozoidae). The method of replication in the Pseudodistomidae n.fam. is not known, nor is it known that the vascular appendix has a role in the process. Although Brewin (1958) found 'bud-like masses' lying beneath the zooids of *P. cereum*, and juvenile replicate zooids are found in the stalk of developing lobes of *P. oriens* n.sp., it is not known whether these developed from the vascular stolon in a process that resembles that of Holozoidae (see Kott 1990); or if they developed from the posterior abdomen and/or abdomen of the parental zooids by horizontal strobilation, as in Polyclinidae. A continuation of the epicardial tube into the vascular stolon of *Pseudodistoma* has not been found.

stomach: see **gut.**

test: see **cloacal systems, colonial systems, colonies.**

trophocytes: see **replication.**

vascular appendix, — process, — stolon: see **replication.**

vesicles, ampullary —, epidermal —, larval —: Hollow spheres, about 0.01 to 0.05mm diameter with an epithelial wall, usually occur in the test of the larval trunk in Protopolyclinidae, Ritterellidae and Polyclinidae. The fine strands attaching them to the larval epidermis sometimes sever as larvae mature. Like the enlarged epithelial cells on the tips of some ampullae, the epidermal cells occasionally are larger on the outside surface of the vesicle than on its mesial wall.

In *Monniotus* (Protopolyclinidae), *Polyclinum* and *Synoicum*, the vesicles exclusively branch off fine strands that detach from the epithelial wall on each side of the mid-line and trail through the test. The ventral strands arise from about one half to two-thirds of the way from the anterior end of the trunk, one extending to the posterior end of the trunk near the posterior-horns of the haemocoelic cavity where the vesicles form a tight cluster, and another shorter one trails anteriorly. Similar pairs of epithelial strands from the anterior end of the dorsal surface trail posteriorly on each side of the dorsal mid-line to the vicinity of the branchial aperture, and in *Monniotus* a corresponding pair of strands extend antero-ventrally on each side of the adhesive organs. The vesicles are especially numerous postero-ventrally. Dorsal and ventral clusters of vesicles arising from similar test strands are present in some larvae of *Aplidium* (*A. lunacratum* nom. nov., *A. multilineatum* n.sp., *A. ornatum* n.sp., *A. protectans* n.sp., *A. robustum* n.sp. and *A. tabascum* n.sp.), but the postero-ventral test strand is much shorter and a postero-ventral cluster of vesicles near the base of the tail does not occur. Larvae of the majority of *Aplidium* species have vesicles directly attached by their short sometimes branched hair-like filament to the larval epidermis rather than to an epithelial strand trailing through the test. These vesicles are arranged in single or multiple series to form a lateral arc around the anterior end of the larval trunk on each side of the lateral line, and sometimes also in the median line between the adhesive organs (Table 2).

The enlarged epithelial cells on the outside of the vesicles suggest that they may be involved with adhesion to the substrate.

Vesicles are not present in the larvae of Clavelinidae, Holozoidae, Polycitoridae, Pycnoclavellidae, Euherdmaniidae and Pseudodistomidae n.fam.

Family POLYCLINIDAE *sensu* Milne Edwards, 1842

Polyclinidae Milne Edwards, 1842 is distinguished from other aplousobranch families by the presence of gonads and heart in a posterior abdomen which also serves as the vegetative stolon. Genera of Diazonidae, in which gonads and heart are sometimes in a posterior abdomen, have internal longitudinal branchial vessels to distinguish them. Certain species of Holozoidae have gonads in a posterior abdominal sac but it is separate from the vegetative stolon (see Kott 1990), the holozoid heart is in the abdomen (rather than the posterior abdomen), and the larvae usually have adhesive organs triradially arranged (rather than in the median line). Certain species of *Euherdmania*, formerly assigned to Polyclinidae, have no posterior abdomen and, with the gonads and heart in the abdomen, can be mistaken for *Polycitor*. Larval characters must then be relied on to distinguish them (see below, Euherdmaniidae).

Like Polycitoridae, the present group of families have longitudinal and oblique muscle bands that extend from the thorax along the length of the zooid. Also, transverse muscle fibres are in the transverse branchial vessels. However, usually they lack the thoracic bands that form an external coat in the parietal body wall of Polycitoridae. Exceptions, in which transverse muscle bands are present in the parietal body wall to form a meshwork with the longitudinal ones, are *Condominium* n.gen., *Ritterella multistigmata* n.sp., *Anadistoma* n.gen. and *Euherdmania fasciculata* Monniot, 1983.

Taxa in Polyclinidae were assigned to one of 2 subfamilies, Euherdmaniinae and Polyclininae, grouped on the basis of shared convergent characters. Thus, *Protopolyclinum*, *Euherdmania*, *Dumus*, *Ritterella*, *Placentela*, *Pseudodistoma*, *Monniotus*, *Citorclinum* and their synonyms which lack cloacal systems comprised Euherdmaniinae; and *Polyclinum*, *Aplidium*, *Synoicum*, *Sidnyum*, *Aplidiopsis* and *Morchellium* which all have cloacal systems were in Polyclininae. However, considerations of larval and adult morphology (set out below) suggest other family groupings (Tables 1,2) that more closely reflect their probable phylogeny, and acknowledge closer relationships with other taxa of Aplousobranchia than those with genera formerly included in the polyphyletic Polyclinidae as defined by Milne Edwards (1842) and subsequent authors (see Berrill 1950).

In developing this new classification, the characters that have been relied on to indicate higher taxon relationships include the length of the oesophagus — a short oesophagus one- to two-thirds the length of the abdomen as in Holozoidae, or a long oesophagus more than two-thirds of the length of the abdomen as in Polycitoridae; the presence or absence of structural folds in the stomach wall, and the shape and orientation of the stomach — whether it is vertical and barrel-shaped or oblique and shortened dorsally; the size of the branchial sac, and number of rows of stigmata; the type of larval adhesive organs — eversible axial cones in shallow epidermal cups, or pycnoclavellid inverted, tubular ones; and the site of fertilisation and incubation of embryos, e.g. in the distal (thoracic) part of the oviduct as in Diazonidae (see Protopolyclinidae n.fam., Ritterellidae n.fam.), or in the base (abdominal part) of the oviduct as in Pycnoclavellidae (see Pseudodistomidae n.fam. and Euherdmaniidae), or in the atrial cavity (see Polyclinidae). Generally, the presence of branchial papillae, long and numerous rows of stigmata, the anus opening well anteriorly, a large number of embryos, and bunched male follicles indicate more primitive taxa than those without branchial papillae, and with narrow thoraces, few rows of stigmata, and testis follicles in longitudinal series.

Most of the taxa in these families have well developed rectal caeca (a rectal valve) at the base of the ascending limb of the gut loop. This probably is an apomorphic character associated with the vertical gut loop. It is known also in *Hypsistozoa*, *Neodistoma* and in some *Distaplia* (see Kott 1990).

Of the following 6 families (which include all the genera formerly included in Polyclinidae), only the monotypic family Placentelidae n.fam. from the north-western Pacific does not occur in Australia. In the other families, all reported from Australia, the only genera that do not occur here are *Protopolyclinum* Millar, 1960 (Protopolyclinidae n.fam.), *Citorclinum* Monniot and Millar, 1988 (Pseudodistomidae n.fam.), and *Pharyngodictyon* Herdman, 1886 (Ritterellidae n.fam.).

Key to families of the genera formerly comprising Polyclinidae Milne Edwards, 1842

1. Atrial apertures 6-lobed; cloacal systems rudimentary or lacking 2
Atrial apertures not 6-lobed; cloacal systems well developed .... POLYCLINIDAE *emend.*

2. Stigmata in 3 rows .... PSEUDODISTOMIDAE n.fam.
Stigmata in > 3 rows 3

3. Stomach at posterior end of long abdomen .... EUHERDMANIIDAE
Stomach near the middle of short abdomen . 4

4. Heart in the abdomen .... PLACENTELIDAE n.fam.
Heart in the posterior abdomen 5

5. Posterior abdomen short, tapering, sometimes separated from abdomen by a constriction .... PROTOPOLYCLINIDAE n.fam.
Posterior abdomen not short, tapering, never a constriction between posterior abdomen and abdomen .... RITTERELLIDAE n.fam.

Family PLACENTELIDAE n.fam.

The monotypic family is characterised by its numerous rows (12 or more) of numerous stigmata (up to 50), relatively short oesophagus, smooth stomach, the anus at the top of the branchial sac (level with the second or third row of stigmata), heart in the abdomen, numerous embryos being incubated in the terminal part of the oviduct in the atrial cavity, almost sessile median larval adhesive organs with an eversible axial cone in an epidermal cup, and 4 rows of stigmata in the larvae. The body muscles are longitudinal and oblique on the thorax and have not been observed on the abdomen or the posterior abdomen.

The type species of the genus *Placentela*, *P. crystallina* Redikorzev, 1913, has been well studied (Tokioka 1968, Nishikawa 1984b). In the latter study Nishikawa examined the existing material (including types) of *Placentela crystallina* and its synonym *Sigillinaria clavata*. The species has embedded zooids and up to 60 eggs and developing embryos in what appears to be an internal brood pouch in the distal end of the oviduct in the atrial cavity. The heart is in the abdomen with the anterior part of the gonads, while the remainder of the gonads and the epicardial sacs are in the posterior abdomen. Gonads spill over from the gut loop into the posterior abdominal extension as they do in *Hypsistozoa* (see Kott 1990). There is parenchymous material in the posterior abdomen of *P. crystallina*, which

Nishikawa (1984b) believed would be the site for formation of replicate zooids.

Kott (1963) first proposed the synonymy of *Sigillinaria clavata* Oka, 1933 and *Homoeodistoma michaelseni* Redikorzev, 1927 with *Placentela crystallina*. All 3 are from the sea of Okhotsk and the Kamchatka Peninsula (north-western Pacific). Nishikawa (1984b) subsequently established the synonymy of *S. clavata* with *P. crystallina*, but did not include *H. michaelseni* in his study. The latter species as well as having the same general colony and zooid morphology (including 12 rows of stigmata, and the anus and gonopores opening at the top of the branchial sac), is sympatric with *P. crystallina* and is here considered synonymous with it.

Species assigned to *Sigillinaria*: Brewin, 1950b (see also Brewin 1958) are not congeneric with *Sigillinaria* Oka (*Placentela*). They have long or short oesophagus, folded or smooth stomach, 3 or more rows of stigmata and some have parastigmatic vessels. Subsequently Brewin (1958) on the basis of "parallelism in classification", reassigned species to genera solely on the presence or absence of stomach folds — those with stomach folds to the genus *Pseudodistoma*, and those without to *Homoeodistoma*. Thus *S. arenosa* Brewin, 1950 and *S. novaezelandiae* Brewin, 1950 were erroneously assigned to *Homoeodistoma* (respectively *Ritterella* and *Pseudodistoma*, see below).

Homoeodistoma longigona Tokioka, 1959 from the Sea of Japan (Wakasa Bay) differs from *H. michaelseni* (*Placentela crystallina*) in the position of the anus (opposite the sixth or seventh row of stigmata — in a pharynx with 20 rows), the position of the heart (at the end of the posterior abdomen), yellow pigment spots in the lobes of the apertures, and a long, narrow posterior abdomen with testis follicles and eggs in longitudinal series. Although a similar longitudinal series of ova is in the proximal end of the oviduct in *Euherdmania*, the long oesophagus of the latter genus is lacking. Millar's (1963) proposal that *H. longigona* is a diazonid may be correct (see Kott 1990, p.33); or it may be related to Ritterellidae (see *R. arenosa* below).

Holozoidae and *Placentela* (see Nishikawa 1984b) have similar large larvae with well developed adult organs and almost sessile adhesive organs, zooids with short oesophagus, and gonads sometimes extending into the posterior abdomen which also contains an epicardial sac. However, in view of the primitive characters of *Placentela*, viz. numerous stigmata, the large number of embryos being brooded, the large testis and the anterior position of the anus, a diazonid ancestor is more likely than a direct relationship.

Although sessile everting adhesive organs and fertilisation at the top of the oviduct occur in Clavelinidae they probably are characters convergent, rather than homologous, with those in *Placentela*. A relationship with Polycitoridae is unlikely in view of the large number of embryos, the relatively short oesophageal neck (the cardiac end of the stomach is about halfway down the abdomen), the anterior position of the anus, and the absence of transverse thoracic muscles.

The type species *P. crystallina*, and *P. translucida* Kott, 1969 from the Antarctic Peninsula are the only species known. The genus has not been recorded from Australian waters. *Placentela areolata* Kott, 1963, *P. ellistoni* Kott, 1972b and *Homoeodistoma omasum* Monniot, 1987 are incorrectly assigned (see *Condominium* n.gen, Protopolyclinidae n.fam. below).

Family PROTOPOLYCLINIDAE n.fam.

Zooids are embedded or separate, with both apertures 6-lobed, the atrial apertures opening separately to the exterior. The pharynx is large, and stigmata are numerous, arranged in 9 or more rows, with or without parastigmatic vessels. Branchial papillae often are on the transverse vessels. The anus opens one third to halfway up the atrial cavity. The oesophagus is short, and curves ventrally to enter the dorsally shortened, obliquely oriented stomach about halfway down the relatively small abdomen. The stomach has (sometimes only faint) longitudinal ridges in *Monniotus*, but irregular ridges or a smooth stomach in the other genera. Gonads, in a broad tapering posterior abdomen (constricted off from the abdomen only in *Protopolyclinum*), consist of numerous bunched testis follicles and a smaller ovary anterior to the testis. Embryos are incubated in the distal end of the oviduct in the posterior part of the atrial cavity.

In the characteristically large thorax, short oesophagus, small abdomen, anterior position of the anus, tapering posterior abdomen, numerous bunched male follicles, and incubation of embryos in the distal part of the oviduct this family resembles *Placentela* (Placentelidae, see above), which, however, differs in having the heart in the abdomen. Further, the presence of branchial papillae, suggests an origin direct from a diazonid ancestor.

The numerous small bunched testis follicles in a broad posterior abdomen, the occasional presence of branchial papillae, the dorsally shortened stomach, and the larval vesicles branching off posteriorly- and anteriorly-trailing stalks on each side of the dorsal and ventral mid-lines suggest a relationship with *Polyclinum*, although *Monniotus*, with shallow longitudinal stomach ridges, may have diverged from the main polyclinid line.

The Antarctic *Tylobranchion* Herdman 1886, has branchial papillae, short oesophagus and folded stomach, but its branchial papillae are forked and it has cionid-type larvae indicating a closer affinity with Diazonidae (see Kott 1990).

Ritterellidae n.fam., often with branchial papillae and larvae like the present family, are distinguished by their narrow zooids, usually with testis follicles in one or 2 longitudinal series and vertical barrel-shaped stomach.

The family, known only from Indo-West Pacific and Australian temperate waters, contains 3 genera, *viz. Condominium* n.gen., *Monniotus* Millar, 1988 and *Protopolyclinum* Millar, 1960 (monotypic, known only from New Zealand).

Key to genera of Protopolyclinidae

1. Zooids embedded 2
Zooids not embedded .... *Monniotus*

2. Branchial papillae present; colonial systems not present .... *Protopolyclinum*
Branchial papillae not present; colonial system present .... *Condominium* n.gen.

Genus **Monniotus** Millar, 1988

Type species: *Monniotus ramosus* Millar, 1988

Zooids are contained separately in the terminal branches of the narrow sandy stalks that comprise the colony. The test consists of a delicate membrane to which sand adheres making a firm brittle casing for the zooid which, when expanded, completely occupies the space inside and adheres closely to the inside of the sandy casing. Body muscles are longitudinal, extending the whole length of the zooid. Rows of stigmata are numerous (up to 10) and one or more branchial papillae are on the transverse vessels, and also on the parastigmatic vessels when these are present. The gut loop is short, and the stomach has only very faint internal longitudinal ridges on the parietal wall. The posterior abdomen is long with the small ovary in front of the bunched follicles of the large testis. The posterior abdomen is especially broad when testis follicles are mature. Testis follicles and embryos are never present at the same time, and the genus appears protandrous (see also Millar 1988). Fertilisation is in the distal part of the oviduct (in the thorax), where a longitudinal developmental series of up to 6 embryos at a time are found being incubated. The larval adhesive apparatus resembles that of *Polyclinum*, in the 3 median adhesive organs, epidermal vesicles branching off trailing epidermal strands, and median and lateral ampullae with columnar epithelial cells, similar to those in the adhesive organs, forming a cap on the tip as in *Polyclinum*. However, the adhesive organs themselves are deeper than those in the latter genus.

In all known species, the incurrent aperture opens in the centre of a transverse, curved strip of delicate, sand-free, test. The sand-strengthened test anterior to the naked strip curves down over the aperture to form a protective lip.

Although a phylogenetic relationship is not implied, the colonies resemble those of *Ritterella* spp., especially those of *R. cornuta* which have narrow sandy lobes, regularly spaced branchial papillae and numerous rows of stigmata. However, in *Ritterella* the zooids are organised into single colonial (not usually cloacal) systems, while in *Monniotus* they are separate from one another, one in each lobe of the colony, the lobes joined basally to common stolons. Colonies also resemble those of *Euherdmania claviformis*, having separate zooids in narrow, sandy stalks. Millar (1988) distinguished *Monniotus* from *Euherdmania* by its branchial papillae. However, these are variable, reduced to one per row in *M. australis*. A more reliable and plesiomorphic difference from *Euherdmania* is the short oesophagus, resembling *Ritterella* and *Aplidium* rather than *Pycnoclavella* (to which *Euherdmania* appears to be most closely related).

The genus is recorded only from Australian temperate waters and from the western Indian Ocean. Two of the 3 known species are indigenous to Australian waters. The western Indian Ocean *M. ramosus* most resembles the eastern Australian species *M. radiatus* n.sp., having numerous papillae on each transverse vessel (see below). *Monniotus australis*, known from western and southern Australian waters, has only a single papilla on each vessel — in the centre of each side of the body.

Monniotus australis (Kott, 1957)
(Fig. 1, Plate 1a)

Euherdmania australis Kott, 1957, p. 103 (part, not specimens from Camden Haven *M. radiatus* n.sp.); 1972b, p. 172.

DISTRIBUTION

NEW RECORDS: Western Australia (Houtmans Abrolhos, WAM 1016.83; off Dongara, WAM 926.89 929.89). South Australia (Great Australian Bight, SAM E2099–100 E2103 E2416, QM GH4147).

PREVIOUSLY RECORDED: South Australia (Elliston Bay — QM G9291 Kott 1972b; Waldegrave I. — SAM E2111–2; Investigator Strait — Kott 1972b). Victoria (Port Phillip Heads — holotype AM Y1317 Y1165 Kott 1957).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are straight-sided, club-shaped lobes, tapering to common stolons at their narrow basal end. The terminal, expanded part is triangular in section with a flattened, triangular, slightly oblique free end. The lobes are from 1cm (Western Australia and Bass Strait) to 4cm (Great Australian Bight) long, and only rarely divided along their length. Sand grains are packed in a single layer in the very thin test to form a hard, rigid but brittle coat. Delicate internal test without sand is present only posterior to the thorax, which, when expanded, fills the inside of each lobe, the body wall adhering closely to the rigid sand-filled coat. The branchial aperture is directed downwards from the middle of the base of the triangular free end of the head just below its margin. The atrial aperture is directed upwards from just inside the apex of the triangle on the free end of the lobe. The openings are sometimes transverse, with 3 well separated small pointed lobes on each lip of the opening.

INTERNAL STRUCTURE: The body wall is very delicate with about 12 fine longitudinal and oblique muscles extending the whole length of the zooid from the thorax to the posterior end of the long, narrow posterior abdomen. About 30 pointed tentacles of various sizes are in a circle around the base of the branchial aperture. The neural duct is short and funnel-shaped with a circular opening into the pharynx. There are 9 or 10 rows of about 30 stigmata anteriorly, but posterior rows are shorter. All except the posterior 3 rows are crossed by a parastigmatic vessel. The transverse and parastigmatic vessels each have a single tongue-shaped to pointed papilla in the centre. Triangular dorsal languets are also on the parastigmatic vessels as well as on the primary transverse vessels. The oesophagus is curved and narrow, opening into the stomach about halfway down the very small abdomen (never more than half the length of the thorax and often less). The stomach has about 12 shallow, often inconspicuous glandular ridges, on its parietal wall. These are obscured when the abdomen is contracted. The mesial wall of the stomach has irregular ridges. A long narrow duodenal region and oval posterior stomach are in the descending limb of the gut loop. A rectal valve is at the junction of the mid-intestine and rectum. The anus opens half-way up the thorax. Its rim is bilabiate, but each lip is subdivided into a fringe of pointed lobes. Gonads consist of numerous small follicles bunched in a long grape-like or narrow cylindrical mass around the vas deferens. A 4- or 5-egg ovary is in the top of the posterior abdomen.

Specimens from Price I. collected in April (QM GH4147), and Encounter Bay collected in October (SAM E2111–2 E2416) have up to 8 embryos aligned in a developmental sequence in the distal part of the oviduct (in the posterior half of the thorax). Thus there appear to be at least 2 breeding seasons.

The larval trunk is 1.1mm long. A median ampulla with a cap of modified columnar epidermal cells is in each interspace between the adhesive organs and 4 rounded lateral ones are on each side of the median adhesive organs. Numerous, crowded ectodermal vesicles are present along each side of the median line from the postero-ventral corner and around the anterior end of the trunk to the branchial aperture. These branch off the sides of fine stalks from the larval ectoderm which trail anteriorly and posteriorly along each side the dorsal and ventral mid-lines of the trunk, and especially cluster around the postero-ventral horns of the haemocoele near the base of the tail. The adhesive organs have an eversible axial cone in a deep tulip-shaped cup.

REMARKS

The larval trunk appears to be similar to that of *M. ramosus* Millar, 1988. The branchial sac of the present species (which has a geographical range from western, across southern Australia to Bass Strait) has only a single papilla on each transverse vessel, while the eastern Australian *M. radiatus* n.sp., although it has colonies similar to the present species, has a branchial sac with numerous papillae like that of the African *M. ramosus*.

The zooids appear to arise from a central axial stalk in 2 (WAM 926.89 and 989.89) of the west-

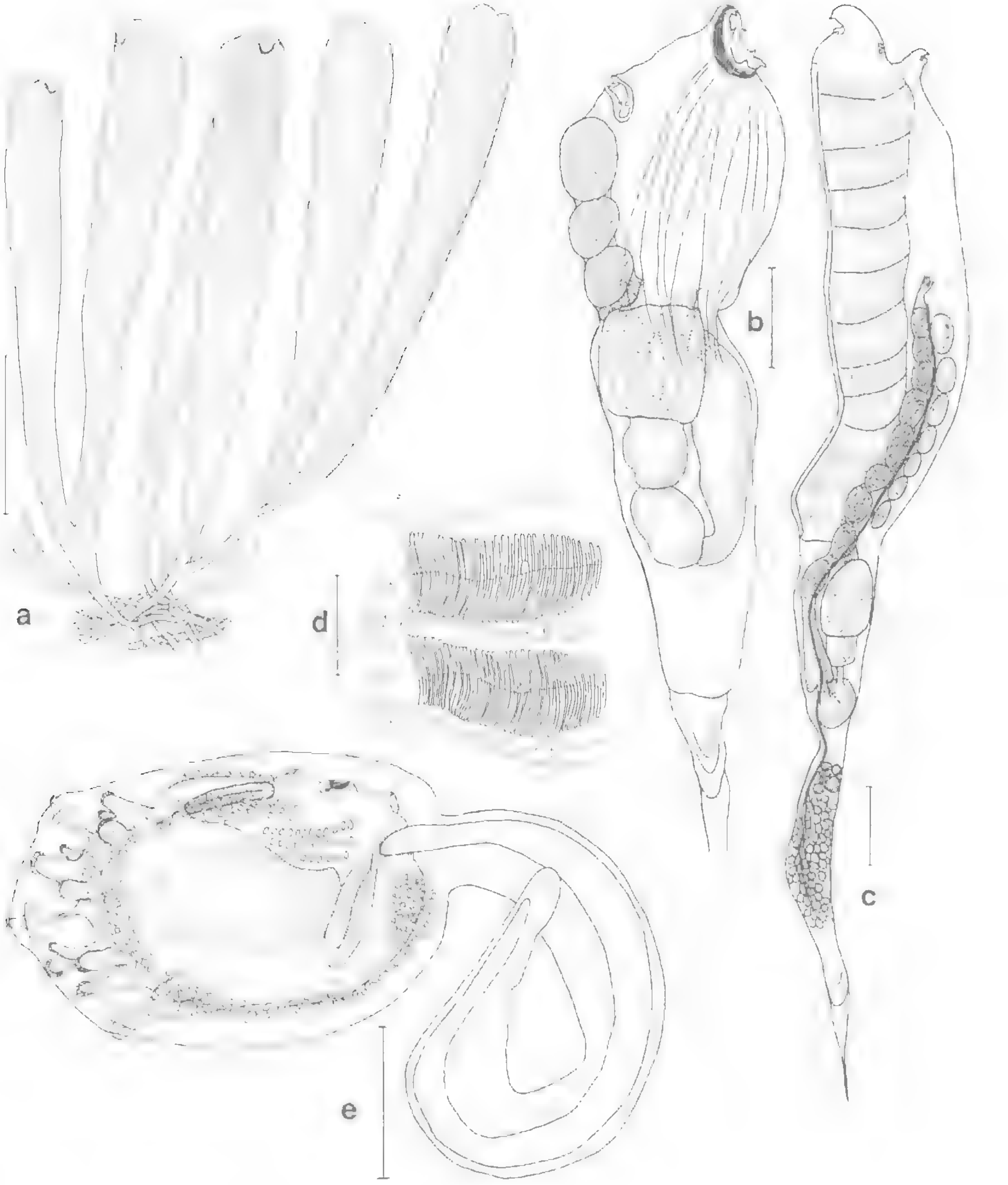


FIG. 1: *Monniotus australis* — **a**, part of colony (QM G14147); **b**, immature zooid with thorax contracted (WAM 929.89); **c**, mature zooid with embryos in oviduct (SAM E2112); **d**, portion of branchial sac showing papillae on primary transverse and parastigmatic vessels (QM G9291); **e**, larva with some partly everted adhesive organs (SAM E2112). Scales: **a**, 1cm; **b** 0.5mm; **c**, 2mm; **d**, 1mm; **e**, 0.4mm.

ern Australian colonies. However this is only apparent, as zooids radiate out from basal stolons fixed around a stem of weed.

Monniotus radiatus n.sp.
(Fig. 2)

Euherdmania australis Kott, 1957, p. 103 (part, specimen from Camden Haven).

DISTRIBUTION

TYPE LOCALITY: New South Wales (Nambucca Heads, 13m, coll. J.E. Watson 11.1.72, holotype QM G10012 *MV F58435*).

FURTHER RECORDS: Victoria (Portland, QM GH93), New South Wales (Camden Haven — paratypes AM G1356 Y1120 Kott 1957).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are a sandy mass of upright, club-shaped lobes, up to 2.5cm long, often with one or two branches along their length. The widest part, i.e. the terminal free end not more than 3mm in diameter. These lobes arise from a common basal mass. Each lobe contains a single zooid.

The thick, terminal part of each lobe is triangular in section and the free end is a flat isosceles triangle, with the branchial aperture directed downwards from the middle of the base of the triangle, just below its margin. The atrial aperture is directed upwards from the upper surface just inside the apex of the triangle.

INTERNAL STRUCTURE: The contracted zooids are about 8mm long, divided into thorax, short abdomen, and a relatively long posterior abdomen (up to half the total zooid length). Apertures are both 6-lobed on short siphons, the branchial one turned ventrally, and the short, atrial siphon directed dorsally, at right angles to the longitudinal axis of the body. A mesh of very fine longitudinal and transverse muscle bands is on each side of the thorax, and the longitudinal bands continue along each side of the abdomen and posterior abdomen.

The thoraces of these zooids are relatively large, with 9 rows of about 20 stigmata. Each row except the last 3 (in which the stigmata are shorter) are crossed by parastigmatic vessels. Each of the parastigmatic and the primary transverse vessels have about 10 rounded tongue-like papillae on them. The papillae on the parastigmatic vessels are smaller than those on the primary transverse vessels. A pointed trianglar dorsal languet is in the mid-line (over the dorsal sinus) also on both parastigmatic and transverse vessels. The parastigmatic vessels appear to be bisecting the rows of stigmata, and increasing their number.

The oesophagus is relatively short, the small stomach (with 12 shallow longitudinal ridges) is halfway down the abdomen and there is a duodenal region and a mid-intestine in the distal part of the descending limb of the gut loop.

Gonads consist of bunched male follicles and a small ovary. Larvae are not known for this species.

REMARKS

The shape of both colony and zooids, including the orientation of their apertures resemble both the Australian *M. australis* and the type species from Mozambique (Millar 1988). The African species differs from the present one in having less regular colony lobes which branch more along their length and appear to be less rigid, zooids with more rows of stigmata, and without parastigmatic vessels. However, in the present species absence of these vessels from the posterior rows of short stigmata indicates that they are actively bisecting the rows of stigmata to increase their number and this may not be a reliable distinction between the species.

Monniotus radiatus overlaps the range of *M. australis* in Bass Strait.

Genus **Condominium** n. gen.

Type species: *Placentela areolata* Kott, 1963.

The genus has large, embedded zooids, arranged in an integrated colonial system but not in cloacal systems. Six-lobed branchial openings directly to the exterior are on one side of the colony, atrial openings on the other. Stigmata are in numerous (at least 12) rows. Transverse as well as longitudinal muscles are present on the thorax. Parastigmatic vessels are present occasionally, but branchial papillae are not. The oesophagus is short, and curves to open along the dorsal side of the shield shaped, bilaterally symmetrical, smooth stomach which is halfway down the abdomen. Testis follicles are bunched, and the ovary is anterior to the testis.

The genus is monotypic, being known only from its type, an indigenous Australian species with a range around the continent.

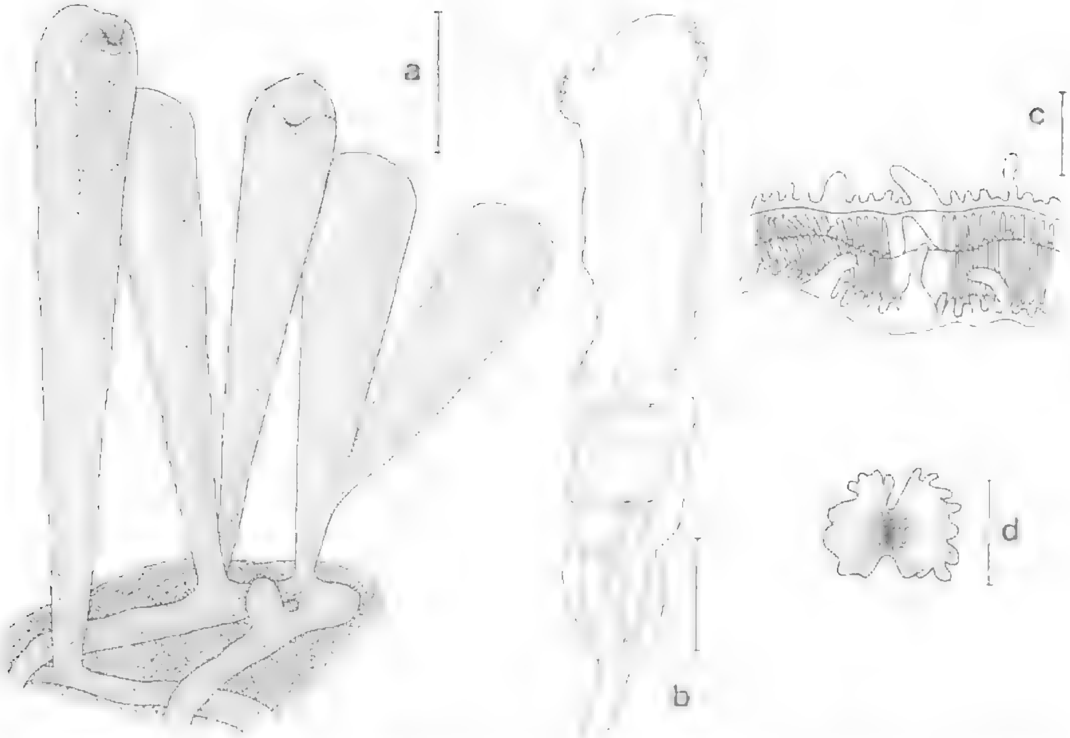


FIG. 2: *Monniotus radiatus* n. sp. (paratype AM G1356) — a, part of colony, b, zooid, c, part of branchial sac showing papillae and dorsal languets on transverse and parastigmatic vessels; d, anus. Scales: a, b, 5mm; c, d, 0.25mm.

Condominium areolatum (Kott, 1963)
(Fig. 3, Plate 1b–d)

Placentela areolata Kott, 1963, p. 74.
Placentela ellistoni Kott, 1972b, p. 173.
Homoeodistoma omasum Monniot, 1987, p. 503.

DISTRIBUTION

NEW RECORDS: Western Australia (Cockburn Sound. WAM 582.31). South Australia (Taylor I., QM GH4161). New South Wales (Lord Howe Is, QM GH4380). Queensland (Heron I., QM GH4937; Central Section, Great Barrier Reef, QM GH5418). Northern Australia (Torres Strait, QM GH4931–6).

PREVIOUSLY RECORDED: South Australia (Great Australian Bight — AM U3925 Y1316 Kott 1972b). Queensland (Mackay — Kott 1963). New Caledonia (Monniot 1987).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are very irregular, with curved, fan-shaped lamellae, from 2 to 4cm along their outer edges, joined basally to common test, and sometimes forming a cornet. Some specimens have lamellae fitting around one another like the petals of a rose (QM GH4161), but in others they arise at random from the common test. The test is brittle with sand externally, but not internally. Internally only a thin layer of fairly tough, translucent test separates the zooids, which lie parallel to one another in a single layer in each lamella. The branchial apertures, directed downwards, open into a groove that is just behind and parallel to the rounded rim on the outer curve of each lamella. The atrial apertures open horizontally into a less well defined groove on the opposite side (inner curve) of the lamella, lower down than the row of branchial apertures. The grooves receiving the apertures are conspicuous in the preserved specimens, although the sand adhering to the outside of the colony obscures the actual openings. In photographs the atrial apertures of living specimens are seen directed upwards from a convex surface, the groove concealing them having disappeared.

INTERNAL STRUCTURE: Zooids are large but transparent. Their total length, even when contracted is about 1.5cm, with thorax, abdomen and posterior abdomen of about equal length. The branchial aperture usually is turned ventrally. The atrial aperture extends laterally from about one third of the distance down the dorsal surface (level with the fourth row of stigmata). Each aperture has 6 minute pointed lobes. Numerous parallel longitudinal muscles are on the thorax, and these cross bands of transverse fibres on the parietal body wall outside each transverse branchial vessel. Fibres from these transverse bands continue into the branchial vessels through the branchial connectives. Longitudinal muscles continue along the abdomen and posterior abdomen. There is a strong but narrow sphincter muscle around the base of each short siphon. The opening of the neural gland is a funnel-shaped ciliated pit. The long rectangular stigmata are numerous, about 50 in each of 17 to 20 rows. Branchial papillae are not present. Very fine parastigmatic vessels are present in the colony from Lord Howe I. (QM GH4380), but not in other specimens.

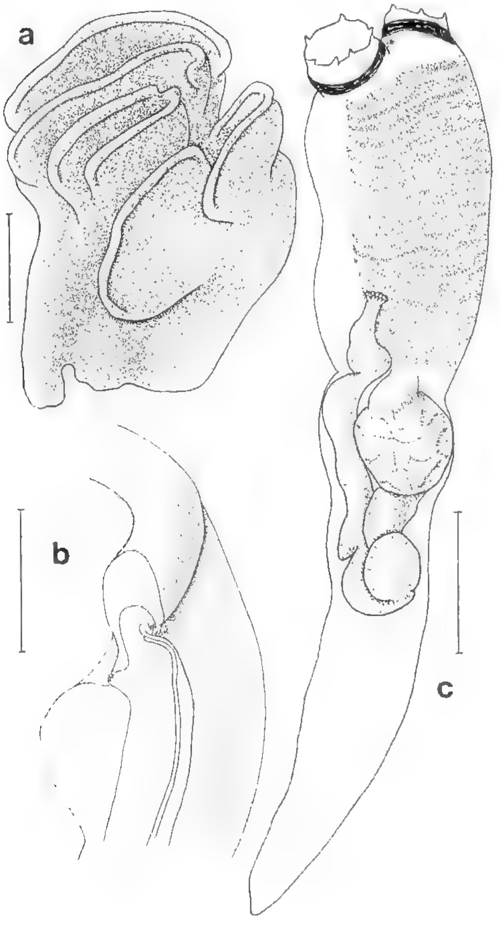


FIG. 3: *Condominium areolatum* gen. nov. — **a**, **b**, colony (QM GH4161) (**a**, external appearance; **b**, section through a lamella); **c**, zoid (QM GH4380). Scales: **a**, 2cm; **b**, 5mm; **c**, 2mm.

The oesophagus is short, and the smooth, almost spherical stomach is in the upper half of the abdomen. The internal wall of the stomach is papillated and sometimes divided randomly into irregular areas and some transverse and irregular wrinkles. Duodenum, posterior stomach and mid-intestine are in the descending limb of the gut loop, the mid-intestine opening into the rectum at the base of the descending or ascending limbs or in the pole of the gut loop. The rectum has two caeca (forming a rectal valve) at its proximal end. The anal opening is near the posterior end of the branchial sac.

Gonads are not present in any of the newly recorded material, although they are present in material from South Australia (Kott 1972b). They consist of a small ovary anterior to the numerous small bunched testis follicles.

Advanced embryos with tails almost completely encircling the trunk (0.44mm) are present in the type material (AM Y3925 Y1316) an ocellus and an otolith are present, but no other organs are developed.

REMARKS

Kott (1963) overlooked the unusual and characteristic lamellae in the irregular type colony of *P. areolata* (*Condominium areolatum*).

The colonies of this species (like *Ritterella asymmetrica* n.sp.) have well developed colonial systems that differ from those of most other species of *Ritterella*, which have rudimentary cloacal systems or homologues of them, in which excurrent streams are expelled into depressions or concavities where they reinforce one another (see *Ritterella cornuta* n.sp., below). Instead branchial and atrial apertures, respectively, are in rows parallel with the outer edge, and on opposite sides of the terminal border of colony lobes. In all lobes, the branchial apertures are turned down toward the base of the colony, while the atrial apertures are directed away from it as they are in the separate zooids of *Monniotus*, *Dumus* and *Euherdmania*. In the present species (as in *R. asymmetrica*) the excurrent streams from each of the zooids are separated from incurrent water, and probably are entrained by the currents that flow over the colony (see Kott 1989).

Colonies newly recorded from Torres Strait are not well preserved. They are very like the more irregular ones of this species taken from other locations, but although the zooids appear to have been identical in size and general outline, details of their structure are obscure.

Homoeodistoma omasum Monniot, 1987 from New Caledonia is conspecific with the present species, its characters falling within the intraspecific range of variations recorded in the Australian populations. Its occurrence in New Caledonia is not inconsistent with the temperate-tropical range recorded for the species.

Despite their considerable colony size and wide geographic range, colonies of this species are seldom recorded. This may be because of the dense coat of sand, concealed zooid openings and irregular colonies which make them inconspicuous and readily overlooked in the field.

Family RITTERELLIDAE n.fam.

The family is erected for colonial aplousobranch species with zooids either entirely embedded, or separate, the former usually organised in colonial, and sometimes rudimentary cloacal systems. Branchial and atrial openings are 6-lobed. Stigmata are in 4 or more rows. Parastigmatic vessels sometimes are present, as are branchial papillae. The oesophagus is short, and the barrel-shaped, vertical stomach has folded or smooth walls. The gonads, in a long posterior abdomen, have the ovary at the top and the male follicles usually in a longitudinal series behind the ovary. The anus opens at least half way up the atrial cavity and there usually is a distinct rectal valve at the proximal end of the ascending limb of the gut loop.

Fertilisation and incubation of embryos is in the distal (thoracic) part of the oviduct. The small (trunk length 1.0mm) larvae have 3 median, narrow-stalked eversible adhesive organs each with a small, shallow axial cone in an epidermal cup. Epidermal ampullae and vesicles suggest affinities either with *Polyclinum* (*Dumus* and the *pedunculata* group of *Ritterella*) or *Aplidium* (*aequalisiphonis* group of *Ritterella*).

Contracted zooids draw away from the surface to the base of the colony, as in Polycitoridae (see Kott 1990).

Many of the species from Australian waters (*Ritterella pedunculata*, *R. asymmetrica*, *R. multistigmata* n.sp., *R. cornuta* n.sp., *R. papillata* n.sp. and *Dumus areniferus*) have colonies like those of the *claviformis* group of *Euherdmania* (see below). Euherdmaniidae are distinguished by their long oesophagus and inverted tubular adhesive organs.

The anterior openings of the anus and the gonoducts, and (in *Ritterella dispar*) incubation of embryos in the distal (thoracic) part of the oviduct, are primitive characters shared with Placentelidae and Protopolyclinidae (e.g. *Monniotus*). The short oesophagus, and small larvae with epidermal vesicles as well as ampullae also occur in Protopolyclinidae from which *Ritterella* is distinguished by its smaller, narrower zooids with fewer male follicles in a long, thread-like or stumpy but never tapering posterior abdomen, barrel-shaped stomach with more pronounced folds and smaller, shallower adhesive organs. However, the relationship of Ritterellidae to Protopolyclinidae is not altogether satisfactorily resolved. A common diazonid ancestor is suggested by the persistence of branchial papillae in both families. The vertical stomach with longitudinally folded wall, and small larvae with shallow, stalked adhesive organs and epidermal vesicles also suggest a relationship with Polyclinidae.

Pharyngodictyon Herdman, 1886, an abyssal genus without stigmata, is represented by 6 species of which only 2 are known from a single specimen (see Millar 1982). Zooids of *P. mirabile* Herdman, 1886, *P. bisinus* Monniot and Monniot, 1991 and *P. mirabile*: Kott 1969 resemble those of some *Synoicum* spp., with a smooth, barrel-shaped stomach, and without a constriction between abdomen and posterior abdomen. However, the zooids of *P. elongatum* Millar, 1982, *P. cauliflos* Monniot and Monniot, 1991 and *P. magnifili* Monniot and Monniot, 1991 have a longitudinally folded stomach. Thus it is possible that the genus is polyphyletic despite the fact that all species have a short oesophagus, zooids opening separately to the surface, and the transverse atrial aperture at the posterior end of the dorsal surface, sometimes with both its anterior and posterior margin divided into rounded lobes (see Kott 1969). Species presently assigned to this genus are separated from Euherdmaniidae by their short gut loop, and from the Placentelidae by the position of the heart (in the posterior abdomen). The vertical, barrel-shaped stomachs are more like *Aplidium*, *Morchellium* and *Ritterella* than the oblique, dorsally shortened ones of Protopolyclinidae, Pseudodistomidae, *Polyclinum* and *Aplidiopsis*. Millar (1982) suggests a relationship between *Protoholozoa* (Holozoidae) and

Pharyngodictyon, but the presence of a posterior abdomen and the shape of the stomach does not support that view. The genus is tentatively assigned to Ritterellidae on the basis of the separately opening zooids, short oesophagus and vertical barrel-shaped stomach.

The genus *Ritterella* (with 5 or more rows of stigmata and folded stomach) is well represented in the Australian fauna. *Dumus* Brewin, 1952 (with 4 rows of stigmata and smooth-walled stomach) is known from 2 species, one possibly indigenous to the temperate waters of New Zealand and southern and eastern Australia, and one from New Caledonia.

Genus **Ritterella** Harant, 1931

Type species: *Amaroucium aequalisiphonis* Ritter and Forsyth, 1917.

The genus contains embedded zooids opening independently, and sometimes organised in colonial systems. Colonies are often, but not always, brittle with sand. The stomach has longitudinal folds in its wall, sometimes shallow and inconspicuous but well defined in other species.

The species of *Ritterella* with parastigmatic vessels are *R. tokioka* nom. nov. and *R. yamazii* Tokioka, 1949 from Japan, *R. arenosa* (Brewin, 1950) from New Zealand, *R. circularis* Monniot, 1987 from New Caledonia, and *R. asymmetrica* and *R. multistigmata* n.sp. from Australia. Kott (1972a) proposed that the presence of 5 primary rows of stigmata (which sometimes are bisected by parastigmatic vessels) is characteristic of *Ritterella*. However, although 5 primary rows occur in many species it is not universal.

The type species *R. aequalisiphonis* (Ritter and Forsyth, 1917) from California was assigned to *Sigillinaria* Oka, 1933 by Van Name (1945), who, like Millar (1960), believed the genera synonymous. However *Sigillinaria* is a synonym of *Placentela* Redikorzev, 1913 (see above). *Distoma pulchra* Ritter, 1901 (*Sigillinaria pulchra*: Van Name, 1945) has a folded stomach, but long oesophagus, and despite its embedded zooids, is more like *Euherdmania* than *Ritterella*.

Most of the species of *Ritterella* can be assigned to one of 2 species groups, viz.:

(1) *Aequalisiphonis* group, containing *R. prolifera* (Oka, 1933), *R. dispar* Kott, 1957, *R. tokioka* nom. nov. (for *R. pedunculata* Tokioka, 1953), *R. sigillinoides* (Brewin, 1958) and *R. glareosa* Monniot, 1974, as well as the type species of the genus. These naked or sandy colonies sometimes are stalked, the zooids are not arranged in distinct systems, and the short, thick posterior abdomina have bunched male follicles. The known larvae (of *R. dispar*, *R. prolifera* and *R. glareosa*) have epidermal vesicles separating directly from the epidermis like larvae of certain *Aplidium* spp. (see Fig. 60).

(2) *Pedunculata* group, containing *R. pedunculata* (Herdman, 1899) and 5 other sandy species, *R. papillata* n.sp., *R. asymmetrica* Millar, 1966, *R. multistigmata* n.sp., *R. cornuta* n.sp., *R. compacta* n.sp., from Australian waters. All have zooids arranged in systems, with sandy, usually narrow-stalked colonies (*R. compacta* excepted), long, narrow posterior abdomina with male follicles in longitudinal series, and larvae with postero-ventral and dorsol vesicles, and anterior ampullae like *Polyclinum*. The naked *Ritterella circularis* Monniot, 1987 from New Caledonia is also a member of this group of species; and *R. yamazii* Tokioka, 1949 from Japan may be.

The known larvae have ectodermal ampullae and clusters of vesicles like those of *Polyclinum*.

Ritterella arenosa (Brewin, 1950) and *R. vestita* Millar, 1960 do not appear to have affinities with either of the species groups (see below). Nevertheless, *Ritterella* appears to be monophyletic.

Ritterella rubra Abbott and Trason, 1958 from California lacks systems, has zooids opening separately to the exterior but has a mulberry-like stomach and curved oesophagus. The species appears to have a similar relationship with *Synoicum* to that of *Ritterella* with *Aplidium*.

Seven species of *Ritterella* are known from Australian waters, 5 from the temperate waters of the southern coast, where the genus appears to have radiated (Table 3). These and other aplousobranch species with separately opening zooids (e.g. *Dumus areniferus*, *Monniotus* spp., and *Condominium areolatum* n.gen.) appear to flourish in the same sandy coastal habitats.

Key to species of *Ritterella* recorded from Australia

1. Lobes of colony long and narrow 2
   Lobes of colony not long and narrow 6

2. Stigmata in 5 rows 3
   Stigmata in more than 5 rows 5

3. Parastigmatic vessels present..... *R. asymmetrica*
   Parastigmatic vessels not present 4

4. Branchial papillae present ..... *R. papillata* n.sp.
Branchial papillae not present .. *R. pedunculata*

5. Parastigmatic vessels present .... *R. multistigmata* n.sp.
Parastigmatic vessels not present .... *R. cornuta* n.sp.

6. Colony sandy; zooids in systems .... *R. compacta* n.sp.
Colony not sandy; zooids not in systems .... *R. dispar*

Species recorded from regions other than Australia.

In addition to the species recorded from Australia, which are all indigenous, the genus is known from the eastern Pacific (southern California) by the type species, and from New Zealand and Japan by the following:

Ritterella arenosa (Brewin, 1950) from New Zealand (Great Barrier I. and Hauraki Gulf; see also Brewin 1958). Despite its smooth stomach (which occurs also in *Dumus*) the species, with its zooids embedded (rather than separate) in sandy flat-topped lobes, parastigmatic vessels (like *R. asymmetrica*), 9 or 10 rows of 20 to 24 stigmata, and narrow posterior abdomen with the ovary in front of the longitudinal series of testis follicles, seems most appropriately assigned to *Ritterella*. It shares some characters with *Homoeodistoma longigona* Tokioka, 1959, although the latter species seems to have closer affinities with the Diazonidae (see above, Placentelidae).

Ritterella circularis Monniot, 1987 from New Caledonia has circular systems with the atrial apertures in a central depression as in *R. compacta* n.sp. The species also has a similar number of rows of stigmata. Unlike *R. compacta* its colony is not sandy, has more stigmata per row, has parastigmatic vessels, and lacks branchial papillae.

Ritterella glareosa Monniot, 1974, from 300m on a sea-mount in the northern Pacific, is thought isolated there. The spherical, sand-encrusted species has 5 to 7 rows of numerous stigmata, and the usual slender muscle bands extend the whole length of the body. Testis follicles are bunched, but this could be the result of contraction of the posterior abdomen. They are not as numerous as they are in Protopolyclinidae. As in other species, the rectum and gonoducts extend at least halfway up the atrial cavity, and there is a rectal valve at the proximal end of the ascending limb of the gut loop. The stomach has 5 faint longitudinal folds. The larvae have ectodermal vesicles but no ampullae, and there is an otolith but no ocellus. The species is distinguished from others by the form of its colony and the number of faint stomach folds. The embryos probably are incubated in the distal part of the oviduct, as are the embryos of *R. dispar* and *R. prolifera*, from which the present species is distinguished by its sand encrusted colony, and fewer stomach folds.

Ritterella prolifera (Oka, 1933) from Japan (see Tokioka 1953) closely resembles *R. dispar*, differing from it only in having 6 (rather than 5) rows of stigmata.

Ritterella sigillinoides (Brewin 1958) from Stewart I. has a fleshy stalked colony without sand, no systems, zooids with 5 rows of stigmata, a folded stomach and

TABLE 3. Summary of characters of species of *Ritterella* recorded from Australia

Species	Biogeographic range[1]	Range anticlockwise around Australia	Colony	Systems	Stigmata: no. rows; no/row	Parastigmatic vessels	Branchial papillae	Stomach folds
R. compacta n.sp.	A,te	Gt Australian Bight	sandy, compact cushion	rudimentary cloacal	15;20	absent	10	6
R. cornuta n.sp	A,te	"	sandy stalks	"	9;15–20	absent	15	6+
*R. papillata n.*sp.	A,te	"	"	"	5;15	absent	15	8
R. pedunculata	A,te	Gt Australian Bight to Solitary Is (NSW)	"	colonial	5;12	absent	0	4–5
R. assymmetrica	A,te	Gt Australian Bight to Port Phillip Bay	"	"	5;20	present	0	15
R. dispar	IWP,tr	NSW to Mackay	naked lobes	none	5;16	absent	0	15

[1] A, indigenous; IWP, Indo-West Pacific; te, temperate; tr, tropical.

neither branchial papillae nor parastigmatic vessels. Colonies superficially resemble *R. prolifera* or *R. dispar*, but these species are sessile, and lack the narrow stalk of the present one.

Ritterella tokioka nom. nov. for *R. pedunculata* Tokioka, 1953 from Japan has 12 rows of stigmata, each crossed by parastigmatic vessels, a short oesophagus and folded stomach. The colonies are stalked heads arising from a basal stolon resembling those of *R. sigillinoides* from New Zealand, but the zooids differ.

Ritterella vestita Millar, 1960 from the North Island, New Zealand. This species has a sandy, stalked head, without systems, zooids with 27 to 34 rows of 40 to 50 stigmata, a folded stomach, and testis follicles in a longitudinal series. It lacks both parastigmatic vessels and branchial papillae.

Ritterella yamazii Tokioka, 1949 from Japan is a soft semitransparent cushion with 5 rows of stigmata with parastigmatic vessels, 10 stomach folds, 2 rows of testis follicles, and epidermal vesicles in the larval test.

Ritterella sp. aff. *aequalisiphonis*: Tokioka, 1967 from Japan, has 14 rows of stigmata. Its naked, clavate colonies distinguish it from most Australian species.

Ritterella asymmetrica Millar, 1966 (Fig. 4, Plate 1e,f)

Ritterella asymmetrica Millar, 1966, p. 361.

DISTRIBUTION

NEW RECORDS: South Australia (Great Australian Bight, SAM E2102 E2104, QM GH4157 GH4195 GH4930; Kangaroo I., QM GH5427; Cape Jaffa, QM GH5445). Victoria (Nelson Bay, MV F57792).

PREVIOUSLY RECORDED: Victoria (Port Phillip — MV H39 Millar 1966).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies consist of upright, sandy, cylindrical to flattened stalks up to 4cm long, branching along their length, with terminal more or less club-shaped but bilaterally symmetrical expansions up to 1cm long and 6mm wide. On one side, the long terminal expansion is slightly flattened, with a scalloped margin. On the other, it is deeply convex. The atrial apertures open around the outside (deeply convex side) of the scalloped margin, and the branchial apertures

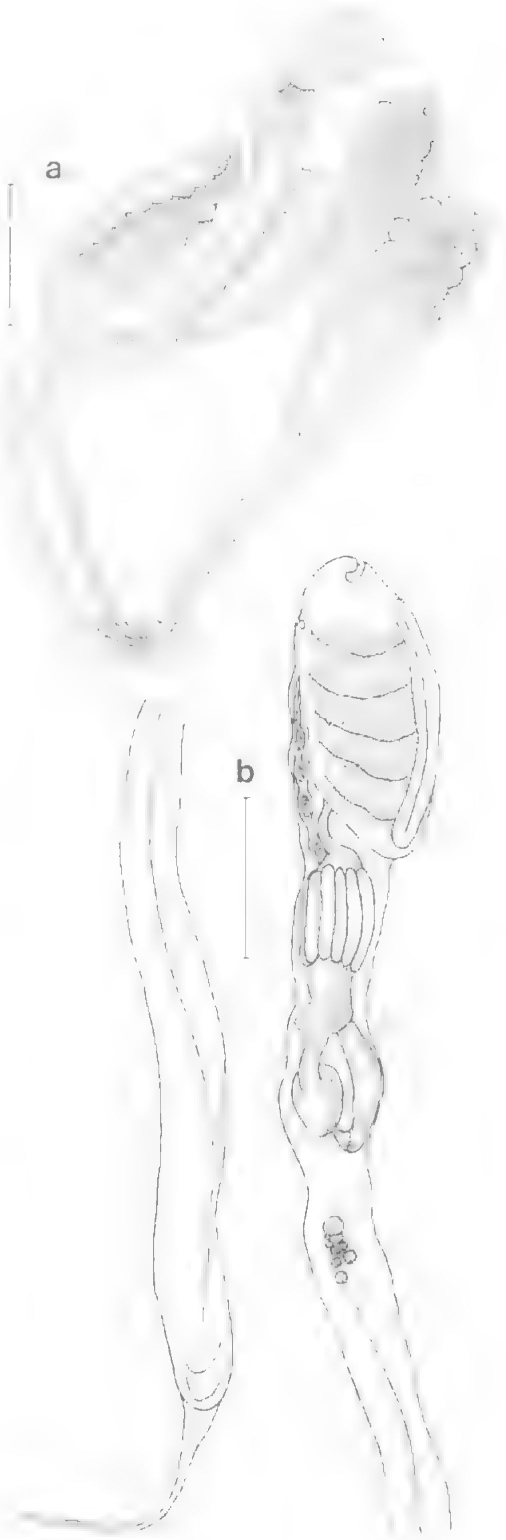


FIG. 4: *Ritterella asymmetrica* (MV F57792) — a, part of colony; b, zooid (posterior half of posterior abdomen shown separately). Scales: a, 1cm; b, 1mm.

are in a groove around the other (flat) side. Sand covers the outside of each stalk but is absent from the delicate internal test. In some of the preserved specimens the internal terminal expansion is spoon-shaped, its flat side slightly concave. In life it is probably slightly convex, presented to oncoming currents, deflecting the current past the branchial apertures that surround it.

The scalloped margin around the free end of each lobe is formed by the surface test swelling over the anterior end of each zooid. Each lobe of the colony contains up to 16 zooids, arranged parallel to one another in a single layer.

INTERNAL STRUCTURE: Zooids are about 1cm long, with thorax and abdomen of more or less equal length, and a longer, thread-like posterior abdomen. Both apertures are sessile, transversely elongated, and the 6 lobes around the rim of each opening are minute, sharply pointed and widely separated from one another, 3 on each facing lip. The branchial aperture is terminal and bent ventrally, the atrial sub-terminal and directed dorsally. A sphincter muscle is present around each aperture. A layer of fine transverse thoracic muscle fibres surrounds the slender longitudinal muscles which extend from the thorax onto the abdomen. Each of the 5 rows of about 20 long, narrow, parallel stigmata, is crossed by a conspicuous parastigmatic vessel. The transverse vessels are wide membranes projecting into the lumen. When contracted the edges of these membranes are drawn into tight frills that superficially resemble branchial papillae. However branchial papillae are not present. Triangular dorsal languets are on parastigmatic vessels as well as on primary transverse vessels.

The short, barrel-shaped stomach is in the anterior half of the abdomen. Twelve to 15 longitudinal folds are in its parietal wall, but the surface of the mesial wall is irregular. A long duodenal area, mid-gut and oval posterior stomach occupy the remainder of the descending limb of the gut loop. The rectum extends halfway up the thorax to open in a bilabiate anus just behind the atrial aperture. A small ovary with up to 12 small eggs is in the anterior part of the posterior abdomen. Mature testis are not present in any of the newly recorded South Australian and Victorian specimens (collected in April and June respectively), although they are present in the type specimen in 2 irregular longitudinal series (Millar 1966).

REMARKS

Millar (1966) believed that the branchial sac contained 10 rows of stigmata rather than 5, misinterpreting the parastigmatic vessels. These are true parastigmatic vessels, with the long stigmata continuous beneath them. The number of stigmata is difficult to determine in contracted specimens, but although at least 20 were counted there do not seem to be as many as the 35 Millar (1966) recorded.

Kott (1972a) discussed the possibility of this species being conspecific with *R. pedunculata*, suggesting that differences between the 2 species, viz. the size of colonies, zooids and branchial sacs, could be associated with growth. However, growth and maturity of *R. pedunculata* is not associated with increases of the order that could explain the differences. Although very large colonies of *R. pedunculata* have been examined, they all consist of the characteristically narrow lobes with not more than 12 zooids, and short stigmata without parastigmatic vessels. Further, the colonies are different, for atrial apertures of *R. asymmetrica* open around the convex sides of a club-shaped terminal expansion to form systems homologous with those of *Condominium areolatum* (see above); while those of *R. pedunculata* open in a row onto the concave side of a flat, fan-shaped expansion to form analogues of cloacal systems (see *R. cornuta* n.sp., below).

Transverse apertures with widely separated minute lobes on their rims are found in *Monniotus* spp., although, no phylogenetic relationship is implied by this. Rather the arrangement is an adaptation associated with the openings on opposite sides of the colony (see Kott 1989).

Ritterella compacta n.sp.
(Fig. 5. Plate 2a,b)

DISTRIBUTION:
TYPE LOCALITY: South Australia (Investigator Group, Flinders I., in caves, coll. N. Holmes 10.4.83, holotype QM GH2399 *SAM E2094*; eastern side of Grindle I., 10-15m, coll. W.H. Sasse, 7.4.87 paratype, QM GH4172 *SAM E2095*; Price I., 15-20m, coll. N. Holmes 9.4.87, paratype QM GH4177 *SAM E2096*).
FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are compact, sessile, and hemispherical to almost spherical, with the surface either undivided or (QM GH4177) subdivided into tightly packed cylindrical lobes, each containing a single circular system of 6 to 8 zooids. The test is sandy throughout and the zooids are in rigid, vertical compartments. The branchial openings are in circular depressions, around the periphery of the rigid sandy swellings or lobes (almost 5mm diameter) on the surface of the colony. Atrial openings are in a depression of varying depths in the centre of each lobe. Sometimes the central depression is deeper and forms a rudimentary cloacal cavity (QM GH2399 GH4172), opening to the surface through a central aperture and receiving the atrial openings of the zooids that surround it. A layer of sand continuous with the layer encrusting the outside of the colony lines the inside of the rudimentary cloacal cavity. It is homologous with the simple depression in the less compact colony (QM GH4177).

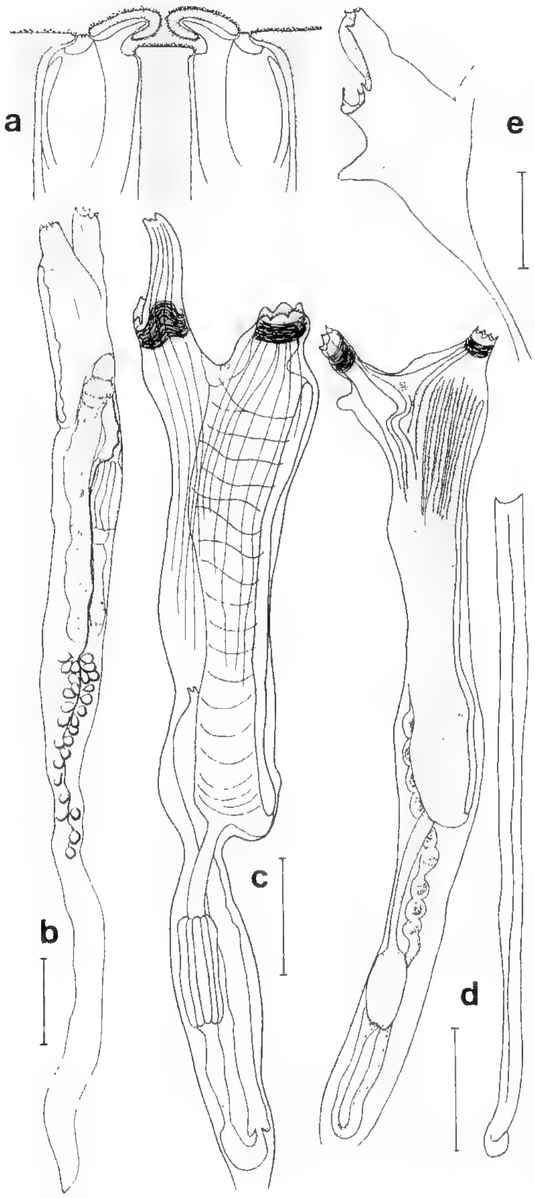


FIG. 5: *Ritterella compacta* n.sp. — **a**, diagrammatic cross section through a system (holotype QM GH2399); **b**, whole zooid (paratype QM GH4177); **c**, **d**, zooids (holotype QM GH2399); **e**, atrial siphon showing extended dorsal rim of aperture and dorsal median papilla (holotype QM GH2399). Scales: **b–d**, 1mm; **e**, 0.2mm.

INTERNAL STRUCTURE: The zooids are about 1cm long, they have a long thorax, a slightly shorter abdomen and a posterior abdomen that varies from about half to one third of the total zooid length. The 6-lobed branchial aperture is terminal, and the large atrial siphon subterminal. Often the anterior rim of the atrial siphon is produced into a lip of various lengths. The tip of the lip is divided into 3 pointed lobes, and the lower (posterior) half of the rim of the atrial aperture has another 3 widely separated small, pointed, lobes. In some zooids a pointed projection, or papilla projects from the dorsal mid-line on the posterior wall of the atrial siphon.

Circular muscles are present around the branchial and atrial apertures, curving out along the anterior atrial lip when one is present. About 12 longitudinal muscles extend down the thorax from each of the siphons. Posteriorly they extend along each side of the abdomen and posterior abdomen. Atrial lips are inserted into the rim of cloacal depressions or into the margin of cloacal apertures, so that the zooids in each system provide some muscular control around the rim of the opening.

Sixteen rows of about 20 stigmata are separated from one another by transverse vessels with about 14 rounded papillae on each. The stomach, with about 6 longitudinal folds on the parietal wall and irregular creases on the mesial wall, is about halfway down the abdomen. There is a duodenum and a mid-intestine in the descending gut loop. A distinct rectal valve is present at the proximal end of the ascending limb of the gut loop.

Gonads are in the upper half of the posterior abdomen, the 3 or 4 egg ovary anterior, and behind it almost spherical male follicles are bunched together.

REMARKS

Variations in length of atrial lip and the shape of the dorsal median papilla (on the posterior wall of the siphon) probably result from muscular action. With the exception of those variations, the zooids in the 3 available colonies of this species have the same characters. However, the colonies are more variable. The compact colonies with rudimentary cloacal systems superficially look very different from the one with its upper surface divided into lobes and with cloacal depressions rather than cavities. Nevertheless, these seem to be differences of degree rather than definitive morphological differences.

The species demonstrates the close relationship between forms without, and others with, true cloacal systems. Despite the variations in the development of separate lobes, this species does not have the same capacity to respond to changes in prevailing currents as the stalked *Ritterella*.

The rudimentary cloacal system is a unique feature in this genus. It has not been observed in other *Ritterella* spp; although it parallels certain species of *Eudistoma* (e.g. *E. angolanum*, *E. carnosum*, *E. reginum*: see Kott 1990). The branchial sac with its branchial papillae and numerous rows of stigmata resembles that of *Ritterella cornuta* n.sp.

Ritterella cornuta n.sp.

(Fig. 6, Plate 2c)

DISTRIBUTION

TYPE LOCALITY: South Australia (Price I., coll. W.H. Sasse 9.4.87, holotype QM GH4176 *SAM E2098*).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony consists of narrow, sandy stalks about 2cm long and 0.4cm in diameter attached basally to branching stolons. Terminally they are divided into 2 or 3 flattened, fan-shaped expansions, and have 2 or 3 branches along their length. The terminal flattened part of each lobe has a median depression. This depression receives the atrial apertures of the zooids which are arranged in a row along each side of the depression. The branchial apertures are along the outside of the rounded rim along each side of the median depression. Sand forms a dense coat around the outside of the colony and there is some embedded in the internal test.

INTERNAL STRUCTURE: The zooids are about 1cm long. Thorax and abdomen together represent slightly more than half the length of the zooid. Each aperture has 6 pointed lobes. The branchial aperture is terminal, oriented slightly ventrally, and the atrial aperture, on a short siphon

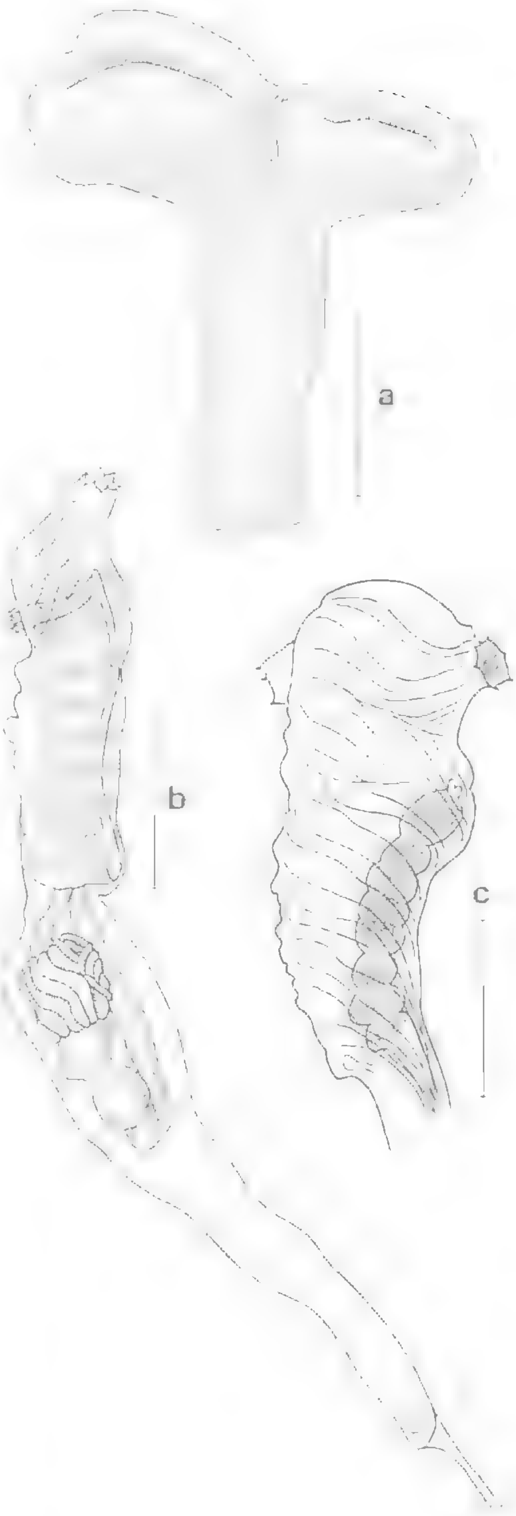


FIG. 6: *Ritterella cornuta* n.sp. (holotype QM GH4176) — **a**, part of colony; **b**, zooid; **c**, thorax. Scales: **a**, 5mm; **b**, **c**, 1mm.

directed at right angles to the long axis of the zooid, is about one quarter of the thorax length along the dorsal surface.

The body musculature is longitudinal and oblique, although in the examined zooids most bands extend transversely across each side to the dorsal surface before running the length of the zooid. About 5 bands are from the branchial siphon and a further 12 are from the endostyle. The muscles extend onto the abdomen and posterior abdomen from each side of the dorsal mid-line of the thorax. Stigmata are arranged in 9 rows of about 15 to 20. About 2 rounded papillae to every 3 stigmata are on the transverse vessels. There are no parastigmatic vessels.

The abdomen is relatively short, the stomach about halfway down, with about 6 indistinct oblique folds on the parietal surface, but with irregular creases on the side facing the ascending limb. A short duodenum and mid-intestine are in the descending limb distal to the stomach. The rectum extends about halfway up the thorax, terminating in a bilabiate anus. Gonads are not present in these specimens. The heart is present in the posterior end of the posterior abdomen.

REMARKS

The species most closely resembles *Ritterella papillata* n.sp., which has similar although narrower colonies and forms rudimentary cloacal systems. The latter species has smaller zooids with only 5 rows of stigmata and is thus distinguished from the present species. The colonies of both resemble those of *R. pedunculata*, but the latter species lacks branchial papillae and has a bilaterally symmetrical concavity at one side, rather than a radially symmetrical one on the free end of the lobe surrounded by zooids, as it is in the present species and *R. papillata* n.sp. Nevertheless, these concavities in *R. cornuta*, *R. papillata* n.sp. and *R. pedunculata* all serve to concentrate the excurrent streams of water and separate them from the incurrent streams. *Ritterella asymmetrica* is different, the atrial openings being around the convex side of the terminal expansion (see *Condominium areolatum*, above).

Ritterella dispar Kott, 1957

(Fig. 7. Plate 2d)

Ritterella dispar Kott, 1957, p. 102; 1963, p. 78 Monniot and Monniot, 1976, p. 360.

Ritterella proliferus: Kott, 1972c, p. 245; 1981, p. 157 (part, specimen from Lord Howe I.).

DISTRIBUTION

NEW RECORDS: Queensland (Moreton I., QM GH4940; Noosa, QM G4969; Capricorn Group, QM G9468 GH881 GH4941–4 GH4947–8 GH4950–1).

PREVIOUSLY RECORDED: New South Wales (Arrawarra QM GH5588), Queensland (Caloundra — AM U3897 Kott 1957; Currumbin — Kott 1963; Moreton Bay, Hervey Bay, Noosa Heads; Sarina — AM Y1116 Kott 1963). Lord Howe I. (QM G12001 Kott 1981). West Indian Ocean (Mauritius — Monniot and Monniot 1976).

The species is very common in the intertidal region on the mid-eastern coast of Australia and the southern part of the Great Barrier Reef. It has not been taken from the western Pacific — reexamination of the specimen from Fiji, which Kott (1981 QM GH102) assigned to *R. proliferus*, has shown it to be an *Aplidium* sp.

DESCRIPTION

EXTERNAL APPEARANCE: Small flat-topped sessile cushions, sometimes lobed, and round to polygonal in outline, form mosaics on hard substrates. They are attached by the centre of the flat basal surface. The relatively thick, but fairly short evenly spaced zooids open on the flat upper surface. Colonies are one or 2cm in maximum extent, and never more than 1cm thick. When expanded, the crowded colonies appear to be continuous with one another, but when either contracted or preserved they are seen to be separate. In life they are a flesh colour, with white zooids showing through, or 'ochraceous buff' (Ridgeway 1886) with iridescent blue zooids.

INTERNAL STRUCTURE: Zooids are relatively short (about 5mm) but quite thick, with a short posterior abdomen, and a wide thorax. Apertures are both anterior, each surrounded with 6 pronounced lobes. The lobes of the atrial aperture are particularly long, petal-like, and sometimes divided into 2, although those of the branchial aperture are shorter and triangular. Sphincter muscles are present around the base of each siphon. About 15 fine, parallel longitudinal muscles are on the thorax, and extend along the ventral side of the abdomen and posterior abdomen. Transverse muscles were not detected. There are 5 rows of 16 stigmata. Neither parastigmatic vessels nor branchial papillae are present. The oesophagus is short, and the stomach broad, with 15 parallel longitudinal folds. There is a broad duodenal region. An oval posterior stomach is in the bend of the gut loop. It is separated from duodenum and rectum by narrow mid-intestinal constrictions. A rectal valve is at the base of the ascending limb. Both gonoducts and anus open in the anterior part of the atrial cavity, near the base of the atrial siphon. The anal border is bilabiate. Gonads are in the short, stumpy posterior abdomen, the testis follicles in a more or less spherical clump, surrounding the ovary.

Specimens taken in May and August from the Capricorn Group (QM GH4941 GH4947) and in May from Noosa (QM GH4969) contained embryos. Embryos were not present in specimens taken from the Capricorn Group in February and April.

Each zooid contains one (QM GH4969) to 3 (QM GH4947) embryos or infertile eggs serially arranged in the distal (thoracic) part of the oviduct. Only the most anterior egg appears to mature to a tailed larva, and it is possible that the other eggs may be infertile. In specimens from Noosa (QM GH4969) there is a single tailed larvae in the distal end of the oviduct with what appears to be an infertile egg just behind it.

In one colony, the larval trunk varies in length from 0.6 to 0.8mm. It has the tail wound three-quarters of the way around it. The 3 median adhesive organs have wide shallow cones of secretory cells, and narrow stalks. Seven to 9 large epidermal vesicles in a row on each side are scattered around the adhesive organs as the larva matures. An ocellus and an otolith are in the cerebral vesicle.

REMARKS

These elegant transparent cushion-like colonies with independently opening zooids are significantly different from the colonies of other *Ritterella* spp. recorded from Australia, with their narrow sandy stalks and zooids arranged in colonial systems. There also are differences in the zooids, those of the present species being similar

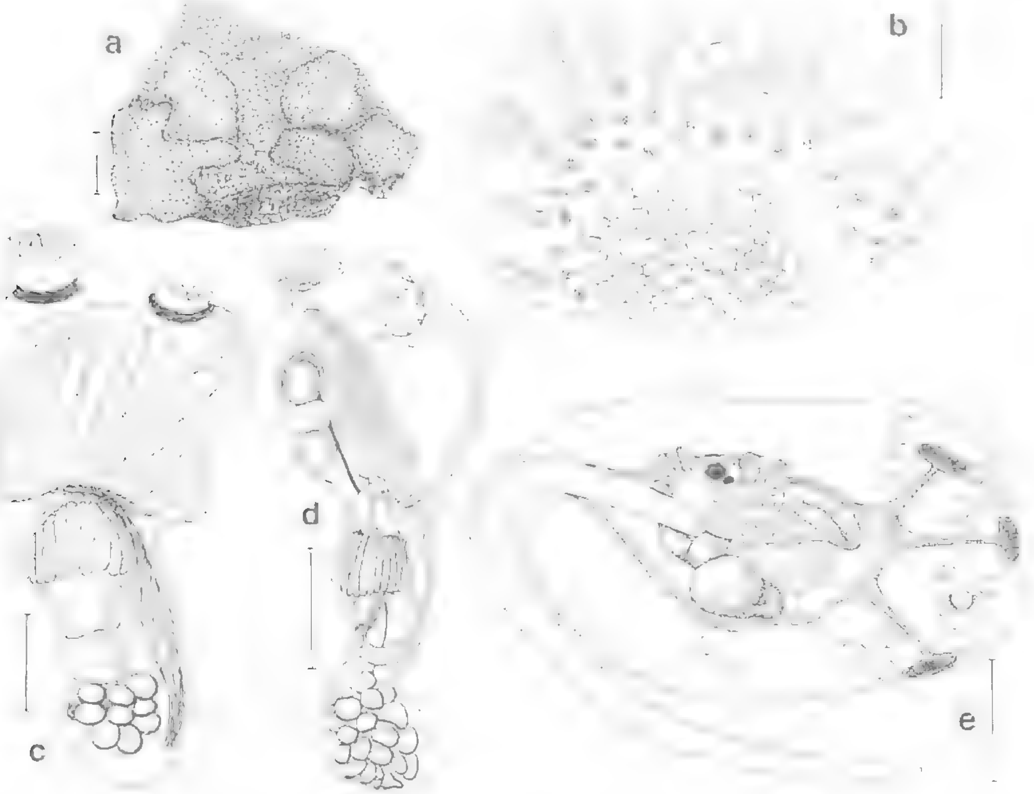


FIG. 7: *Ritterella dispar* — **a**, colonies viewed from above (QM GH4969); **b**, zooids seen in margin of colony viewed from below (QM GH4951); **c**, **d**, zooids (c, QM GH4951; d, QM GH4943); e, larva (holotype AM U3897). Scales: **a**, 1cm; **b**, 2mm; **c**, **d** 1.0mm; **e**, 0.2mm.

to others of the *aequisiphonalis* group, while zooids of other Australian species belong to the *pedunculata* group.

The relationship between *R. prolifera* (Oka, 1933) from Japan (see Tokioka 1953, Nishikawa and Tokioka 1976) and the present species is also very close, the only difference detected being the 6 rows of stigmata in the Japanese species as against 5 in *R. dispar*. Both species have deep, petal-shaped and sometimes bifid atrial lips, fine longitudinal body muscles, a short stomach with parallel folds, short posterior abdomen with bunched male follicles, up to 3 eggs in the distal end of the oviduct, and an identical larval trunk with a row of large, spherical ampullary vesicles each side of the adhesive organs, but no ectodermal ampullae. The colonies also are very similar, *R. prolifera* having the same flat, cushion-like, whitish, iridescent colonies that form mosaics on hard substrate and weed. On the basis of these similarities, Kott (1969, 1972d) proposed the synonymy of *R. dispar* and *R. prolifera*. They are presented here as separate species solely on the basis of the difference in the number of rows of stigmata.

The lack of continuity in the geographic range of the present species, with populations in Mauritius (Monniot and Monniot 1976) and on the sub-tropical coast of eastern Australia, is puzzling. There are no records from further north than Mackay, despite the fact that the species is common on the central coast. It is probable that the West Indian Ocean populations are isolated from the Australian ones.

Ritterella multistigmata n.sp.
(Fig. 8. Plate 2e)

DISTRIBUTION

TYPE LOCALITY: Western Australia (Sisters Reef, Murray Reef Warnbro Sound near Rockingham, 46°21.3S 115°41.3E, coll. AIMS Bioactivity Group 22.3.89, holoytpe QM GH5463).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The holotype colony is a large one, consisting of long (to 7cm), narrow (to 4mm diameter) sandy stalks, branched up to 3

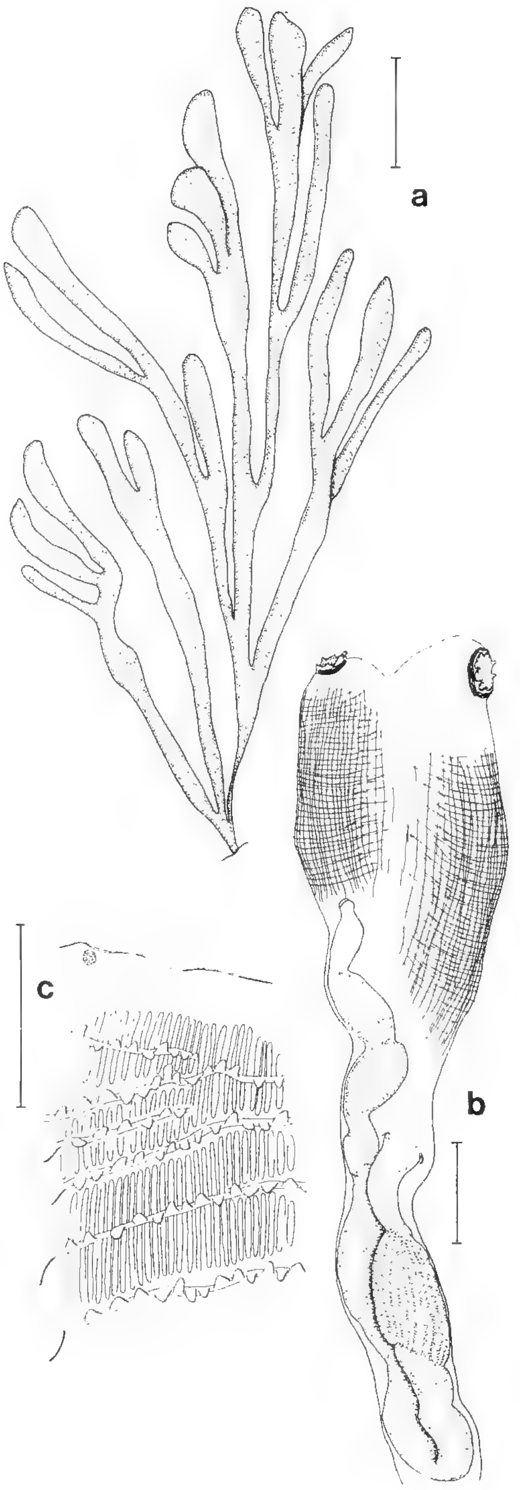


FIG. 8: *Ritterella multistigmata* n.sp. (holotype QM GH5463) — **a**, part of colony; **b**, thorax and abdomen; **c**, portion of branchial sac showing the neural gland and its opening, transverse and parastigmatic vessels, dorsal languets, and branchial papillae. Scales: **a**, 1cm; **b**, 1mm; **c**, 0.5mm.

times along their length. The terminal free ends are slightly expanded club-, or spoon- or fan-shaped. Each contains one to 3 zooids. Sand is crowded on the outer surface and is embedded in the surface layer of test making it brittle. However there is no sand internally, where zooids are in narrow longitudinal compartments in the transparent but tough test.

The long branching stalks of the colony are parallel to one another, and are crowded together to form compact masses.

INTERNAL STRUCTURE: Zooids are long and delicate, extending from the free end of a terminal lobe to the base of the colony. Most of that length is the narrow, thread-like posterior abdomen. The thorax and abdomen are together about 9mm long, with the abdomen about two-thirds the length of the thorax. The branchial aperture is turned ventrally, and the atrial aperture is directed anteriorly. Each of the apertures has 6 small points around the rim.

The thoracic body wall has an open meshwork of fine longitudinal and transverse muscle bands. Only the longitudinal bands extend to the posterior end of the zooid. The branchial sac has 10 rows of long, narrow stigmata each row crossed by a sturdy parastigmatic vessel which appears to be further subdividing the row of stigmata. Each transverse and parastigmatic vessel has about 12 large conspicuous rounded papillae evenly spaced along it. There are large triangular dorsal languets on parastigmatic as well as on primary transverse vessels. About 35 stigmata per row are in the rows about halfway down the pharynx, but fewer anteriorly, and even fewer posteriorly. Sixteen stigmata are in the most posterior row.

The long, oval stomach is halfway down the abdomen. The stomach wall is smooth externally but has fine longitudinal ridges internally. The post-pyloric part of the gut is wide, and has no marked divisions. The bilabiate anus opens about halfway up the branchial sac.

Gonads are not developed in this specimen.

REMARKS

Although they seem to branch more, the sandy stalks of this species with their asymmetrical tips most resemble those of *Ritterella pedunculata* and *R. asymmetrica*. Other *Ritterella* spp. have similar sandy stalks but radially symmetrical tips. Nevertheless *Ritterella cornuta* and *R. papillata* n.sp. are the only other stalked species that have numerous branchial papillae on the transverse vessels. However, both species lack parastigmatic vessels, *R. papillata* n.sp. has only 5 rows of stigmata, and although *R. cornuta* has a similar number of rows of stigmata (9) to the present species, it has a folded stomach wall rather than internal ridges. *Ritterella compacta* also has numerous rows of stigmata and branchial papillae, stomach folds, an atrial siphon with a long anterior lip adapted for circular colonial systems, and a compact colony, but it lacks parastigmatic vessels.

The unique characters of the present species are its branchial papillae, parastigmatic vessels, internally ridged stomach, and fine meshwork of longitudinal and transverse muscles on the thorax.

Ritterella papillata n.sp.

(Fig. 9)

DISTRIBUTION

TYPE LOCALITY: South Australia (Price I., coll. W.H. Sasse 9.4.87, holotype QM GH4148 *SAM E2097*; Taylor I., coll. W.H. Sasse 6.4.87, paratype QM GH4217).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies consist of a tangle of narrow, sandy stalks up to 5cm long, with a terminal inverted conical expansion, concave on the free end. The atrial apertures open around the inside of the terminal concavity and the branchial apertures are in a single circle around the outside of its rounded margin. The sandy test is sometimes raised in rounded swellings over the anterior end of each zooid. Up to 10 zooids are in each lobe. The terminal concavities often are turned to the side, presumably facing away from the oncoming current, which, as it passes the colony, probably entrains the excurrent stream of water (see Kott 1989).

INTERNAL STRUCTURE: Zooids are long and thread-like, with a long posterior abdomen that is up to 3cm long — many times the length of the thorax and abdomen together (about 2mm). There are black pigment cells scattered in the body wall. Each aperture has 6 small sharply pointed lobes. The branchial aperture is terminal, turned slightly ventrally. The atrial aperture is about one-third of the distance down the dorsal surface of the thorax. About 20 thoracic muscles are oblique (from the branchial siphon to the dorsal surface) and transverse (from the ventral mid-line), joining into bands along each side of the abdomen and posterior abdomen

In the branchial sac about 15 stigmata are present in each of 5 rows. The transverse vessels have flat, rounded papillae, containing dark black

pigment, about one to each stigma, along their edge. There are no parastigmatic vessels. The short stomach lies halfway down the abdomen. It has 6 broad but faint, oblique, parallel folds on the parietal wall, but its mesial wall is smooth. The bilabiate anus is halfway up the branchial sac. The gonads are in the posterior half of the posterior abdomen the small (about 3-egg) ovary anterior to a single longitudinal series of male follicles. In the type specimens, there are 4 or 5 embryos in the atrial cavity, but these do not include tailed larvae.

REMARKS

Although the colonies of *R. cornuta* are similar, those of the present species are narrower, and the terminal expansion is less flattened and not so wide. The zooids of the present species are smaller, with fewer rows of stigmata but much longer posterior abdomina. The accumulations of black pigment in the branchial papillae are not present in *R. cornuta*. *Ritterella pedunculata* and *R. asymmetrica* differ in not having branchial papillae. The terminal depressions containing the atrial openings are homologous with those of *R. cornuta* (see *R. cornuta* n.sp. REMARKS) and *R. compacta* n.sp. They are also radially symmetrical like those of *R. cornuta*, not bilaterally symmetrical like *R. pedunculata*.

Ritterella pedunculata (Herdman, 1899)
(Fig. 10. Plate 2f,g)

Psammaplidium pedunculatum Herdman, 1899, p. 88.

Not *Ritterella pedunculata* Tokioka, 1953, p. 184 (*R. tokioka* nom. nov.).

Ritterella herdmania Kott, 1957, p. 102 (part specimens from NSW); 1963, p. 78; 1972a, p. 11 (part); 1972b, p. 172; 1975, p. 2.

DISTRIBUTION

NEW RECORDS: South Australia (Great Australian Bight, SAM E2417; Spencer Gulf, QM GH1823 GH4927; St. Vincent Gulf, QM G9323; Margaret Brock Reef, SAM E2101; Cape Northumberland QM GH4928–9). Tasmania (Bruny I., MV F57793; St. Helens, QM G10156). Victoria (90 ml Beach, QM G12713; Portland, QM GH95; Port Phillip Bay, QM G10160 GH4682; Westernport, MV F57790 F57794). New South Wales (Port Hacking, AM Y2170; North Solitary I., QM G9642; Arrawarra, QM GH5393).

FIG. 9: *Ritterella papillata* n.sp. (holotype QM GH4148) — **a**, part of colony; **b**, thorax and abdomen; **c**, part of posterior abdomen with gonads. Scales: **a**, 5mm; **b**, 0.5mm; **c**, 2mm.

PREVIOUSLY RECORDED: South Australia (Great Australian Bight — SAM E2105–10 QM G9292 Kott 1972b, 1975; St. Vincent Gulf — SAM E2450 Kott 1972a). New South Wales (Port Hacking, Newport — AM U3862 U4017 Y821 Y1131 Y2170 Kott 1957, 1963; Port Jackson — Herdman 1899).

Specimens are from depths to 12m, often in fast-flowing currents. The species is very common in Port Phillip Bay.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are sometimes very large tangles of thin, sandy, branching stalks, one to 6cm long, attached to

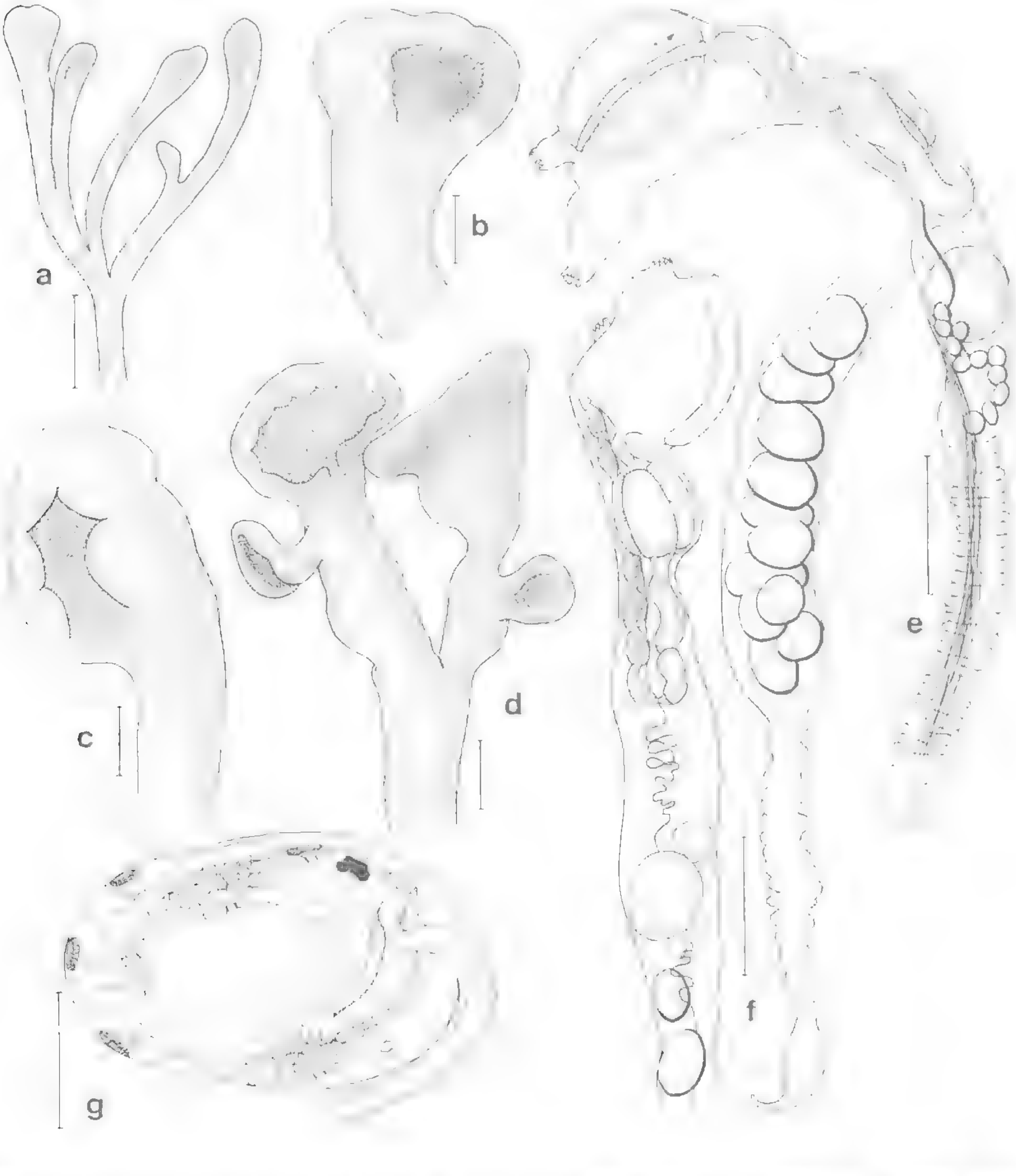


FIG. 10: *Ritterella pedunculata* — **a–d**, parts of colony and separate lobes (**a–c**, QM G9292; **d**, MV F57794); **e**, **f**, zooids (**e**, F57793; **f**, MV F57794); **g**, larva (MV F57793). Scales: **a**, 5mm; **b**, **c**, 1mm; **d**, 2mm; **e**, **f**, 0.5mm; **g**, 0.2mm.

basal stolons, and with flattened spatulate to fan-shaped tips which sometimes curve around to form a cornet, interrupted at one side. Up to 12 zooids are present in each lobe although usually there are fewer. The atrial openings are around the inside rim of the terminal, curved lamella and the branchial apertures around the outside of its rounded rim. Sand is thick externally but absent internally. Despite their outer layer of sand, collector's notes record specimens from St. Vincent Gulf (SAM E2450) to have been bright red.

INTERNAL STRUCTURE: The zooids are thread-like, the thorax and abdomen together up to 5mm long and with a much longer posterior abdomen. The apertures are almost sessile on short siphons, the rim of each with 8 small triangular lobes. Some fine circular muscle bands are on the thorax and the siphons. The longitudinal bands are delicate and extend the length of the zooid. There are 5 rows of about 12 stigmata. Neither parastigmatic vessels nor branchial papillae are present. Triangular dorsal languets are present over the dorsal sinus, on the transverse vessels.

The gut loop is slightly longer than the thorax, the oesophagus is short and the small stomach, smooth when distended but with 5 folds when collapsed, is not quite halfway down the abdomen. There is a distinct duodenal region and a posterior stomach in the descending limb of the gut loop. A rectal gland is at the junction of the mid-intestine and rectum.

The testis follicles are almost cylindrical, oriented longitudinally, and in a single series. When the posterior abdomen is contracted the male follicles are slightly bunched together. The small ovary is anterior to the testis, just behind the gut loop.

Up to 2 embryos, some developed to tailed larvae, are in the atrial cavity of specimens collected in February from Bruny I. (Tasmania) and Elliston Bay (S. Australia), in July from Portland (Victoria), and November (St. Vincent Gulf). The larval trunk is 0.6mm long. Single median ectodermal ampullae alternate with the adhesive organs. Ampullary vesicles are in bilateral clumps, about 3 deep postero-ventrally, antero-dorsally and around the anterior end of the trunk. Both otolith and ocellus are present.

REMARKS

Colonies from Green Pools (AM U3896, see below) assigned to this species by Kott (1957) are specimens of *Dumus*, having single zooids in each lobe, and 4 rows of stigmata.

Superficially, colonies of *R. pedunculata* resemble *R. cornuta*, *R. papillata*, and *R. asymmetrica* as well as *Monniotus* spp. and *Dumus* spp. However *Dumus* and *Monniotus* are distinguished by having only one zooid in each lobe; and the other *Ritterella* spp. have differently organised colonial systems, the shapes of the terminal free ends of each lobe being different (see *R. cornuta*, REMARKS). *Ritterella pedunculata* can also be distinguished from other *Ritterella* spp. by details of the branchial sac — from *R. asymmetrica* and *R. cornuta* by the 5 simple rows of stigmata, and from the latter and *R. papillata* by the absence of branchial papillae.

The specimens with both parastigmatic vessels and a branchial papillae on each transverse vessel reported from St. Vincent Gulf by Kott (1972a) are juveniles of *Monniotus australis*. There are neither branchial papillae nor parastigmatic vessels in *R. pedunculata*. Larvae from Elliston Bay (Kott 1975, Fig. 1) have a larval trunk 0.6mm long as do the newly recorded larvae from Bruny I. (MV F57793).

Genus **Dumus** Brewin, 1952

Type species: *Dumus areniferus* Brewin, 1952.

Only 2 species are known. Colonies are narrow, sandy, branched vertical lobes, the terminal branch containing only a single zooid, with 4 rows of stigmata, and a smooth or mulberry-like (but never folded) stomach wall. Possibly associated with the reduction in size of the branchial sac, there are no branchial papillae. Parastigmatic vessels sometimes are present. Testis follicles are in a single longitudinal series, relatively numerous eggs (to about 10) are present in the ovary and up to 12 embryos at a time are incubated in the atrial cavity. Many species of *Ritterella* (e.g. *R. pedunculata*) have similar colonies but otherwise are separated from *Dumus* by their more numerous rows of branchial stigmata, embedded zooids and longitudinal stomach ridges.

Nevertheless, the relatively large numbers of eggs in the ovary and the number of embryos incubated in *Dumus* suggest a more primitive condition than in *Ritterella* (in which not more than 3 embryos at a time are incubated in the atrial cavity).

The only species known are the type from New Zealand and temperate Australian waters, its northern limit in Moreton Bay), and *Dumus dumosus* (Monniot, 1987) from New Caledonia, a species originally assigned to the genus *Euherd-*

mania. It has neither the long oesophagus nor the folded stomach wall, nor the characteristic larval adhesive organs of *Euherdmania*. Its colonies are similar to those of *D. areniferus*, from which it differs in the presence of scattered circular swellings in the stomach wall and the parastigmatic vessels (as in *R. arenosa*, *R. asymmetrica*, *R. tokioka*, *R. yamazii*, and occasionally in *Condominium areolatum*, see above).

Dumus areniferus Brewin, 1952
(Fig. 11)

Dumus areniferus Brewin, 1952, p. 453. Kott, 1976, p. 58. Millar, 1982, p. 43.
Ritterella herdmania Kott, 1957, p. 102 (part, specimens from Green Pools).

DISTRIBUTION

NEW RECORDS: South Australia (Price I., QM GH4152). Victoria (Portland, QM GH92). New South Wales (South Ulladulla, QM G8585). Queensland (Moreton Bay QM G12725 GH3901 GH3903 GH4247).

PREVIOUSLY RECORDED: Western Australia (Green Pools — AM U3896). Victoria (Westernport — MV H286 QM G7509, AM Y1980 Kott 1976). New Zealand (Otago — Brewin 1952).

The range of this species, in Queensland and New Zealand, suggests a Gondwana component of the fauna.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are aggregations of long, narrow, sandy, branching vertical stalks up to 6cm long, joined to basal common stolons. The vertical stalks adhere to one another by the sand that covers them to form sandy platforms. The free ends of each terminal branch are expanded into a short bulb bent ventrally at right angles to the long axis of the stalk, onto which the zooids open. A single zooid is in each terminal branch of the colony. The branchial apertures face downwards from the front of the bulb and the atrial aperture upwards from the top. The thorax is slightly flattened dorso-ventrally. The stalks all taper slightly toward the base.

INTERNAL STRUCTURE: Zooids are up to 6mm long, and thread-like, at least half of the length being posterior abdomen. Six sharply pointed lobes surround each aperture. The body wall is muscular with 10 external longitudinal bands extending obliquely across the thorax from the branchial siphon to the postero-dorsal corner and then along the whole length of the zooid. From 10 to 16 stigmata are in each of 4 rows. Neither branchial papillae nor parastigmatic vessels are present. The smooth-walled almost cylindrical stomach occupies the middle third of the abdomen. The anal opening is halfway up the thorax. The ovary in the anterior part of the posterior abdomen has up to 10 eggs. Long and oval or, when compressed by contraction, circular to pear-shaped testis follicles are in a single series, although with contraction they tend to become bunched. Kott (1976) reported testis follicles confined to the posterior half of the posterior abdomen, but in the newly recorded specimens from South Australia and Queensland they occupy its whole length.

Up to 12 embryos are crowded in the atrial cavity of specimens collected in July (QM G8586) and August (QM GH3901 GH4247) from Moreton Bay, and November (AM Y3896 Y1980) from Green Pools and Westernport. The larval trunk is 0.4 to 0.5mm long. The 3 adhesive organs have narrow stalks and small, shallow cones of secretory cells. They alternate with median ampullae, each of which has a lateral ampulla near its base. On each side, there also are clumps of postero-ventral and antero-dorsal ampullary vesicles, the latter extending around the anterior end of the trunk, outside the lateral ampullae. The tail is wound about two-thirds of the way around the trunk. An otolith and ocellus are in the cerebral vesicle. The adhesive organs in this species are particularly small, and the robust ectodermal ampullae appear to be the most important structures at the anterior end of the trunk, and they have a cap of enlarged epidermal cells similar to those in *Polyclinum*.

REMARKS

The great geographic range of this species is not reflected in a variable morphology, for there is little variation, even between Australian and New Zealand populations. Although the larva is smaller, and lacks the lateral ampullae, it generally resembles the larva of *Ritterella pedunculata*.

Family EUHERDMANIIDAE Ritter, 1904
emend.

Zooids are either separate or embedded, with 6-lobed atrial openings directly to the surface. A long oesophagus opens into a small, longitudinally ridged stomach at the posterior end of the abdomen. The wide rows of stigmata (50 to 100 per row) vary in number from 5 to 20. Neither parastigmatic vessels nor branchial papillae are present. The anus opens in the base of the atrial cavity. Gonads are bunched, in a relatively short abdomen. Fertilisation takes place at the proximal end of the oviduct and embryos are brooded in the oviduct. Larvae have long pycnoclavellid-type inverted tubular adhesive organs.

Usually longitudinal and oblique muscles from the branchial and atrial siphons cross the thoracic wall to join into a wide band along each side of the ventral border, and continue onto the abdomen and posterior abdomen in 2 wide bands. In *E. vitrea* Millar, 1961 a dorsal rather than ventral band of muscles is reported and in *E. morgani*

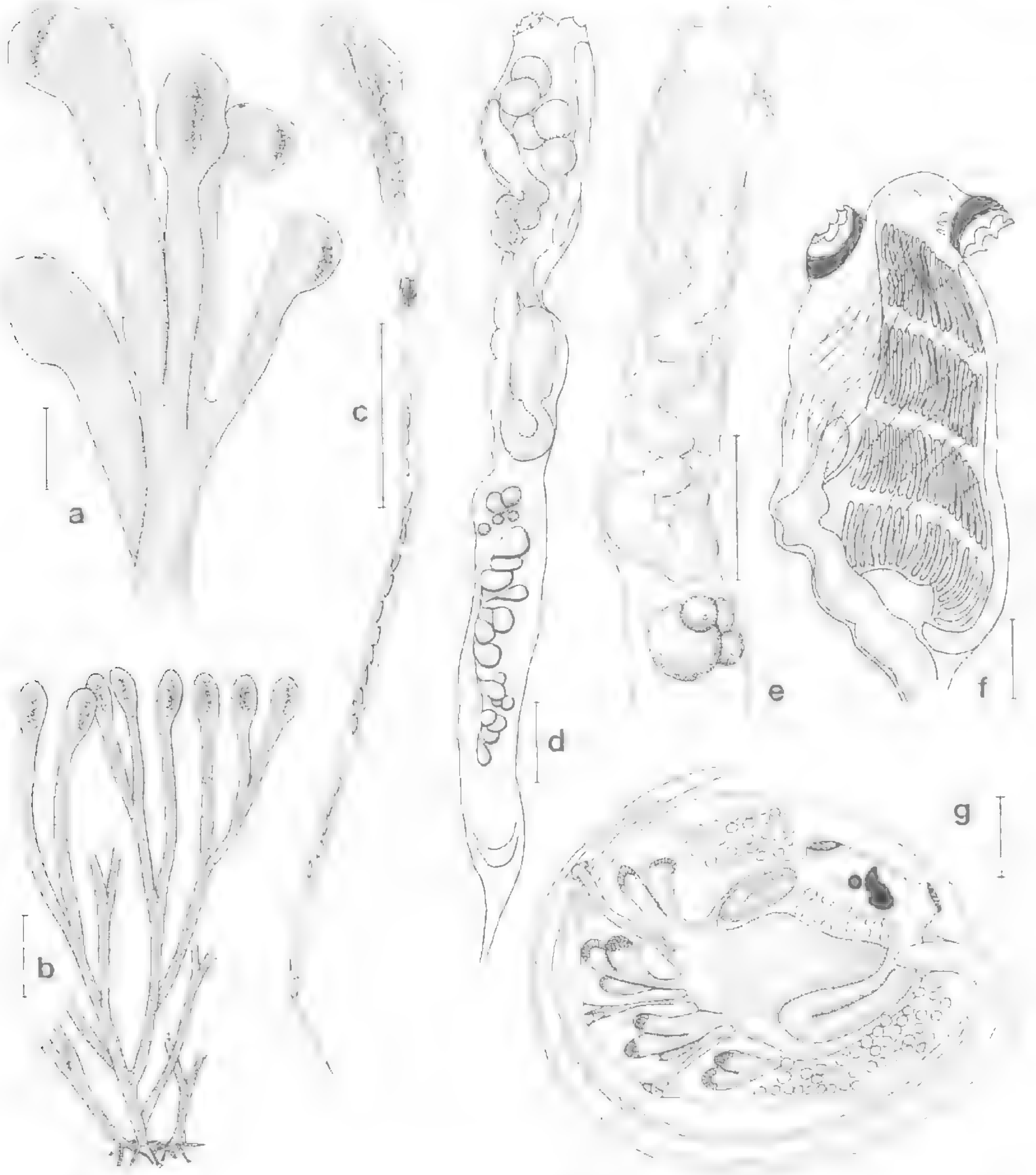


FIG. 11: *Dumus areniferus* — **a**, **b**, parts of colonies (**a**, QM GH4152; **b**, QM GH3901); **c–f**, zooids and parts of zooids (QM GH3901); **g**, larva (AM Y1980). Scales: **a**, 2mm; **b**, **c**, 5mm; **d–f**, 0.5mm; **g**, 0.1mm.

Millar and Goodbody, 1974 both ventral and dorsal bands are present. Transverse muscles have been reported only for *E. fasciculata* Monniot, 1983.

Pycnoclavellidae (see Kott 1990, p.66) have the same range in colony form as the present family, having zooids completely or partially embedded, or separate from one another for most of their length. Pycnoclavellidae also resemble the species of the present family in the position of the anal opening, the long oesophagus, fertilisation at the base of the oviduct and the same type of larval adhesive organs.

The principal characters distinguishing Euherdmaniidae from Pycnoclavellidae are the 6-lobed (rather than smooth) apertures, and the relatively large gonads sometimes located in a posterior abdomen (rather than in the gut loop). The relationship between the families seems to be closer than either has with other families.

Euherdmania is the only known genus of the family Euherdmaniidae.

When a posterior abdomen is not present (*Euherdmania dentatosiphonis*, *E. digitata* and *E. translucida* n.sp.), difficulties can arise in separating certain species of *Euherdmania* from *Polycitor*. Both have a long oesophagus and lobed apertures. The presence of larvae can resolve the difficulty as those of *Euherdmania* have long, inverted tubular (pycnoclavellid-type) adhesive organs. In the absence of larvae, reliance must be placed on the width of the thorax, position of the anal opening, and other details of the siphonal lobes to separate the genera.

Genus **Euherdmania** (Ritter, 1904)

Type species: *Euherdmania claviformis* (Ritter, 1903).

The genus is characterised by its separately opening zooids with long oesophagus and folded stomach wall.

In addition to the new species described below, the known species of *Euherdmania* are:

Euherdmania gigantea (Van Name, 1921) from Florida has embedded zooids and conspicuously serrated lobes around the apertures. Kott (1981) argued that the denticulate lobes of the apertures may indicate synonymy with *Stomozoa*. However, this is denied by the position of the gonads and the presence, in *E. gigantea*, of a series of embryos in the abdominal part of the oviduct (see Millar 1977) — as in *Euherdmania* but not in *Stomozoa*. The serrated lobes around the apertures probably occur in parallel in these taxa. Millar (1977) re-examined the holotype of *E. vitrea* Millar, 1961 from the Brazilian coast and thought that it may be conspecific with *E. gigantea*. A doubt remains, however, since the holotype zooids described (Millar 1961) have a dorsal rather than the ventral muscle bundle present in *E. gigantea*.

Euherdmania dentatosiphonis (Millar, 1975) from the western Pacific, was thought to be a synonym of *E. digitata* (see Kott 1981). However, it differs from *E. digitata* in having similar serrated lobes around the apertures to those in *E. gigantea*.

Euherdmania morgani Millar and Goodbody, 1974 differs from *E. gigantea* in its shallow and smooth (rather than serrated) oral and atrial lobes, its dorsal, as well as ventral, thoracic muscles, and zooids opening around a stalked, fan-shaped head rather than on top of a thick, sessile upright colony.

Euherdmania digitata Millar, 1963 from north-western Australia and the Western Pacific (Kott 1981, Tokioka 1967, Nishikawa 1984a) and southern Australia (see below) has separate zooids joined by basal stolons or common test. Occasionally its gonads are in the gut loop rather than in a posterior abdomen. It differs from *E. claviformis* in that the test is not sand-covered and the lobes of the colony are thicker. The larvae have the characteristic inverted tubular adhesive organs.

Euherdmania solida Millar, 1953 from the Gold Coast (Ghana) differs from *E. digitata* only in having partially embedded zooids. Its body musculature is like that of *E. digitata* and *E. vitrea*.

Euherdmania rodei Pérès, 1949 from the Gold Coast (Ghana) has fewer stomach folds than *E. solida* and completely embedded zooids.

Euherdmania claviformis (Ritter, 1903) from California has, like *Monniotus* spp. long, narrow, sandy lobes, each containing a single zooid, united basally. It is distinguished from zooids of the latter genus by the long oesophagus characteristic of *Euherdmania*. A related species from Senegal, *E. claviformis*: Pérès, 1949 has 15 to 16 rows of stigmata rather than 8 to 12 found in the Californian species. *Euherdmania claviformis*: Monniot, 1987 from New Caledonia with 18 rows of 40 stigmata is wrongly assigned (see *E. digitata* below).

Euherdmania fasciculata Monniot, 1983 from Guadaloupe has long, narrow branching stalks with the thoraces, at least, separate from one another. Sand is present only on the base of the colony. Longitudinal and transverse muscles form a meshwork and the longitudinal ones go to the end of the posterior abdomen. There are 12 to 17 rows of up to 30 stigmata. The anterior row of stigmata curves anteriorly along dorsal line. The anus opens at the second-last row of stigmata. The oesophagus is long, and the stomach is in the posterior end of the long abdomen. The species is separated from *E. claviformis* by its more numerous stomach folds (10 rather than 6), and its naked test.

Euherdmania areolata Millar, 1978 from the western Atlantic (Guyana shelf), has long, narrow, sandy lobes, each of the terminal branches containing a single zooid. These colonies resemble *E. claviformis* but they have more branches. The stomach has internal folds which are not obvious externally and distinguish the species from *E. claviformis* and *E. fasciculata*.

Thus, there appear to be 3 groups of species in *Euherdmania*, viz.:

a.*Gigantea* group with separate or embedded zooids, and pronounced serrations on siphonal lobes (*E. gigantea*, *E. dentatosiphonis*, *E. translucida* n.sp. and possibly *E. vitrea*).

b.*Digitata* group with separate or embedded (partially or completely) zooids, gelatinous sand-free test, and shallow, smooth siphonal lobes (*E. digitata*, *E. solida*, *E. rodei*, and probably *E. morgani*). *Distoma pulchra* Ritter, 1901 (<*Sigillinaria pulchra*: Van Name, 1945) is a likely member of this group.

c.*Claviformis* group with separate zooids in long, narrow, sometimes sandy, sometimes branching stalks, and pronounced but not serrated siphonal lobes (*E. claviformis*, *E. areolata* and *E. fasciculata*). The colonies of this group of species resemble those of many Ritterellidae, and *Monniotus* spp.

Larvae are known for *E. vitrea* (see Millar, 1961), *E. claviformis* (see Trason 1957); *E. digitata* (see Millar 1963, Kott 1981 and below). The larvae of *E. gigantea*, *E. rodei*, *E. dentatosiphonis*, *E. translucida* n.sp., *E. areolata* and *E. solida* are not known.

Euherdmania australis Kott, 1963 is incorrectly assigned having a short oesophagus, branchial papillae on the transverse branchial vessels, parastigmatic vessels, a stomach wall areolated but not longitudinally ridged, and a polyclinid-like larva with ectodermal ampullae and vesicles, and stalked adhesive organs (see *Monniotus*). *Euherdmania dumosa* Monniot, 1987 is also incorrectly assigned (see *Dumus*).

Species of *Euherdmania* are known mainly from tropical oceans and generally they have relatively restricted ranges. *Euherdmania translucida* n.sp. from South Australia related to *E. dentatosiphonis*, and the eastern Pacific *E. claviformis* are the only records from temperate waters.

Key to species of *Euherdmania* recorded from Australia

1. Siphonal lobes serrated 2
   Siphonal lobes not serrated .... *E. digitata*
2. Thoracic muscles not more than 3; colonial .... *E. dentatosiphonis*
   Thoracic muscles more than 3; solitary .... *E. translucida* n.sp.

Euherdmania dentatosiphonis (Millar, 1975) (Fig. 12)

Clavelina dentatosiphonis Millar, 1975, p. 211.

DISTRIBUTION

NEW RECORDS: None.

PREVIOUSLY RECORDED: Queensland (Coral Sea, Millar 1975).

The single small colony was taken at 100m.

DESCRIPTION (after Millar 1975)

EXTERNAL APPEARANCE: The single small colony consists of 4 narrow-stalked, club-shaped lobes attached to a basal stolon. Each lobe contains a single zooid, although in 2 they are degenerate or developing. The largest lobe is about 2cm high. The test is gelatinous and translucent, the thoracic part delicate and the stalk rather firm. The branchial aperture is terminal, but turned ventrally, and the atrial aperture is on the dorsal surface. Zooids are pink in preservative and can be seen through the test.

INTERNAL STRUCTURE: The larger zooid is 6mm when removed from the test. Each of the 6 lobes of each aperture is denticulate. The anterior lobe of the atrial aperture and the dorsal lobe of the branchial are broad. There is a half velum inside the 5 smaller lobes of each aperture which partly occludes the opening. The branchial tentacles, numbering about 45 are on the edge of a velum at the base of the branchial siphon. There are 3 wide oblique muscle bands on each side of the thorax, extending from the base of the atrial siphon to the postero-ventral corner of the thorax. These join into a single band running along the ventral surface of the abdomen, one on each side of the mid-line. Millar (1975) found 16 rows of stigmata alternating with high transverse branchial vessels. Triangular, pointed dorsal languets are present on the dorsal sinus. The abdomen of Millar's specimen may have been mutilated, as there was no sign of either stomach or gonads, although there is an entire gut loop.

FIG. 12: *Euherdmania dentatosiphonis* (after Millar 1977) — a, part of colony; b, zooid contracted; c, lobes of branchial aperture. Scales: a, 1cm; b, c, 1mm.

REMARKS

Kott (1981) believed that this species was a junior synonym of *Euherdmania digitata* Millar, 1963, which is known from the Western Pacific (Tokioka 1967, Kott 1981), north western Australia (Millar 1963) and southern Australia (see below). However, as well as lacking the denticulate lobes of the present species, *E. digitata* differs in the arrangement of its body muscles, including the presence of transverse thoracic muscles. The present species has similar siphonal lobes to *Euherdmania translucida* n.sp. from southern Australia. However, *E. translucida* has a larger zooid, more numerous thoracic muscles, and a solitary habit, all of which distinguishes it from *E. dentatosiphonis*. Further, the different locations in which they have been found and the discontinuity in their ranges is a compelling argument in favour of separate species.

Euherdmania gigantea (Van Name, 1921), from the western Atlantic (see Millar, 1977), has similar denticulate lobes and half velum in the aperture. It differs from the present species mainly in the form of the colony with its embedded zooids, and its more numerous oblique thoracic muscles (joining the usual bands each side of the mid-ventral line).

Millar (1975) thought that the upper part of the corrugated tube in the abdomen of the type specimen of *E. dentatosiphonis* may be the stomach, and Kott (1981) thought that the presence of a stomach at more or less the same level in the abdomen of *Euherdmania digitata* confirmed Millar's view. However it seems more likely that the abdomen of the type of *E. dentatosiphonis* has been damaged, and that it will be found to have a longitudinally folded stomach in the posterior part of the abdomen, as in all known *Euherdmania* spp., including species such as *E. translucida* n.sp. and *E. gigantea* which have other characters in common.

Euherdmania digitata Millar, 1963
(Fig. 13. Plate 2e)

Euherdmania digitata Millar, 1963, p. 698. Tokioka, 1967, p. 58. Kott, 1981, p. 154. Nishikawa, 1984a, p. 113. Monniot and Monniot, 1987, p. 83.
Euherdmania claviformis: Monniot, 1987, p. 501.

DISTRIBUTION

NEW RECORDS: South Australia (Investigator Group, QM GH4920 GH4183). Queensland (Capricorn Group, QM GH2455 GH4919 GH4921-5; Lizard I., QM G9772 GH2442).

PREVIOUSLY RECORDED: Western Australia (Cape Boileau — Millar 1963). New Caledonia (Monniot 1987). Fiji (QM G12469–70 G12867–8 Kott 1981). Palau Is (Tokioka 1967). Ponape (Nishikawa 1984a). Moorea, Tahiti (Monniot and Monniot 1987).

FIG. 13: *Euherdmania digitata* — a, part of colony (QM GH4920); b, single zooid in test (QM GH4183); c–e, zooids at various states of contraction (c, d, QM GH4920; e, QM GH4183); f, larva (QM G9772). Scales: a, 5mm; b, 1mm; c–e, 2mm; f, 0.2mm).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are up to 4cm in maximum extent, consisting of separate zooids up to 3cm high attached to a tangle of basal stolons or solid basal test. The lower one-third of each upright zooid is covered with very firm test, which becomes progressively softer and more transparent toward the upper (thoracic) part. The upright stalks sometimes branch along their length.

The thoracic test has a thickening each side of the terminal branchial aperture and another median one just postero-dorsal to the subterminal atrial opening.

The living specimens from the Capricorn Group are a clear, bright canary-yellow, and one of the zooids (from QM GH4925) had *Prochloron* symbionts evenly and densely distributed around, and in the lining of, the branchial siphon. Yellow pigment is especially dense in both siphon linings.

The rim of each of the apertures is divided into 6 shallow lobes, each lobe with a yellow (light sensitive ocellus?) pigment spot in the centre. The branchial aperture often is inclined ventrally, and the atrial aperture directed upwards.

INTERNAL STRUCTURE: Zooids are long (up to 3cm) and narrow. The thorax is about a quarter of the length of the abdomen. The posterior abdomen, only slightly shorter than the abdomen, terminates in several blunt vascular processes. Up to 20 fine parallel longitudinal thoracic muscles, which when contracted form 8 to 10 wide bands, cross the thorax obliquely from atrial and branchial apertures to the endostyle, and continue along each side of the mid-line on the abdomen and posterior abdomen in a pair of wide ventral bands. A layer of fine transverse muscles lies beneath the longitudinal muscles on the thorax. About 20 very slender branchial tentacles are in a circle at the base of the branchial siphon. About 16 to 18 rows of stigmata have approximately 50 to 60 stigmata per row in the anterior rows. Shorter rows with about 30 stigmata are at the posterior end of the branchial sac. Transverse vessels are broad, flat membranes projecting between the rows of stigmata. These expand into long, pointed dorsal languets over the dorsal sinus.

The gut loop is long and narrow, with a long oesophagus and a narrow stomach at the posterior end of the descending limb. The stomach wall has from 8 to 12 longitudinal irregular, or oblique and sometimes shallow folds. The anal opening has two smooth lips and opens in the base of the atrial cavity.

Gonads are in the anterior part of the posterior abdomen, just behind the stomach. They consist of a cluster of pyriform male follicles, surrounding 3 or 4 oocytes. In one of the specimens there are also orange eggs in the oviduct and in others a developmental series of embryos is in the oviduct from just distal to the stomach to the atrial cavity. Embryos are present in the oviduct in June from Lizard I. (QM G9772), but were not present in October at Heron I. Larvae have a long (1.0mm) trunk, with 2 long inverted tubular adhesive organs, an ocellus and an otolith. The tail is wound about halfway around the trunk. The postero-ventral part of the trunk is very yolky.

REMARKS

The zooids and larvae of the north-western Australian (Millar 1963), and Palau Is (Tokioka 1967) specimens deviate from the present ones only to the extent that a lesser number of stigmata (15) was recorded for the Palau Is specimen. However, Tokioka was uncertain about the numbers he recorded and it is possible that he was misled by the narrow thorax.

Monniot (1987) assigned New Caledonian colonies (an unspecified number) to the indigenous Californian *E. claviformis*, which has fewer rows of stigmata and narrower thoraces. There is neither morphological nor geographic grounds for this assignation. Larvae are the same size as the other western Pacific specimens. It is presumed that the 2 adhesive organs recorded by Monniot are the usual inverted tubes characteristic of this genus.

Kott (1981) tried to establish a synonymy between the present species and *E. dentatosiphonis* Millar, 1975. She thought the denticulate siphonal lobes of *E. dentatosiphonis* were not essentially different from the smooth lobes of the Fijian specimens of *E. digitata*. However, comparison of the Fijian with the newly recorded Australian specimens shows them to be similar to one another, and distinct from *E. dentatosiphonis*. The larvae and embryos being incubated in the oviduct of Fijian and Australian specimens are also identical; and re-examination of the Fijian specimens has shown that although only 20 stigmata were recorded, at least twice that number is present.

Of concern to the interpretation of intrageneric phylogeny of these taxa is the variation in the position of the gonads, which are in the abdomen (in the Fijian specimens), or in a posterior abdomen. However, although the former have embryos in the oviduct, and tubular larval adhesive organs like *Pycnoclavella*, their siphonal lobes indicate that the specimens are members of the genus *Euherdmania*, and in view of their other characters, they appear to be specimens of *E. digitata*.

Variation in the number, orientation and depth of the stomach folds apparently is a characteristic of this species, Millar (1963) and Kott (1981) reporting 12 folds, Tokioka (1967) reporting 8, and Monniot (1987) 6 to 10 but mostly 8.

Euherdmania translucida n.sp.

(Fig. 14, Plate 3a)

DISTRIBUTION

TYPE LOCALITY: South Australia (Sir Joseph Banks Group, Marum I., N Point, offshore, in sand and root-mat of *Posidonia*, 8m, coll. W. Zeidler 11.1.84, holotype SAM E2092, paratype SAM E2056; Sir Joseph Banks Group, Reevesby I., NW Point 150–200m, coll. W. Zeidler, paratype SAM E2093).

FURTHER RECORDS: South Australia (Spencer Gulf, Banks and Investigator Groups, QM GH2310, SAM E2091; Yorke Peninsula, SAM E2455; Kangaroo I., SAM E2529).

DESCRIPTION

EXTERNAL APPEARANCE: Individuals are solitary, up to 4cm high. They have hard, long, narrow stalks with basal branching root-like extensions. Only 3 specimens (SAM E2056 E2092 E2455) are complete. The others have been cut off across the long oesphageal neck and the posterior end of the abdomen is missing. The base of the stalks of the holotype and one paratype (SAM E2056) expand into a holdfast amongst the *Posidonia* root mat. The firm stalk has whitish, translucent test internally, and is leathery externally. The terminal expanded balloon-shaped thoracic part, occupying about one-fifth of the total length, has thick, soft, and glassy test containing spherical test cells which are crowded together forming spots about 0.5mm apart. The branchial aperture is terminal and the atrial aperture subterminal. Each aperture is surrounded by 6 large, rounded petal-like lobes.

Photographs of living specimens show them to have very transparent thoraces, with bright spots which may be light sensitive at the tips of the siphonal lobes.

INTERNAL STRUCTURE: The zooid occupies the whole length of the stalk, with only a fine blood vessel extending into the basal holdfast.

Each aperture is surrounded by 6 flat lobes. A crescent-shaped half velum is around the ventral side of the lumen of the branchial aperture, and another is inside the dorsal side of the atrial aperture. The adjacent lobes of the respective apertures, viz., the dorsal lobe of the branchial and the ventral (or anterior) lobe of the atrial aperture are especially wide, each containing parallel longitudinal muscles and fringed with about 12 pointed tongues. The inner faces of these 2 large, fringed lobes are continuous with the lining of the pharyngeal and atrial cavities respectively. Continuity between the linings of these cavities and the inside surfaces of the slightly smaller lateral lobes (fringed with 6 to 8 points) on each side of the large median lobes is interrupted by the ends of the crescent-shaped vela. Outside the widest part of the vela, the tip of the opposite median and lateral lobes are divided into one or 2 long points.

A sphincter muscle in each velum seems to derive its fibres from the longitudinal thoracic muscles. Seen in section, the velum appears to be a fold of the body wall at the base of the siphons. The branchial velum in particular projects from just in front of the branchial tentacles, and its sphincter muscle may be homologous with that usually found beneath the tentacles. There are 12 strong longitudinal thoracic muscles, viz. 4 branchial contributing fibres to the branchial velum, 3 dorsal contributing fibres to the 2 large median siphonal lobes, and 3 atrial contributing fibres to the atrial velum. These muscles extend obliquely toward the postero-ventral corner of the thorax, and join into a wide band on each side of the long oesophageal neck, terminating at the posterior end of the abdomen. Transverse muscles were not detected.

About 40 relatively long, slender branchial tentacles are of various sizes. The dorsal gland is large, and a fleshy dorsal tubercle has a vertical opening in a V-shaped peritubercular area that projects into the pharynx so that the opening of the neural duct is directed forwards, toward the branchial aperture. There are 20 long rows of relatively short stigmata, with 100 or more stigmata in the anterior rows, although the rows become shorter posteriorly. The transverse vessels between the rows of stigmata are very wide, flat membranes. Over the dorsal sinus these expand into triangular languets with long points that coil over to the right side. Neither parastigmatic vessels, nor papillae are on the transverse vessels.

The oesophageal neck is long and straight, and the abdomen swells into an onion-shaped bulb only at the posterior end. Both the oesophagus and rectum are transversely wrinkled. In the only 2 specimens with a complete abdomen, the stomach, and other parts of the gut loop, have very thin walls and are packed with trophocyte cells. The abdomen appears to be degenerating and possibly the body organs are being resorbed. The stomach is almost cylindrical with about 6 longitudinal folds. There is no apparent posterior abdomen. The pole of the gut loop curves around in the posterior end of the abdomen. The anal opening is at the posterior end of the atrial cavity. There were no gonads detected in these specimens; nor were larvae present.

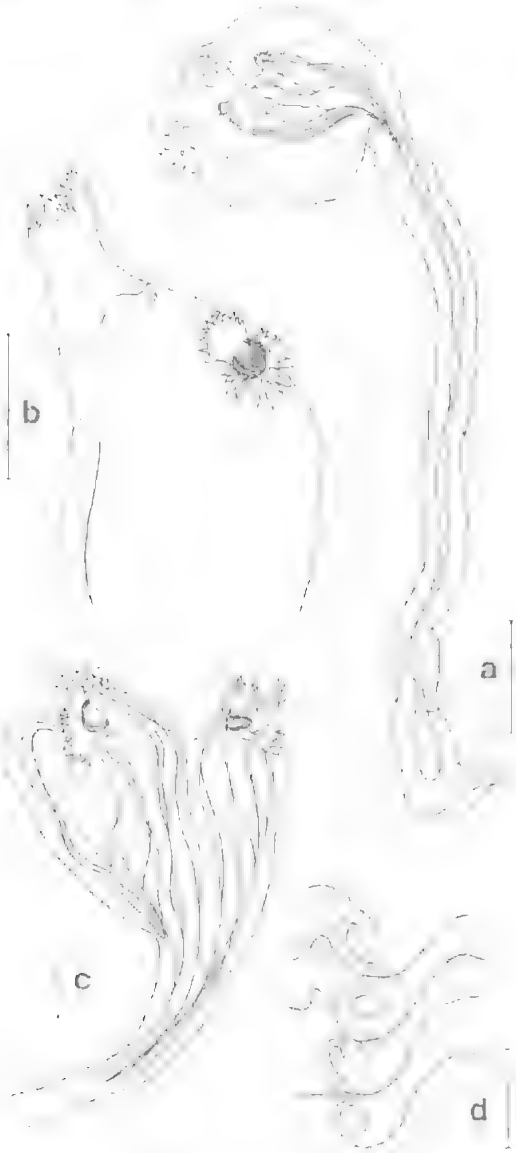


FIG. 14: *Euherdmania translucida* n.sp. — a, zooid in test (holotype SAM E2092); b, c, thoraces showing lobes of apertures and muscles (SAM E2093 E2091); d, part of dorsal lamina (SAM E2091). Scales: a, 5mm; b, c, 2mm; d, 0.5mm.

REMARKS

A number of characters can cause confusion in identifying this species. There are certain solitary *Clavelina* (e.g. *C. meridionalis*, *C. ostrearium*, *C. dagysa*) that superficially resemble the solitary individuals of *E. translucida*, but they have a characteristically conspicuous vascular stolon and plain-rimmed apertures (the present species has only a small inconspicuous vascular stolon and lobed apertures). The size of the pharynx, the number of stigmata as well as the number of rows, the absence of a posterior abdomen and the large siphonal lobes suggest *Stomozoa* but, in addition to their colonial habit, *Stomozoa* spp. have complete rather than partial siphonal vela, the so-called ocelli are on each side of the siphonal lobes rather than in the tips as they are in the present species, and the oesophagus is not as long as it is in the present species.

The long abdomen, long oesophagus and anus in the posterior end of the atrial cavity are characteristic of both *Pycnoclavella* and *Euherdmania*. Nevertheless, the species seems closer to *Euherdmania* than *Pycnoclavella* because of its large pharynx with numerous rows of stigmata, folded stomach, siphonal lobes, and muscular velum (which resembles that of *Euherdmania dentatosiphonis* Millar, 1975). Only its solitary habit, larger zooids and more numerous thoracic muscles distinguish the present species from *E. dentatosiphonis*. Thus, although the gonads are not always in a posterior abdomen, *Euherdmania* seems to be the most appropriate genus for this species.

Family PSEUDODISTOMIDAE n. fam.

The family is characterised by its colonies with embedded, separately opening zooids with 6 well defined lobes around the atrial and the branchial apertures, 3 rows of stigmata with the anterior row on each side continuing anteriorly along each side of the mid-dorsal line, fertilisation in the oviduct, and a generally smooth stomach wall with 4 broad longitudinal compartments or quadrilateral in outline. Generally the oesophagus is short and the stomach is in the middle third of the abdomen.

However, a group of species, viz. *P. arborescens*, *P. aureum*, *P. novaezelandiae*, *P. opacum* and *Anadistoma* n.gen. (see below) have a longer oesophagus, with the stomach two-thirds to three-quarters of the distance down the abdomen. The curved heart is in the posterior tip of the posterior abdomen. Gonads are in longitudinal series or bunched in the long posterior abdomen. The vascular processes from the tip of the posterior abdomen are moderately long (longer than those in the Polycitoridae) and longitudinal muscle fibres (from the muscle bands on each side of the abdomen) sometimes continue onto them. Larvae are large, with a trunk often exceeding 1.0mm in length. The adhesive organs are large, with a deep, wide, eversible axial platforms which, when everted, form large thin-walled balloon-like structures in the anterior mid-line. They appear to lack the tall columnar cells that comprise the axial elements of the adhesive organs of most taxa (see Cloney 1977, Turon 1991).

Apart from the presence of gonads in a posterior abdomen, zooids resemble those of *Sigillina* in having 3 rows of stigmata, a relatively short oesophagus, smooth stomach, a long vascular stolon sometimes with longitudinal muscle fibres on it, fertilisation and incubation of the especially large embryos in the oviduct or in a brood pouch, and wide platforms of adhesive cells in the deep epidermal cups of the large, eversible adhesive organs. Further, in *Anadistoma* n.gen. transverse muscles are present on the thorax as in *Sigillina*.

Zooids are smaller than those of *Sigillina*, and, like those of *Eudistoma* and *Pycnoclavella*, have the anterior row of stigmata deflected anteriorly. This could be the result of convergent evolution associated with size reduction and does not necessarily indicate a direct relationship with Pycnoclavellidae. Nevertheless an alternative hypothesis for the origin of the Pseudodistomidae is from a pycnoclavellid ancestor by shortening of the gut loop, leaving gonads and heart in the posterior abdomen, while the tubular larval adhesive organs reduce in length and partially evert. Evidence against the pycnoclavellid relationship is the position of the anus halfway up the short thorax (not at the posterior end of the atrial cavity as in *Pycnoclavella*), and the 6-lobed rather than smooth apertures.

The monotypic genus *Citorclinum* Monniot and Millar, 1988, containing a single species *Citorclinum laboutei* Monniot and Millar, 1988 known only from the New Caledonian lagoon, appears to belong to this family. It has 3 rows of stigmata, the anterior row inclined forward along the mid-dorsal line, a smooth-walled stomach halfway down the abdomen, and the testis follicles in a long series in the posterior end of the posterior abdomen. As in *Pseudodistoma* incubation is in the abdominal part of the oviduct. The large larva (trunk about 1mm long) has 2 elongate everting adhesive organs in the mid-line. These are hollow, without columnar cells, and are like those of *Pseudodistoma* rather than *Sigillina*, or other Holozoidae, Polycitoridae and most families of the Aplousobranchia. The genus is distinguished from *Pseudodistoma* by the withdrawal of the heart and ovary to the abdomen with the gut loop, leaving the testes in the posterior abdomen

In addition to *Citorclinum* and *Pseudodistoma* the family contains the monotypic new genus *Anadistoma*. The latter has transverse thoracic muscles and a longer oesophagus than *Pseudodistoma*.

Genus **Pseudodistoma** Michaelsen, 1924

Type species: *Pseudodistoma cereum* Michaelsen, 1924

Brewin (1958) on the basis of what she called 'parallelism in classification' assigned species to genera solely on the presence or absence of stomach folds — those with stomach folds being in *Pseudodistoma*. This definition is based on the type species which has a quadrate stomach or one partially divided into 4 chambers. True stomach folds do not occur. Brewin's definition must also be amended to exclude *Ritterella* in which true stomach folds do occur, and which has other characters separating it from *Pseudodistoma*.

Species of this genus appear to be less prolific than most ascidians. Gonads apparently mature for only a short time, and were not seen in many of the examined specimens. Further, the ovaries are small, and in most species only a single ovum develops at a time. The testis follicles are confined to the posterior, middle, or anterior part of the posterior abdomen, and never occupy its full length. Fertilisation appears to be at the base of the oviduct, for embryos are found being incubated in the posterior abdomen in *P. oriens* n.sp. and *P. kanako*; and in the abdomen in *P. arborescens*, *P. aureum*, *P. opacum*, *P. cereum*, and *P. brieni*. In the last 2 species embryos are lined up in the abdominal part of the oviduct in a developmental sequence. In the new Australian species *P. acuatum* n.sp., *P. pulvinum* n.sp., and *P. grac-*

TABLE 4. Summary of characters of species of *Pseudodistoma* recorded from Australia

Species	Biogeographic Range[1]	Range anticlockwise around Australia	Colony	Sand (embedded)	Stomach position (thirds of abdomen)	Length vascular stolon	Stigmata: maximum number/ row	Gonads: ♂ position in posterior abd.; ♀ relative to ♂	Embryos: maximum number; site of incubation[2]	Larva: trunk length (mm); adhesive organs	Other
P. gracilum n.sp.	A,te,tr	Kangaroo I. to Coral Sea	sessile cushion	none	middle	moderate	30	middle;anterior	1;bp stalks	1.75;short	mucus-like test
P. pulvinum n.sp.	A,te	"	"	"	"	"	30		"	?	—
P. aureum	WP,tr	Heron I. to Fiji	sessile cushion — mushroom	"	posterior	short	25	posterior;anterior	1–4;b	0.63;short stalks	—
P. inflatum n.sp.	A,te	NSW	"	centre of colony	"	"	20	anterior;amongst	?	?	sometimes surface lobed
P. pilatum n.sp.	A,te	Gt Australian Bight	stalks branched along length	"	middle	long	20	posterior;anterior	?	?	short, flat heads
P. acuatum n.sp.	A,te	"	"	layer beneath surface	"	"	8	posterior;?	?;bp	?	pointed heads
P. australe	A,te,tr	Exmouth Gulf to Port Phillip Bay	one or more lobes sessile or stalked joined basally	in stalk	"	"	25	posterior;anterior	1;bp	1.0;short stalks	few, short lateral larval ampullae
P. oriens n.sp.	A,te	Cockburn Sd to Port Phillip Bay	"	sometimes in stalk	"	"	30	"	1–2;b	1.35;sessile	"
P. candens n.sp.	A,te	Abrolhos to Pearson I.	stalked heads	"	"	"	25	anterior;amongst	1;b	1.5;long stalks	numerous long lateral larval ampulla

[1] A, indigenous; te, temperate; tr, tropical; WP, Western Pacific. [2] bp, brood pouch; b, no brood pouch.

ilum n.sp. and in *P. australe*, *P. cymusense*, *P. kanoka* and *P. fragile*, incubation of embryos is completed in a brood pouch constricted from the top of the abdomen, near the postero-dorsal corner of the thorax.

Brewin (1958 p.444) refers to 'bud like masses' that lie beneath the zooids of *Pseudodistoma cereum*; and in the present collection *Pseudodistoma oriens* n.sp. has juvenile replicate zooids in the stalk of a developing colony lobe. It therefore seems possible that replication does not involve the abdomen. However at this stage it is not clear whether it involves strobilation of the posterior abdomen (as in *Aplidium* spp.), or the posterior vascular stolon (as in Holozoidae).

Colonies of *Pseudodistoma* often (though not always) are stalked, with the zooids regularly arranged, the atrial apertures opening toward the top of the colony or the centre of the upper surface, and the branchial apertures toward the stalk or the outer margin. Colonies thus have colonial, but not cloacal, systems.

The zooids of most species of *Pseudodistoma* are basically similar to one another and this has resulted in confusion in their taxonomy. The zooids are, moreover, very muscular and preserved specimens usually are so contracted that details of their morphology, such as the numbers of thoracic muscle bands and stigmata, are obscured. When relaxed the posterior abdomen is long and narrow, but it is short and thick when contracted. There often is a vascular stolon of appreciable length with some longitudinal muscle fibres on it. Male follicles, when present, are either clustered in the posterior, middle or anterior third of the posterior abdomen, or spread out in longitudinal series. Sometimes the small ovaries are surrounded by the clustered male follicles but in other species they are anterior to them. The gut loop is very conservative — the quadrate stomach and rectal valve being present in most species (*P. fragile* being the exception). However there is some variation in the length of the oesophagus (see family discussion, above). At this stage, the larvae (which vary in numbers of ampullae), the position of the gonads, and the form and colour of the colony constitute the principal characters distinguishing species of this genus from one another.

Only one known species, *Pseudodistoma aureum* has a character that implies a polyphyletic origin for the genus, viz. tufts of columnar cells in the adhesive organs of the unusually small larvae rather than the everting, balloon-like organs of other species.

The majority of species are known from either Mediterranean, Japanese or southern hemisphere temperate waters. The type species is recorded from New Zealand. The only tropical species known are *P. brieni* Pérès, 1949 from Senegal and *P. aureum* (Brewin, 1957) from the Western Pacific (see below).

Although only one species from Australia (*P. australe* Kott, 1957) was previously regarded as indigenous, revision of the material has shown that all Australian species are (Table 4). As in *Sigillina*, it is probable that gene flow for many species is inhibited by the relatively large and few larvae, longer incubation and shorter free-swimming life, and the probability that the relative size of the trunk and tail are unlikely to enhance a long free-swimming life.

Key to species of *Pseudodistoma* recorded from Australia

1. Test soft, mucus-like .... *P. gracilum* n.sp.
Test firm, not mucus-like 2

2. Colonies flat-topped mushrooms or sessile cushions, the surface sometimes raised into lobes or swellings 3
Colonies not flat-topped lobes or sessile cushions, usually with branched stalks 5

3. Sand embedded in test .... *P. inflatum* n.sp.
Sand not embedded in test 4

4. Embryos incubated in a brood pouch .... *P. pulvinum* n.sp.
Embryos not incubated in a brood pouch .... *P. aureum*

5. Sand crowded in central or sub-surface test... 6
Sand not crowded in central or sub-surface test 7

6. Sand in central test; head not pointed ....*P. pilatum* n.sp.
Sand in layer beneath surface; head pointed .... *P. acuatum* n.sp.

7. Embryos in a brood pouch; stalk soft, fleshy .... *P. australe*
Embyros not in a brood pouch; stalk not soft, fleshy 8

8. Ovary anterior to testis follicles . *P. oriens* n.sp.
Ovary surrounded by testis follicles .... *P. candens* n.sp.

Species recorded from regions adjacent to Australia

Stalked species

Pseudodistoma africanum Millar, 1954 (see also Millar 1962) from Cape Province, South Africa, has a variety of colonies, probably not all conspecific, assigned to it. The Walker Bay (type) specimens have stalks tapering to the base, and resemble *P. oriens* n.sp, (see below) except for the sand embedded in the central test, and the spherical shape of the head of the South African species. The specimen from Natal (Millar 1962) with long tapering stalk has a smaller larval trunk than *P. oriens*.

Pseudodistoma antinboja Tokioka, 1949, from Japan (see also Nishikawa 1990, Rho 1971), has conical heads on short, thick, wrinkled cylindrical stalks and resembles the New Zealand *P. cereum*, differing in having only 8 to 9 stigmata per row (rather than 20 to 24). The Australian *P. australe* also is similar (see below).

Pseudodistoma arborescens Millar, 1967 from Madagascar, New Caledonia (Monniot 1987) and the Philippines (new records: QM GH456 GH471–3) has distinctive colonies of narrow, branching stalks with embedded sand, and soft, rounded or conical heads. Zooids have up to 15 stigmata per row, and a relatively long, narrow oesophagus, with the stomach in the posterior half to one-third of the abdomen. Larvae have a trunk 0.6mm long, deep pseudodistomid-like adhesive organs, and lateral ampullae.

Pseudodistoma cereum Michaelsen, 1924 (see also Brewin 1958) from New Zealand resembles *P. australe*, especially in its colour, it has similar wide, thick, short, stalks, 20–24 stigmata per row, and similar but smaller larvae with the trunk about 1.0mm long. It also differs in having a developmental sequence of up to 8 embryos in the top of the oviduct (Brewin, 1958) rather than the single one being incubated in the thoracic brood pouch in the Australia species (see below). It resembles, but is larger than, an undescribed tropical species from the Philippines (see *P. aureum* remarks, below).

Pseudodistoma novaezelandiae (Brewin, 1950), from New Zealand, has colonies with pointed lobes on short, thick stalks that resemble those of *P. cereum*, differing in the relatively long oesophagus with the stomach in the posterior third of the abdomen.

Pseudodistoma opacum (Brewin, 1950) from New Zealand has flat-topped, sessile lobes attached to basal test. These differ from the stalked lobes of *P. antinboja* Tokioka, which similarly has few stigmata per row. Like *P. novaezelandiae*, *P. opacum* has relatively long oesophagus.

Sessile species

Pseudodistoma brieni Pérès, 1949, from Senegal, forms massive, sessile lobes, rose-yellow or brown in life, with cartilaginous test. Zooids are numerous, irregularly placed. Twelve to 14 stigmata are in each row. A developmental sequence of up to 4 embryos are in the top part of the oviduct (as in *P. cereum*) which distinguishes the species from the Australian *P. pulvinum* n.sp. (see below) which has similar colonies. The larval trunk is probably about 1.0mm long and the larvae look like those of *P. australe*.

Pseudodistoma cyrnusense Pérès, 1952, from Corsica is yellow in life, with an orange pigment patch each side of the cerebral ganglion and one at the anterior end of the endostyle which distinguish the species from others (see *P. australe* n.sp., below).

Pseudodistoma fragile Tokioka, 1958, from Japan has soft mucus-like test that readily disintegrates as in *P. gracilum* n.sp. The Japanese species has up to 5 embryos being incubated in a brood pouch rather than only the one found in the Australian species.

Pseudodistoma kanoko Tokioka and Nishikawa, 1975, from Okinawa has massive sessile colonies, with translucent, firm test, red with white patches around zooid openings. Zooids have weak longitudinal muscles on the thorax, and 10 stigmata per row. Embryos are incubated in the posterior abdomen, sometimes projecting from it, and larvae have a trunk 2.1mm long with the tail and atrial siphon apparently displaced. Zooids of *P. australe* have lighter yellow patches anteriorly, but these are at the top of endostyle and between the apertures rather than surrounding them. A specimen with a leathery tapering stalk was assigned to *P. kanoko* (see Nishikawa and Tokioka 1976), but there is insufficient information to establish whether it is a normal variation in colony form or a different species related to *P. africanum* or *P. oriens* n.sp.

Pseudodistoma acuatum n.sp.

(Fig. 15. Plate 3b)

Distribution

Type Locality: South Australia (Ward I., 20-25m, coll. S. Shepherd 31.3.82, holotype SAM E2120 *QM GH923*; Ward I., on undercuts and ledges, 8m, coll. N Holmes 12.4.83, photo 0064 R893, paratype QM GH2323).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies, up to 10cm high, consist of a basal primary trunk, secondary, and tertiary branches (the terminal pointed lobes), each of about the same length (3cm). The colonies are firm throughout, and have a layer of sand embedded beneath the surface of the colony. The branches are crowded and vertical. Sand is absent from the central test. Zooids are crowded and project through the sand to open around the sides of the terminal lobes of the colony. Living colonies are white.

INTERNAL STRUCTURE: The zooids are very long, extending down through the stalk to the base of the colony. Fine longitudinal muscles extend the whole length of the zooid, and terminate each side of the tip of the posterior abdomen. The pharynx is narrow, with only about 8 stigmata per row. The oesophagus is relatively long, the stomach being in the middle of the posterior half rather than in the middle third of the abdomen. It is smooth walled, and quadrate in section. the male follicles are in the posterior end of the posterior abdomen.

A single embryo is incubated in a brood pouch projecting from the zooid at the top of the abdomen in specimens collected in January.

REMARKS

These stalked colonies have a superficial resemblance to *P. cereum*, however they have longer and more pointed heads and branching, rather than simple cylindrical stalks. The sympatric species *Pseudodistoma pilatum* n.sp. has sand throughout the centre of the colony (rather than confined to a layer beneath the surface as it is in the present species), its stalks are thicker, shorter and not as long as those of the present species, the terminal expanded head has a more or less flat upper surface (where the zooids open) rather than being long and pointed, and it has more numerous stigmata.

Pseudodistoma aureum (Brewin, 1957)
(Fig. 16)

Sigillinaria aurea Brewin, 1957, p.580.
Pseudodistoma aurea: Kott, 1981, p.157. Nishikawa, 1984a, p.114. Monniot and Monniot, 1987, p.81.

FIG. 15: *Pseudodistoma acuatum* n.sp. — a, part of colony (holotype SAM E2120); b, zooid (paratype QM GH2323). Scales: a, 1cm; b, 0.5mm.

DISTRIBUTION

NEW RECORDS: Queensland (Capricorn Group, QM GH4958 –73 GH5103 GH5177 GH5199 GH5206 GH5259 GH5502 GH5691).

PREVIOUSLY RECORDED: New Zealand (North I. — Brewin 1957). Fiji (Dravuni — QM GH106 Kott 1981). Majuro Atoll (Nishikawa 1984a). French Polynesia (Monniot and Monniot 1987).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are sessile, flat-topped pillow-, or mushroom-shaped, to 2cm high and 3cm diameter, sometimes narrowing to a short stalk from the lower surface. The test is firm, transparent in preservative with zooids evenly distributed in it. Each zooid opens (on the upper surface only) by 2 apertures. In living colonies the test is transparent, 'orange buff', 'ochraceous buff', 'tawny ochraceous', 'buff yellow', 'maize yellow', 'Indian yellow', 'deep chrome', 'chrome yellow', 'orpiment orange', 'cadmium orange', 'vinaceous pink', or 'saturn red' (Ridgeway 1886). Occasionally there is a honeycomb pattern, of 'orange ochraceous' (blood?) around the zooids. Zooids are opaque, and usually a darker shade of the same colour as the test. One collector (PK) has referred to the appearance of these colonies as 'orange ice' or 'soft orange look'.

INTERNAL STRUCTURE: Zooids are long (about 8mm) and slender. Anteriorly they project slightly from the upper surface and posteriorly they extend into the base of the colony and into the stalk (when one is present). The thorax and abdomen together are only about 2mm long, the remainder of the length consisting of posterior abdomen. Only very short vascular stolons are present at the posterior end of the zooid. The atrial siphon is sometimes longer than the branchial one. About 12 longitudinal muscles extend along each side of the thorax and along the abdomen and posterior abdomen which, when muscles are contracted, may be drawn up behind the abdomen in a short, blunt appendage no longer than the abdomen. About 25 stigmata are in the anterior rows, the dorsal end of each row extending anteriorly along each side of the dorsal mid-line. The posterior and middle rows each have 20 stigmata.

The oesophagus is relatively long, and the short, smooth-walled stomach with the usual 4 compartments is two-thirds to three-quarters of the distance down the abdomen. The duodenal area is relatively short. An oval posterior stomach is in the pole of the gut loop. The testis follicles are in a single series in the middle of the posterior third of the posterior abdomen, and the small ovary is just anterior to the male follicles. Up to 4 embryos are present in a developmental series in the distal part of the oviduct (in the thorax and at the top of the abdomen) in specimens collected in May, October and November, but not in January, April, August, or September. Gonads were not present in the small colonies taken in April

FIG. 16; *Pseudodistoma aureum* — a, part of colony surface (QM GH4958); b, zooid (QM GH4970); c, larva (QM GH4970). Scales: a, 2mm; b, 0.5mm; c, 0.2mm.

and August. A colony taken in September has male follicles but no ovary, and it is possible that the species is protandrous.

Larvae are relatively large, the trunk being 0.6 to 0.65mm long. The tail is wound slightly more than halfway around it. The 3 median adhesive organs are on short thick stalks, and four rounded lateral ampullae are on each side of the anterior mid-line. The axial cone of adhesive cells has a narrow stalk attaching it to the base of the epidermal cup, and it has a tuft of what appear to be columnar cells diverging out from the base to a flat terminal platform.

REMARKS

Characteristic of the present species is the relatively clear, transparent test and the rounded cushion-like colonies. The oesophagus described for the New Zealand colonies (Brewin 1957) is longer than that in the present material, and the duodenal region between the stomach and mid-intestine appears to have been overlooked. In all other respects, however, zooids, colony and larvae from the type material are the same as those from Fiji (Kott 1981), French Polynesia (Monniot and Monniot 1987) and Heron I.

The firm, clear, golden colonies are readily distinguished from other species of *Pseudodistoma*. The zooids also differ from most other species in their relatively long oesophagus, short vascular stolons and small larvae with a tuft of columnar cells rather than the thin-walled everting balloon of other species. *Pseudodistoma cereum* has a similar larva of about the same size, but a short oesophagus (see Brewin 1958) and stalked colonies; *P. novaezelandiae* has a longer oesophagus, but also has stalked colonies; and *P. opacum* (Brewin, 1950) has a longer oesophagus, but lobed colonies and only 9 or 10 stigmata.

Of the known indigenous Australian species the oesophagus is a similar length in *P. inflatum* n.sp., which can be distinguished by its less regular, opaque orange colonies with sand in the base, and gonads in the anterior half of the posterior abdomen. *Pseudodistoma arborescens* Millar, 1967 from Malagasy, New Caledonia and the Philippines (new records: QM GH456 GH471–3) has a similar long oesophagus, and gonads in the posterior end of the posterior abdomen but is distinguished by its colony, with rounded to conical heads on long branched stalks.

Pseudodistoma australe Kott, 1957

(Fig. 17. Plate 3c,d)

Pseudodistoma australis Kott, 1957, p.101; 1963, p.78; 1972b, p.172 (part, not specimens from Waldegrave I. < *Sigillina grandissima* Kott).

Pseudodistoma cereum: Kott 1972a, p.12.

DISTRIBUTION

NEW RECORDS: Western Australia (Exmouth Gulf, QM G9289 G9290 G9473; Shark Bay, WAM 867.83 *QM GH2133*, WAM 1018–9.83; Houtman's Abrolhos, WAM 764.82 814.83 950.83 1015.83 198.87 198.88 234.88 238.88; Cockburn Sound, WAM 152.75 928.89). South Australia (Great Australian Bight, QM GH4160; Cape Jaffa, SAM E2486). Victoria (Port Phillip Head, QM GH51).

PREVIOUSLY RECORDED: Western Australia (Rottnest I.— holotype AM Y0919, AM U3982–3 Y1314 Kott 1957 1963). South Australia (Elliston Bay — SAM E2549 Kott 1972b; Nora Creina Bay — SAM E2440 Kott 1972a).

DESCRIPTION

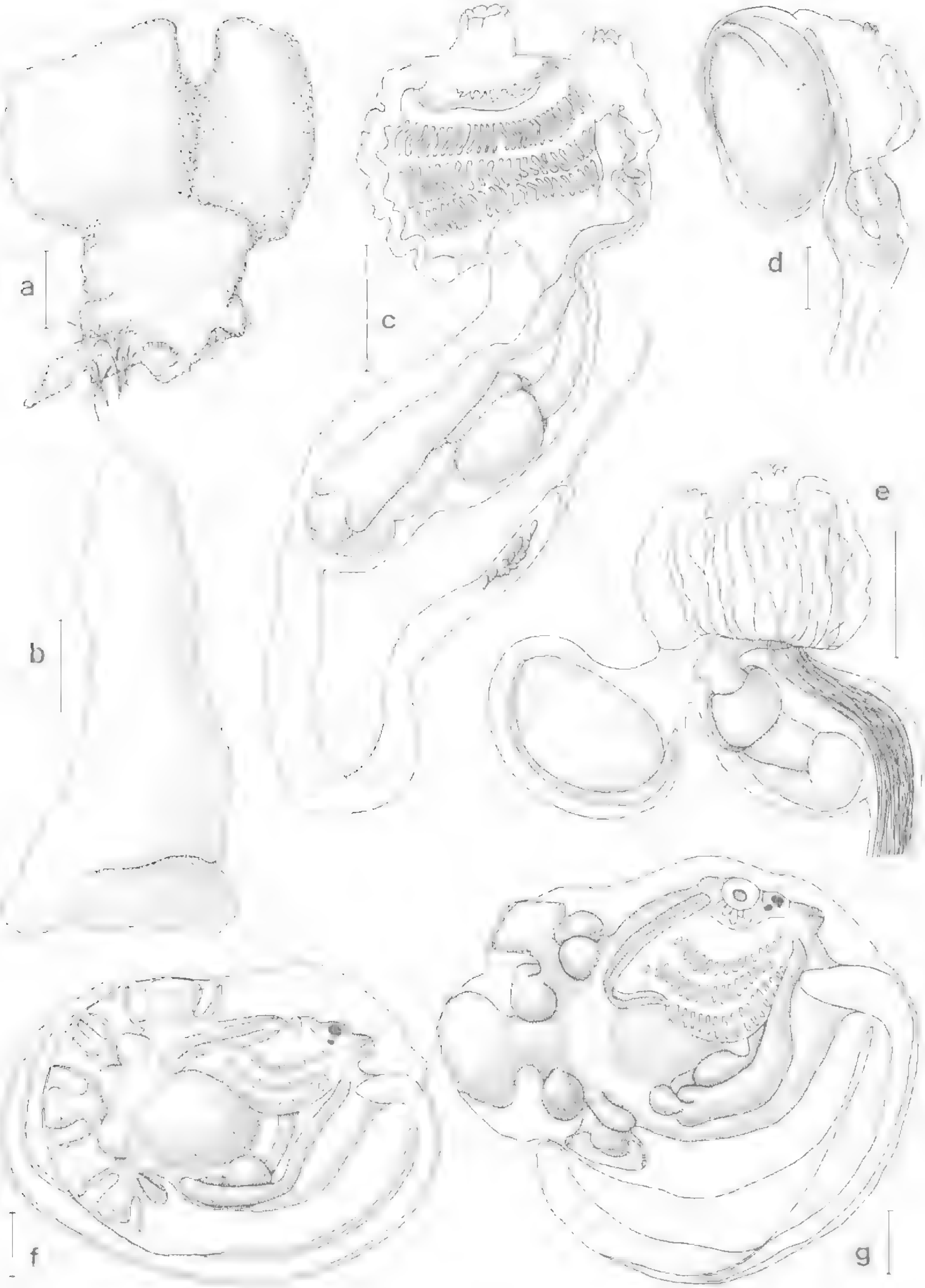
EXTERNAL APPEARANCE: The colonies are stalked or sessile, conical to rounded fleshy lobes or stalked heads arising from a common basal test mass or upright fleshy stalk. The zooids open all around the lobes but not on the common base or stalk.

The smaller conical heads (about 1.5cm long) on relatively long (to 2.5cm) narrow stalks (WAM 1015.83) probably are younger colonies than those in which the almost sessile heads, up to 5cm, are on a fleshy basal test mass to 1.5cm high (WAM 867.83). The test is very soft but fibrous, and firmer in the stalk than the head. The stalk contains scattered sand grains. In preservative the colonies are often very squashed.

In life, the head is rose-pink to red-orange, with the outer layer of test translucent and a white to yellow opaque ring around the rim of each aperture. The stalk is brown. Zooids are orange in preservative, fading to whitish-beige. The white particles that form the opaque ring around the apertures persist in the surface test around the apertures.

The laterally flattened specimens from South Australia (SAM E2486) have a patch of yellow or brown pigment over the dorsal tubercle. The faded, preserved zooids of the holotype colony have an opaque, white, circular patch in the same

FIG. 17: *Pseudodistoma australe* — **a**, **b**, colonies (**a**, QM G9473; **b**, WAM 859.83); **c–e**, zooid and parts of zooids (**c**, **e**, holotype AM Y919; **d**, WAM 152.75); **f**, **g**, larvae (holotype AM Y919). Scales: **a**, **b**, 1cm; **c–e**, 0.5mm; **f**, **g**, 0.2mm.


a
b
c
d
e
f
g

position over the dorsal tubercle. Similarly, there are yellow spots over the dorsal tubercles of the orange lobed colony photographed at Exmouth Gulf (AMPI 76, Plate 3c).

INTERNAL STRUCTURE: Contracted, the thorax and abdomen together are sometimes only about 1.5mm long. The posterior abdomen is straplike, and about the same length. However, in less contracted zooids the posterior abdomen and delicate vascular stolon extend down into the stalk of the colony and zooids are long and threadlike, most of their length being posterior abdomen. Longitudinal muscle bands (from 12 to 20 on each side) extend along the length of the zooid, half from the atrial and branchial siphons and about half from the anterior part of the ventral border (across the endostyle). They terminate at the end of the posterior abdomen. The branchial tentacles are in about 4 rows, the 6 largest ones in the posterior circle. The branchial sac is wide, with 22 stigmata in the second and third rows, and about 25 in the anterior row, which is deflected anteriorly along the dorsal midline.

The oesophagus is moderately long. The stomach, divided into 4 longitudinal quarters by shallow grooves in its otherwise smooth wall, is about halfway down the abdomen. The duodenal area is long, an oval posterior stomach interrupts the narrow mid-intestine in the pole of the gut loop. A rectal valve at the proximal end of the ascending limb of the gut loop separates the mid-intestine from the rectum. The anus, with a bilabiate border, opens halfway up the branchial sac.

A short double series of small male follicles were observed in the posterior end of the posterior abdomen in the holotype, although they are half to three quarters of the way down the posterior abdomen in the South Australian specimens (SAM E2486).

A single series of about 8 mature male follicles are present about two-thirds of the way down the contracted posterior abdomen in a mature colony from Exmouth Gulf collected in August (QM G9473). They are flattened against one another into discs, but this may not be their shape when the zooid is extended. Zooids in a colony off Rottnest have a single embryo being incubated in the oviduct at the top of the abdomen, just behind the postero-dorsal corner of the thorax. The large embryo protrudes from the zooid, distorts the thorax, and is partially constricted off from it.

The larval trunk is 1.0mm long and the tail wound halfway around it. It has 3 large, stalked adhesive organs in the anterior mid-line, each consisting of an ectodermal cup around a large hollow eversible axial cone or platform, all on a long narrow stalk. Four wide ampullae alternate with the adhesive organs. These are flattened antero-posteriorly and are produced laterally on each side into rounded lobes that curve ventrally, forming a cushion around the stalks of the adhesive organs. There is an ocellus and an otolith. In some zooids of colonies collected in November and December (AM Y919, U3982) a single embryo is present in a brood pouch, partially constricted off from the top of the abdomen. Ova were not detected in any of the other colonies.

REMARKS

The type colony, although mutilated, appears to have been stalked rather than the investing cushion which Kott (1957) thought it to be.

The species resembles *P. cereum* from New Zealand, which has similar stalked colonies although the heads are regular and rounded; and although its larvae are also similar they are smaller (trunk 1mm long). Some of the colonies resemble some of those of *P. africanum* Millar, 1954 which are also said to be pink in life (see Millar 1962). However the head and stalk of South African material remain distinct, in even the largest colonies, and the long sessile lobes found in the present species do not develop. Two sessile colonies from Western Australia differ from the present species in having sand in the stalk, and larger larvae without ampullae around the sessile adhesive organs; and in lacking a distinct brood pouch constricted off from the abdomen. They have been assigned to *Pseudodistoma oriens* n.sp. (WAM 859.83 923.83).

Pseudodistoma cyrnusense from Corsica is a sessile species with pigment patches in a similar position to the present species. However the Corsican species has 2 (one each side of the dorsal tubercle) rather than the single median one of *P. australe*.

Pseudodistoma candens n.sp.

(Fig. 18, Plate 3e,f)

Pseudodistoma cereum: Kott, 1975, p.4.

DISTRIBUTION

TYPE LOCALITY: South Australia (Pearson I., coll. S.A. Shepherd 28.3.82, holotype QM GH977, paratype SAM E2118).

FURTHER RECORDS: Western Australia (Cervantes, WAM 197.87; Dongara; Cockburn Sound, WAM 70.75 841.83 *QM GH2132*, WAM 1014.83 QM GH5462). South Australia (Cape Jaffa, SAM E2117

E2119 E2446 E2526, QM G9286 Kott 1975); Ward I., QM GH1295; Topgallant I., QM GH972; Hotspot, QM GH2421; Nuyts Archipelago, SAM E2408); Victoria (Cape Nelson, SAM E2407).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are long (to 5cm) and oval (to 2cm diameter), to short and rounded (to 3cm diameter) or conical and sometimes laterally flattened heads, usually on a thick (1cm diameter) stalk of variable length (to 5cm), sometimes tapering to the base. It is always tough, leathery and transversely wrinkled. The head sometimes overlaps the top of the stalk. On the head the test is tough, in larger specimens almost opaque, and more or less smooth on the surface with cloudy brown pigment cells.

The stalked heads often appear to be solitary, but occasionally the stalk is branched. Replicated zooids with small abdomina sometimes are present in the stalk and appear to move up into the head as it develops. The zooids open all around the outer surface of the head. Living specimens are said to be wine red, although the colour appears to be in the zooid, and the test is translucent. In photographs of a living specimen (Pl. 3e,f) fine red bands are present around each aperture. In preservative the zooids are yellow but subsequently fade to white.

INTERNAL STRUCTURE: The zooids are up to 2cm or more, although most of their length is taken up by the posterior abdomen, and the thorax and abdomen are together only about one to 2mm. There is a long (up to 2cm) vascular stolon extending posteriorly from the end of the posterior abdomen. Twenty to 40 longitudinal muscles extend the length of the zooid and some of these extend along the length of the vascular stolon. The branchial and atrial lobes are especially conspicuous. Up to 20 long, rectangular stigmata are in each of the second and third rows, and in the anterior row additional stigmata extend forward along each side of the mid-dorsal line. The stomach has the usual 4 longitudinal compartments. A long, duodenal area and oval posterior stomach are in the distal part of the descending limb of the gut loop. The heart is a U-shaped tube at the end of the posterior abdomen.

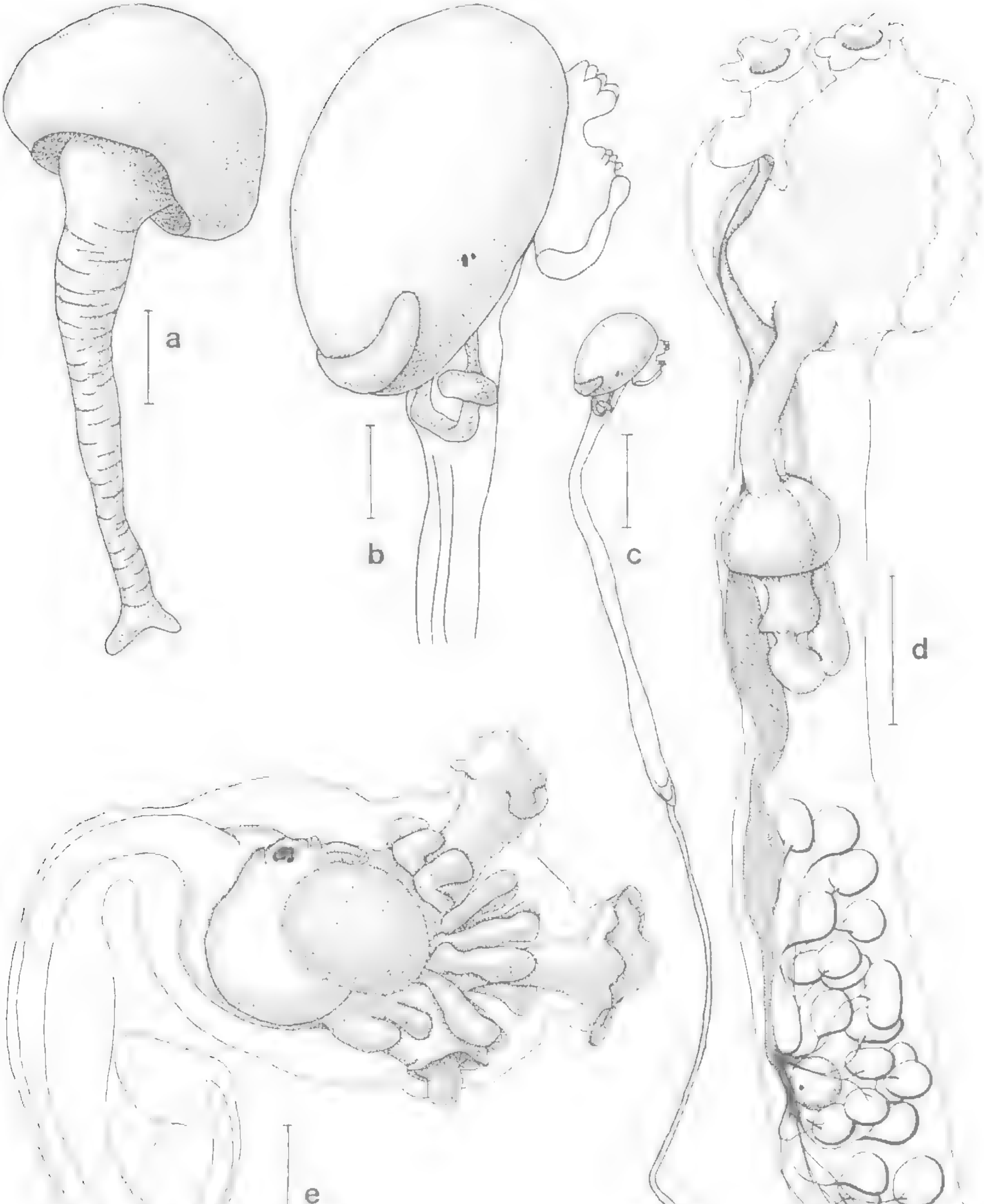
The gonads are in the anterior part of the posterior abdomen just behind the gut loop. The testis follicles are large and pear-shaped and are in a long, loose or a tightly bunched cluster around the small ovary. The vas deferens is long, extending from halfway down the side of the male follicles to a point level with the ovary, where it is joined by the vasa efferentia from the follicles. The length of the testis probably depends on the state of contraction of the posterior abdomen. A single large embryo is found in the oviduct at the top of abdomen in the holotype. Some specimens (QM GH972) collected in March from South Australia have a conspicuous egg in the posterior abdomen but male follicles are not developed. Mature male follicles are in specimens from Point Peron (WAM 70.75) collected in April and from Cervantes I. (WAM 189.75) collected in May. Large larvae (1.5mm trunk) project from the side of the zooid along the length of the oesophagus to just behind the atrial cavity in specimens collected from Pearson I. in March (QM GH977). Larvae have 3 large, stalked eversible adhesive organs in the midline anteriorly. The axial protrusions are rounded and the everted organs seem to expand into thin-walled balloon-shapes. About 8 long, digitiform ectodermal ampullae per side bend anteriorly at right angles to lie parallel to the stalks of the adhesive organs. The tail winds three-quarters of the way around the trunk. An ocellus and otolith are present.

REMARKS

Pseudodistoma africanum Millar, 1954 (also Millar 1962) from South Africa, has rounded heads on stalks tapering toward the base, as in the present species. With the exception of one specimen from Natal which is 8cm long and may be a different species (Millar 1962), the African species has smaller colonies, softer stalks without an outer leathery cuticle, and less muscular zooids with only about 8 longitudinal bands. The large specimen from Natal more closely resembles *P. candens*, having about 20 longitudinal muscles. However its larva is smaller (1mm long trunk).

Pseudodistoma cereum Michaelsen, 1924 from New Zealand, has shorter, fleshy and cylindrical stalks (see Brewin 1958) rather than the long ones of *P. candens*.

The present species does not have sand included in its test, and thus is distinguished from other Australian stalked species (e.g. *Pseudodistoma pilatum* n.sp., *P. acuatum*). The species most readily confused with the present one is the sympatric *Pseudodistoma oriens* n.sp., which sometimes has long tapering, leathery, wrinkled stalks like the present species. *Pseudodistoma oriens* has pointed conical heads rather than rounded ones, softer more transparent test on the head, and slightly larger zooids. It also has larger larvae with sessile (rather than stalked) adhesive organs, a long irregular series of testis follicles in


a
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the posterior half of the posterior abdomen and separated from the ovary (rather than being bunched around the ovary in the anterior half as they are in *P. candens*), and a wide band of strong muscles on the vascular stolon. Colonies of *P. candens* from off Cape Jaffa may be found to be a separate species. However they differ from the type only in their darkly pigmented zooids, thick fleshy stalks, and large opaque flattened heads, and for the present they have been assigned to *P. candens*.

Pseudodistoma gracilum n.sp.
(Fig. 19. Plate 4a–c)

Pseudodistoma cyrnusense: Kott, 1972b, p.173.
Pseudodistoma cereum: Kott, 1976, p.58.
Pseudodistoma fragile: Monniot, 1987, p.508.

DISTRIBUTION

TYPE LOCALITY: South Australia (Top Gallant I. 10m, coll. S. Shepherd March 1982, holotype SAM E2413 *QM GH971*; Grindal I., coll. W.H. Sasse 6.4.87, paratype QM GH4167).

FURTHER RECORDS: South Australia (Top Gallant I., QM GH973; Investigator Group, QM GH2422; Elliston Bay — SAM E2414 Kott 1972b; Beachport, SAM E2412; Kangaroo I., QM G11989; Cathedral Rock, QM GH4158). Victoria (Western Port — MV F57789 Kott 1976). New South Wales (Jervis Bay, QM G10092; Port Jackson AMY2263). Queensland (Heron I. QM GH4954; Lizard I., QM GH3808; Lihou Reef, QM GH4955; northern Great Barrier Reef, QM GH5334).

DESCRIPTION

EXTERNAL APPEARANCE: The test is mucus-like and disintegrating in preservative, often with the zooids lying free and the colonies so soft and flaccid their shape cannot be seen. In preservative all colonies are pale cream with beige zooids and contain evenly distributed cloudy morula cells in the test.

In photographs of some living specimens (QM GH4167 GH5334) the test is colourless and the extended zooids show as white streaks converging into the centre of the colony. The collectors notes record the holotype specimen to have had a 'colourless matrix with cream zooids'. However a colony (QM GH973) taken from the holotype location at the same time (March 1982) but at a greater depth (20m rather than 10m) is said to have been 'dark green with blue zooids'. One colony is recorded by the collector to have been a 'white jelly-like ascidian', but the photograph of the specimen (QM G11989) *in situ* has pale violet zooids, and a photograph from the same location shows white streak-like zooids in a colourless test (AMPI 223). The specimen from Cathedral Rock (QM GH4158) appears from its photograph to be bluish-purple like the Kangaroo I. specimen (QM G11989). Other collectors report living colonies with 'black-purple zooids' (QM G10092), and white zooids in 'a very fluid pale brown gel' test (QM GH3803). One living colony is reported to have been a 'fragile gelatinous mass about 50cm square and 3cm thick under a large rock' (QM G10092). The colony from Lihou Reef is saucer-shaped (QM GH4955). Only one bluish colony from South Australia (QM GH4158), in which zooids are in a vegetative condition, has relatively firm test and the colony entire in preservative. From photographs, colonies vary from spherical to extensive masses with the surface produced into lobes.

INTERNAL STRUCTURE: Zooids are robust up to 3cm long, most of the length being a narrow thread-like posterior abdomen. Thorax and abdomen are together about 3mm long, the thorax slightly longer than the abdomen when relaxed. The atrial siphon is sometimes longer than the branchial siphon, but sometimes the whole dorsal surface of the zooid swells out behind the atrial aperture forming a conical projection. Each aperture has 6 well-defined, evenly rounded lobes around its rim. From 12 to about 20 longitudinal muscles are on the thorax, and extend along each side of the abdomen and posterior abdomen. Fine transverse branches from the ventral longitudinal muscles terminate along each side of the endostyle. The longitudinal muscles terminate posteriorly in well-defined horns each side of the heart at the end of the posterior abdomen. Muscles do not extend onto the one to 4 fine vascular stolons, which vary from short to moderately long. Stigmata are from 0.4mm to twice that length, depending on the state of contraction of the thorax. They reduce in length at the ventral end of each row. From 20 to 25 stigmata are in the second and third rows and about 25 to 30 in the anterior row (which deflects anteriorly along the mid-dorsal line).

FIG. 18. *Pseudodistoma candens* n.sp — a, colony (holotype QM GH977); b–d, zooids and parts of zooids showing embryos being incubated, proportions of zooids, relatively long vascular stolon, bunched testis follicles surrounding ovary, and distended vas deferens (b–c, holotype QM GH977; d, QM GH5462); e, larva (holotype QM GH977). Scales: a, 1cm; b, d, 0.5mm; c, 2mm; e, 0.4mm.

The smooth-walled stomach halfway down the abdomen is partially divided into 4 broad, shallow longitudinal compartments. An oval posterior stomach is in the pole of the gut loop. A distinct rectal valve is at the proximal end of the ascending limb of the gut loop. A bunch of pyriform male follicles is about three-quarters of the way down the posterior abdomen or sometimes in the posterior quarter. A small ovary is anterior to the male follicles in a specimen collected in April (SAM E2412 from South Australia) and from Lihou Reef (QM GH4955: unknown date). These colonies have a single round embryo in the brood pouch constricted off from the top of the abdomen. Embryos were not in other examined material.

The single larva in each brood pouch of specimens from New Caledonia (Monniot 1987) has the tail wound halfway around the 1.75mm long trunk, and, like larvae of *P. aureum*, has deep conical adhesive organs, 2 lateral ampullae and median dorsal and ventral ampullae.

REMARKS

A specimen of this species (QM G10092) analysed for vanadium was found to have 800–1600 ppm (Paul Fredrickson *pers. comm.*).

The species has a range in the number of stigmata but neither this nor any other morphological or geographical feature has been identified to correlate with colony appearance in photographs. However, it is not known what the colonies with zooids fully extended and appearing as white streaks would look like when contracted. Further, the zooids of colonies appearing as blue-purple in photographs always are contracted (in one case they also are in their vegetative phase). Possibly when extended they would appear as characteristic white streaks in colourless test.

Pseudodistoma fragile: Monniot 1987 seems not to be distinct from the present species. Monniot has recorded about 40 stigmata, although in the figured specimen (Monniot 1987, Fig. 5A) they are not so numerous, being near the top of the range recorded for the Australian specimens (see QM GH4167 from South Australia and QM

FIG. 19: *Pseudodistoma gracilum* n.sp. — **a**, zooid showing fine transverse branches from ventral longitudinal muscles, bunched male follicles and ovary halfway down posterior abdomen, and brood pouch (QM GH4955); **b**, contracted zooid (QM G10092); **c**, posterior end of posterior abdomen showing heart, the insertion of the longitudinal muscles, and vascular appendices (QM G11989). Scales: **a**, **b**, 1.0mm; **c**, 0.5mm.

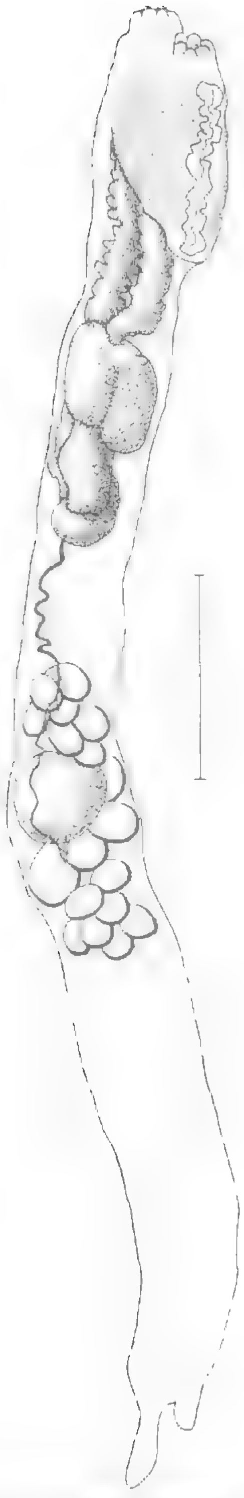


FIG. 20: *Pseudodistoma inflatum* n.sp. — zooid (QM G9636). Scale: 1mm.

GH4955 from Lihou Reef in the Coral Sea). The fact that one of the colonies with the maximum number of stigmata is from southern Australia and the other from the Coral Sea tends to support the view that the New Caledonian and Australian specimens are conspecific.

Pseudodistoma fragile Tokioka, 1958 (from Japan) has similar fragile colonies and similar zooids to the present species. However, the Japanese species has greenish-yellow (rather than blue or white) living zooids, the long curved brood pouch contains up to 5 embryos (rather than one), and the larvae have a trunk 2.3 to 2.6mm long (instead of 1.75mm in the New Caledonian specimen). Apart from the size difference, the larvae of the Japanese species and the present one are similar. Larvae with a large trunk are not unusual in this genus, but the absence of median ampullae and the limited number of lateral ampullae is.

Pseudodistoma inflatum n.sp.
(Fig. 20, Plate 4f)

DISTRIBUTION

TYPE LOCALITY: New South Wales (South Solitary Is. rock faces 10m, coll. N. Coleman 27.9.76, AMPI 184, holotype QM G10157; Julian Rocks, Byron Bay, reef, 15m, coll. N. Coleman 29.3.75, AMPI 158, paratype QM G9472).

FURTHER RECORDS: New South Wales (Byron Bay, AM Y2002; Coffs Harbour, QM G9636). Queensland (Ngeering Reefs off Mooloolabah, QM GH5666–7).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies, to 3cm in maximum extent and 2cm high, are flat-topped and mushroom-like or sessile cushions with rounded margins, or wedge shaped narrowing to the upper free margin. The surface sometimes is raised into ridges and rounded to conical elevations, or divided into flat-topped lobes. Sand is present in the centre of the colony, just beneath the surface in the base, becoming less crowded and removed from the surface toward the top of the colony. Sand always is absent from the surface layer of test, which is opaque (in preservative) and contains a white cloudy suspension.

Living colonies are opaque, orange-red over each zooid and bright yellow between them. In preservative they are grey and firm.

INTERNAL STRUCTURE: Zooids are small and slender, often less than 1cm long when contracted. Atrial and branchial siphons are about the same size, and both apertures are bordered by 6 well defined rounded lobes. The longitudinal muscles extend in a wide band along each side of the abdomen and posterior abdomen. The heart is at the posterior and of the posterior abdomen the vascular stolon is relatively short.

There appear to be about 20 stigmata per row, however the exact number could not be determined owing to contraction of the thorax. The oesophagus is long, and the conspicuously 4-chambered stomach is in the anterior half of the posterior third of the abdomen. Gonads, when present, are in the anterior half of the posterior abdomen, the testis follicles in 2 clumps, one anterior and one posterior to a large ovum. Sometimes the anterior clump of testis follicles extends up into the abdomen alongside the gut loop. However in other specimens there is a gap between the anterior testis follicles and the posterior end of the abdomen. Larvae are not known.

REMARKS

This species appears to be indigenous to the southern (temperate) half of eastern Australia. Like the tropical species *P. aureum* and *P. arborescens* Millar, 1967, and *P. opacum* and *P. novaezelandiae* (from New Zealand), it has a long oesophagus. It most closely resembles *P. aureum* from which it is distinguished by its irregular opaque colonies with sand in the basal half, and the posterior position of its gonads.

Pseudodistoma oriens n.sp.

(Fig. 21. Plate 5a)

Pseudodistoma cereum: Kott, 1972b, p.173 (part, not specimens from Elliston Bay < *P. pilatum* n.sp.).

DISTRIBUTION

TYPE LOCALITY: Victoria (Port Phillip Heads Channel, 20m very fast current, on ledges, common, coll. J.E. Watson 25.11.76, holotype MV H306; paratypes QM GH4953).

FURTHER RECORDS: Western Australia (Rottnest I., WAM 859.83 *QM GH2134*; Geographe Bay, WAM 923.83). South Australia (Waldegrave I. — SAM E2115 E2116 Kott 1972b; off Cape Jaffa, SAM E2525; St. Vincent Gulf, QM G9287). Victoria (Port Phillip Heads, QM GH116).

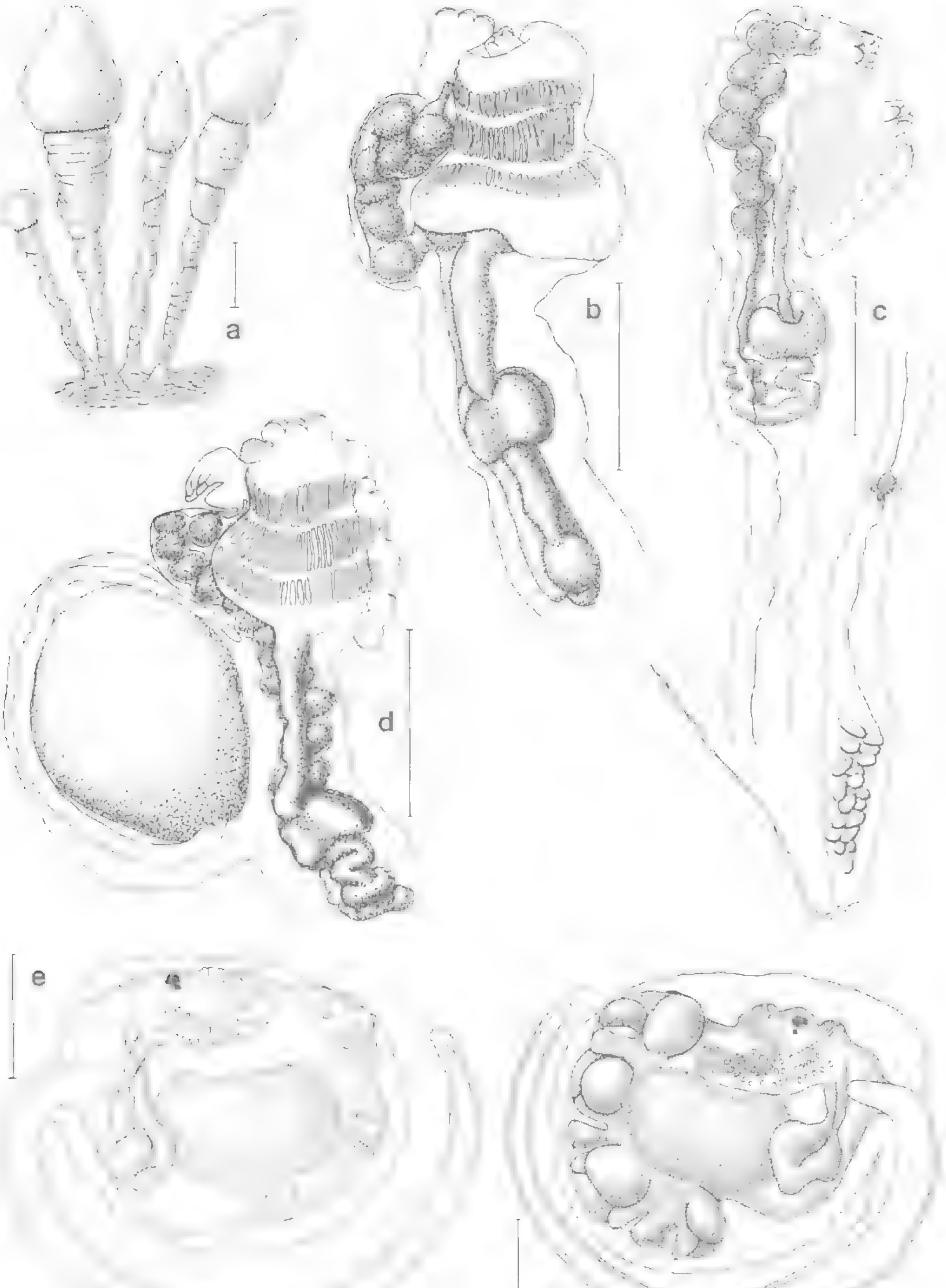
DESCRIPTION

EXTERNAL APPEARANCE: Colonies consist of stalked, pointed heads (up to 6cm long), the stalk usually longer than the head. Although most of the specimens in the examined material are solitary, the holotype has a number of stalked heads attached to a basal membrane. Stalks are up to 10cm long. Usually they are leathery and wrinkled with an outer hard cuticle, tapering to the base (MV H306, QM GH4953, SAM E2115 E2116). A few of the specimens have short, cylindrical stalks with some embedded sand (WAM 859.83 923.83). Zooids are conspicuous with the atrial openings toward the free end of the head. The branchial openings are closer to the stalk. The zooids bend at right angles so that, despite the orientation of the thoraces, the posterior ends extend down into the stalk, as is usual for most stalked aplousobranch species (Kott 1989).

Living colonies are said to be 'horizon red'. In preservative the test is translucent and the zooids pink to orange, subsequently fading to opaque cream.

INTERNAL STRUCTURE: Zooids are small, the thorax and abdomen (contracted) together are about 1mm long but about 3 times that length when partially relaxed (SAM E2115). About 20 longitudinal muscles extend along each side of thorax, abdomen and posterior abdomen. On the posterior abdomen the longitudinal muscles are in a wide, conspicuous band along each side and these continue onto the vascular stolon. Unperforated pharyngeal areas are anterior and posterior to the 3 rows of stigmata. The 2 posterior rows each have about 22 stigmata and the anterior row has an additional 5 or 6 perforations continuing anteriorly along the mid-dorsal line. The stomach, with the usual 4 longitudinal grooves, is halfway down the abdomen, and a long duodenal region and an oval posterior stomach are in its posterior half. A narrow mid-intestine is in the pole of the gut loop. A rectal valve is at the base of the ascending limb of the gut loop, which extends to about halfway up the thorax, ending in a bilabiate anus. Mature male follicles are in a long series in the posterior half of the posterior abdomen in specimens from Waldegrave I. collected in October (SAM E2116). The small (2 or 3 egg) ovary is anterior to the testis follicles and well separated from them. Immature follicles can

FIG. 21: *Pseudodistoma oriens* n.sp. — **a**, colony (holotype MV H306); **b**, zooid showing thorax and abdomen (paratype QM GH4953); **c**, zooid showing ovary about halfway down the posterior abdomen, and the narrow vascular stolon from the tip of the posterior abdomen (SAM E2116); **d**, zooid showing larva in brood pouch (paratype QM GH4953); **e**, **f**, larvae (WAM 923.83: **e**, less mature; **f**, mature). Scales: **a**, 2cm; **b**, **c**, **d**, 1mm; **e**, **f**, 0.4mm.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be seen irregularly branching off the vas deferens in the posterior half of the posterior abdomen in specimens from Hotspot collected in June (SAM E2115).

In the type material from Port Phillip Heads collected in November (MV H306; QM GH4953), and the specimen from Geographe Bay collected in January (WAM 923.83) there are one or 2 embryos being incubated in the distal part of the oviduct at top of the abdomen behind the postero-dorsal corner of the thorax. These embryos become very large, project from the side of the abdomen, and distort the zooid (the abdomen as well as the thorax). However there is no brood pouch constricted from the side of the zooid.

The larval trunk is variable, from 1.1 to 1.7mm long, and the tail winds three quarters of the way around it. A large, almost spherical yolk mass occupies a large part of the trunk, and the larval pharynx and gut are at the posterior end. An otolith and ocellus are present. The 3 median adhesive organs are large, sessile, consisting of an eversible, hollow axial cone depressed into the larval trunk. One mature larva from the specimen from Geographe Bay (WAM 923.83) has 5 adhesive organs, and 4 rounded ampullae from each lateral line. Other larvae examined from the same specimen lot lack the lateral ampulllae, and have the usual 3 adhesive organs.

Juvenile, presumably replicate, zooids are present in the stalk of a developing colony lobe.

REMARKS

Pseudodistoma oriens has long-stalked colonies like those of many specimens of *P. candens*, zooids have a similar long vascular stolon behind the posterior abdomen, and the species are sympatric for part of their range (viz. southern Australian waters). *Pseudodistoma oriens* is distinguished by its more robust zooids with wider bands of longitudinal muscles along each side of the posterior abdomen and vascular stolon, and the arrangement of its testis follicles in the posterior half of the posterior abdomen, its sessile larval adhesive organs, and its translucent test. Another sympatric species, *P. australe* is distinguished by its larvae, its lobed colonies and short vascular stolon.

The testis follicles branch off both sides of the vas deferens and when mature appear as a double or triple series in the posterior part of the posterior abdomen. This distinguishes the species from others with testes follicles in a single series posteriorly or bunched in the anterior part of the abdomen.

The large colonies of *P. africanum*: Millar, 1962 resemble those of the present species. However, all the specimens assigned to this South

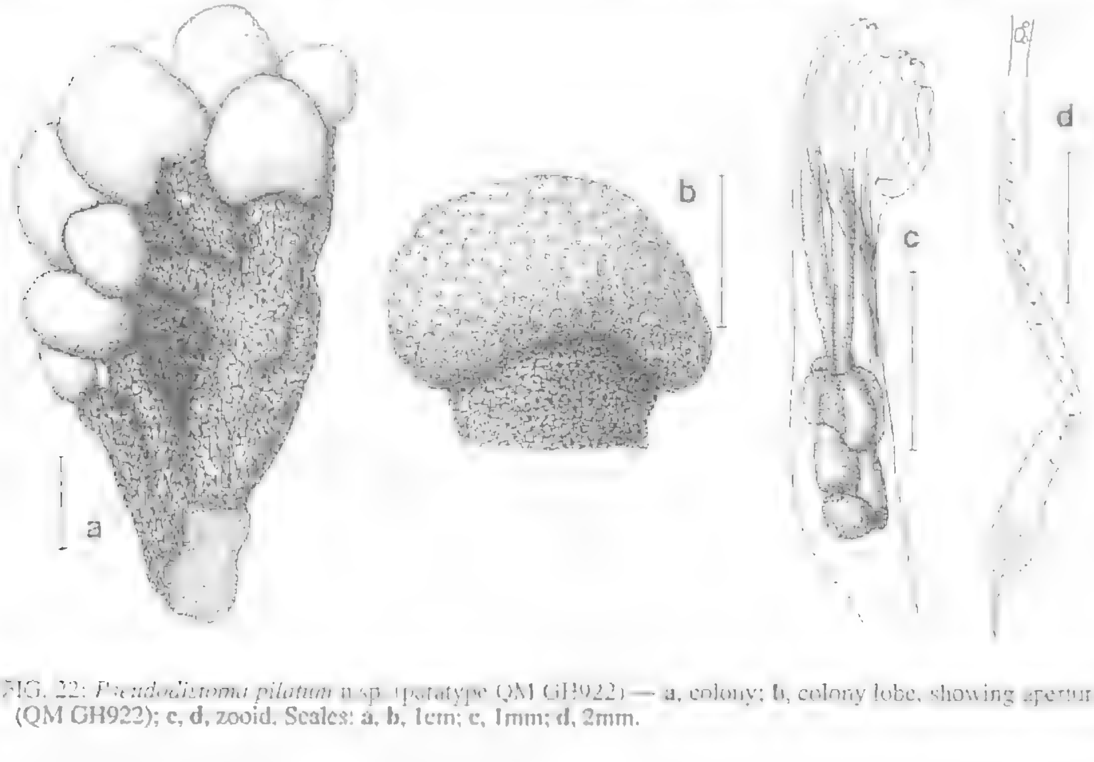

FIG. 22: *Pseudodistoma pilatum* n.sp. (paratype (QM GH922) — a, colony; b, colony lobe, showing apertures (QM GH922); c, d, zooid. Scales: a, b, 1cm; c, 1mm; d, 2mm.

African species (Millar 1954, 1962) may not be conspecific. Larvae are known only for large colonies from Natal (Millar 1962), and these, although not fully developed, appear to have ampullae developing and resemble larvae of *P. candens* rather than those of the present species.

The short conical or spherical colonies from Western Australia (WAM 859.85) with sand in the basal half of the colony, but without the long tapering stalk, could be distinct, although their larvae are the same as those of the present species.

Pseudodistoma pilatum n.sp.

(Fig. 22. Plate 5b–d)

Pseudodistoma cereum: Kott 1972b, p.173 (part, not specimens from Waldegrave I < *P. oriens* n.sp.).

DISTRIBUTION

TYPE LOCALITY: South Australia (Ward I., 20–25m, coll. S.A. Shepherd 31.3.82, holotype SAM E2114 *QM GH921*, paratype QM GH922; 1–5m, paratype QM GH1296; Golden I., paratype QM GH4140; Cathedral Rock, paratype SAM E2409).

FURTHER RECORDS: South Australia (Elliston Bay — Kott 1972b SAM E2410; Nora Creina Bay SAM E2113).

DESCRIPTION

EXTERNAL APPEARANCE: The colony has solid branching, more or less cylindrical, stalks up to 1cm in diameter, and up to 2cm long, arising from a solid basal test mass. The upper free end of each stalk has a rather shallow, circular to elongate cap-like head, convex on its upper surface. In the stalk sand is present around the zooids, and the stalk and projects up into the centre of the head. The surface layer of test on the head is translucent, free of sand, and in preserved specimens contains small yellow pigment cells. Zooids open onto the upper surface of the head, each zooid with its 2 apertures close together in a small oval area. Living specimens are yellow to pink, with a sandy stalk.

INTERNAL STRUCTURE: Zooids are long, the thorax and abdomen together up to 3mm, of which the abdomen is about two-thirds. The posterior abdomen is often about 1.5cm long, with a fine sometimed forked vascular stolon from its posterior extremity. However, it is often contracted. About 20 distinct longitudinal muscles extend from the thorax to the tip of the posterior abdomen. There are about 20 stigmata in each of the 3 rows. The oesophagus is rather long, and the quadrilateral stomach is in the posterior half (rather than the middle) of the middle third of the abdomen. The small ovary is just anterior to the small male follicles which in extended zooids, are in a single series in the posterior half of the posterior abdomen although with contraction the follicles become bunched into 2 or 3 rows. A small ovary is anterior to follicles halfway down the posterior abdomen. The U-shaped heart is in the posterior tip of the posterior abdomen.

REMARKS

The species is distinguished from *Pseudodistoma acuatum* by its flat-topped (rather than pointed) lobes; the colour of the colonies ; the presence of sand in the central test; the number of stigmata per row (only 8 in *P. acuatum*). *Pseudodistoma opacum* (Brewin 1950), from New Zealand also has only 9 or 10 stigmata per row, its lobes are sessile rather than stalked, and it lacks the sand embedded in the present species.

Pseudodistoma pulvinum n.sp.

(Fig. 23. Plate 5e,f)

DISTRIBUTION

TYPE LOCALITY: South Australia (Ward I., in caves, 8m, coll. N. Holmes 12.4.83, holotype SAM E2411 *QM GH2396*, paratypes QM GH2397).

FURTHER RECORDS: South Australia (Flinders I., QM GH2300; Ward I., QM GH2423).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are sessile cushions about 1.5cm thick, fixed by most of the basal surface, and with rounded margins. The zooids open all over the more or less flattened upper surface. The test is soft and gelatinous. Living specimens are usually a translucent golden colour, although one specimen (QM GH2423) is pink. In preservative colonies are white to grey with minute black pigment cells throughout.

INTERNAL STRUCTURE: Zooids are threadlike. Extended, the thorax and abdomen are of equal length, together about 3mm long and the posterior abdomen about 1cm. One or two fine vascular processes of various lengths project from the posterior end of the zooid. About 15 longitudinal muscles extend along each side of the zooid, to the posterior end of the posterior abdomen (on each side of the heart), not extending onto the vascular processes. Sometimes the posterior abdomen is drawn up into a short, thick tapering mass behind the gut loop. Twenty-five stigmata are in the second and third rows, and at the dorsal

FIG. 23: *Pseudodistoma pulvinum* n.sp. — **a**, colony (QM GH2423); **b**, zooid, thorax contracted (QM GH2300). Scales: **a**, 1cm; **b**, 0.2mm.

end of the anterior row additional stigmata extend it along each side of the mid-dorsal line. The oesophagus is short, the stomach is halfway down the short abdomen, the duodenal area is relatively long, and an oval posterior stomach is in the pole of the gut loop. The rectal valve is conspicuous. A small ovary is present halfway down the posterior abdomen (see QM GH2300), but testis follicles have not been detected in any of the examined specimens.

REMARKS

The test is firmer than that of *Pseudodistoma gracilum*, the colonies are smaller, and their appearance in life with their golden translucent and slightly iridescent test is different. The dark pigment cells in the preserved material also helps to distinguish them.

Genus **Anadistoma** n.gen.

Type species: *Anadistoma attenuatum* n.sp.

The genus is erected to accommodate species with 3 rows of stigmata, transverse thoracic muscles as well as longitudinal ones, a smooth stomach, a long oesophagus with the stomach more than three-quarters of the distance down the abdomen, and gonads in the posterior abdomen. These muscular zooids with their long oesophageal neck suggest a relationship with the genus *Eudistoma* (Polycitoridae) rather than *Sigillina* (Holozoidae; see Kott 1985). The possession of these eudistomid characters together with the relatively large zooids, may mean that the relationship of this genus with *Pseudodistoma* is not as close as the presence of 3 rows of stigmata and the position of gonads in the posterior abdomen suggest.

It is unfortunate that only one specimen lot of this monotypic genus is available, and that it has no larvae which could help to confirm its relationships.

Anadistoma attenuatum n.sp.
(Fig. 24)

Pseudodistoma cereum: Kott, 1963, p.77.

DISTRIBUTION

TYPE LOCALITY: New South Wales (Montague South, near Eden, 94m, coll. CSIRO cruise CC/34 1938C, holotype AM Y1315, paratypes AM Y2212).
FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The living colonies appear to have been spherical up to 5cm in diameter. The lower half is impregnated with sand, which becomes more sparse toward the upper surface. Sand is absent from the upper part of the colony, where the test is very soft and delicate. The zooids open around the upper half of the colony and converge toward the centre of the base.

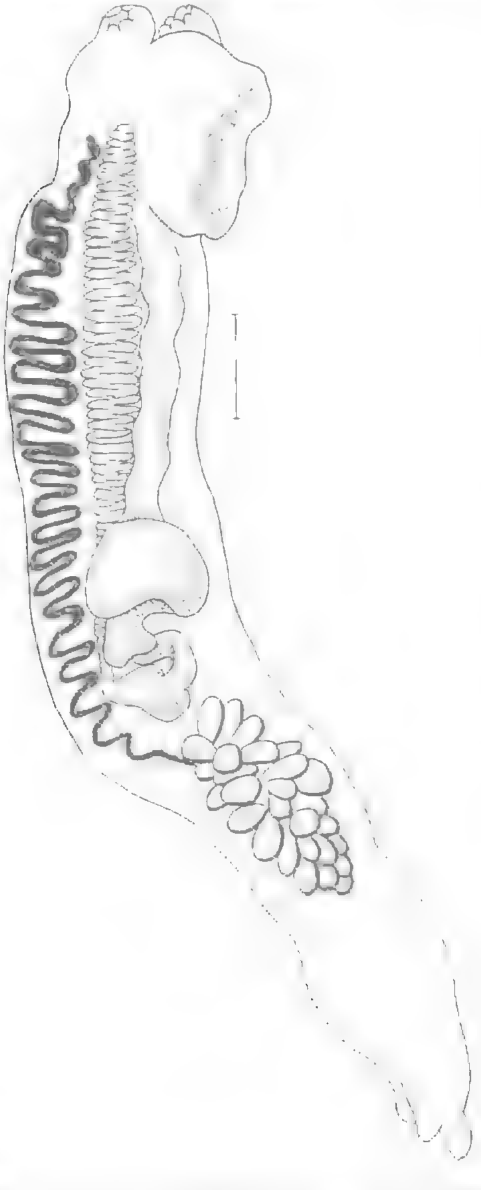

FIG. 24: *Anadistoma attenuatum* n.gen. n.sp. (holotype AM Y1315) — contracted zooid showing bunched male follicles. Scale: 0.5mm.

INTERNAL STRUCTURE: The zooids are large, and robust, up to 1cm even when contracted, and probably about 3 times that length in extended condition. The thorax and abdomen together are at least two-thirds of the total length of the zooids. The vascular stolons are very short. Both siphons are well developed with distinct lobes around the apertures and sphincter muscles. The 20 strong longitudinal muscles on the thorax extend in wide bands along each side of the abdomen and posterior abdomen. Beneath the longitudinal muscles on the thorax is an almost continuous coat of about 50 horizontal, circular muscles. About 25 long, narrow stigmata are in the second and third rows. The first row of stigmata has more perforations, and is longer, extending forward along each side of the mid-line at its dorsal end. The oesophagus is long and wrinkled in these contracted specimens. The relatively large smooth-walled stomach is in the posterior fifth or sixth of the abdomen. A wide duodenal region, and a narrow mid intestine are at the end of the descending limb of the gut loop, and an oval posterior stomach is in its pole. A rectal valve is at the proximal end of the ascending limb of the gut loop. The rectum, convoluted and pleated in these specimens, accompanies the vas deferens and the oesophagus up the long oesophageal neck to about halfway up the pharynx.

Gonads are in the anterior half of the posterior abdomen, the large, pyriform male follicles crowded together, around a small ovary.

REMARKS

There is no other taxon that displays the unique combination of characters that distinguish this monotypic species from the genus *Pseudodistoma*. It is the only species of the family in which the abdomen and thorax together are longer than the posterior abdomen.

Family POLYCLINIDAE Milne Edwards, 1842 *emend.*

The family (type genus *Polyclinum* Savigny, 1816) originally was established for genera with the gonads in a posterior abdomen. In the present more restricted sense, the family is further defined by the presence of cloacal systems, new families being erected to accommodate the genera with separately opening atrial apertures formerly comprising the subfamily Euherdmaniinae (see above).

Polyclinidae Milne Edwards, 1842 has priority over Synoicidae Hartmeyer, 1908 (type genus *Synoicum* Phipps, 1774) which Hartmeyer erroneously had proposed as the senior synonym because *Synoicum* was the earliest described genus of the family.

In the family Polyclinidae, the branchial aperture has a regularly lobed rim, but the atrial aperture is not lobed. The latter opens into the common cloaca, guided by an anterior lip that either is a projection from the body wall anterior to the opening, or is produced from the anterior border of the opening. Minute branchial papillae that may be relicts of internal longitudinal vessels are present in one genus only (*Polyclinum*). The oesophagus is short, with the stomach halfway down the abdomen. Gonads are in the posterior abdomen. These consist of a small ovary and numerous male follicles, either bunched or in longitudinal series. Larvae are small (the trunk usually less than 1mm). They have an otolith and ocellus, 3 small median adhesive organs, ectodermal ampullae and vesicles. Fertilisation is in the atrial cavity and incubation is either in the atrial cavity, or in a thoracic brood pouch constricted from the body wall.

In the Ascidiacea prolific replication results in fast growth rates and rapid responses to environmental pressures, large sized colonies, strengthening of the test allowing for greater diversity in shape than would otherwise be possible, and a high level of colony integration, organisation and the evolution of cloacal systems.

Evolutionary experiments with colonial systems occur in Polyzoinae (Stolidobranchia), and in Polycitoridae, Ritterellidae and Pseudodistomidae (Aplousobranchia), but only in exceptional cases (*Exostoma* and *Hypodistoma* see Kott 1990) are cloacal systems developed in these taxa. Nevertheless cloacal systems have evolved in a number of lineages in the Ascidiacea, viz. in some Holozoidae and all Polyclinidae and Didemnidae (in Aplousobranchia), and all Botryllinae (in Stolidobranchia).

In all these taxa the replicative process is prolific. However Polyclinidae may have particular advantages (possibly shared with Didemnidae) in flexibility and colony size and form that derive from the strength of the test, the amount of test in relation to zooid size and the use of embedded sand and other material to strengthen it. Some of the largest ascidians and the greatest diversity in shape and form of colonies occurs in this family (e.g. the three-dimensional reticulum of *Aplidium acroporum* n.sp., the large vertical buttresses of *Aplidium arboratum*. As well as extensive investing sheets and upright branched, lobed and convoluted colonies). Morphological structures of the test, independent of the overall colony habit, also occur to moderate interactions with the environment, and to insulate and protect the zooids and their apertures and enhance the advantages of the cloacal systems. Examples of this may be seen in *Synoicum castellatum* n.sp., *Aplidium crateriferum*, and *A. lobatum* colonies with surface ridges and depressions (that protect the incurrent apertures), and upstanding cloacal apertures (that elevate the excurrent water high above the rest of the colony). It may be these morphological characteristics of the colony that have enabled Polyclinidae to adapt to a wide diversity of habitats resulting in the remarkable radiation of genera, especially *Aplidium*.

The relationships of most genera of Polyclinidae (*Polyclinum*, *Aplidiopsis*, *Sidneioides*) appear to be with Protopolyclinidae through *Polyclinum*. Branchial papillae, such as those in *Polyclinum* occur in *Monniotus*, and the stomach is similarly inclined and dorsally shorted. A curved oesophagus, smooth and obliquely or horizontally oriented stomach such as those found in *Polyclinum* are also in Holozoidae, but the larvae and the branchial sacs of Holozoidae are completely different.

However, Ritterellidae also has a claim to a close phylogenetic relationship with some (but not all) species of *Polyclinum*, *Aplidiopsis*, *Sidneioides*, and *Synoicum*, through the presence of a median dorsal papilla which protrudes from the body wall just posterior to the atrial siphon as in *Ritterella compacta*. Certain *Ritterella* species (e.g. *R. compacta*, *R. cornuta*, *R. multistigmata*, and *R. papillata*) also have papillae on the transverse branchial vessels as in *Polyclinum*. *Aplidium* with its vertical barrel-shaped and longitudinally folded stomach also may be related to the Ritterellidae.

Thus, it is possible that even the newly defined family Polyclinidae is polyphyletic, the evolution of cloacal cavities proceeding in parallel in several evolutionary lines, viz. from both Protopolyclinidae and Ritterellidae. Convergence, rather than a phylogenetic relationship, may also be the reason for similarities in the cloacal cavities and atrial apertures of many species of *Synoicum* (e.g. *S. suarenum* n.sp.) and those in the *angolanum* species group of *Eudistoma* (Polycitoridae; see Kott 1990).

The 6 genera of the family Polyclinidae are *Polyclinum*, *Aplidiopsis*, *Synoicum*, *Sidneioides*, *Aplidium* and *Morchellium*. The last 2 are separated from the others by their vertical barrel-shaped stomachs, which in *Aplidium* have a longitudinally folded wall. *Morchellium* has a mulberry-like stomach and 8 branchial lobes. Eight branchial lobes also occur in some species of *Aplidium* that were formerly assigned to the genus *Sidnyum*, which here is regarded as a synonym of *Aplidium*. Branchial papillae are present only in *Polyclinum*. The position of the ovary (in the thorax) distinguishes *Sidneioides* from the other genera. *Polyclinum*, *Aplidiopsis* and *Sidneioides* are distinguished from the other genera by a constriction between abdomen and posterior abdomen. Embryos are known to develop in a brood pouch in some species of *Polyclinum*, *Synoicum* and *Aplidium*. The brood pouch (when it occurs) of the former is at mid-thoracic level, while that of the last 2 is at the postero-dorsal corner of the thorax.

The differences between *Polyclinum* and *Aplidiopsis* are often obscured. There is a particular problem in assigning those species of *Polyclinum* in which the branchial papillae are ephemeral (e.g. *P. vasculosum*). In *Polyclinum* the longitudinal muscles do not continue past the thorax to form ventral abdominal and posterior abdominal bands as they do in some species of *Aplidiopsis*, but there also are species of *Aplidiopsis* with longitudinal muscles present only on the anterior part of the zooid. The small usually horizontal, and twisted gut loop of *Polyclinum* as opposed to the large vertical one of *Aplidiopsis*, is the only reliable difference, but sometimes it is difficult to interpret.

The larvae of *Aplidium* differ from those of the other genera in that they have ectodermal vesicles that separate directly from the larval ectoderm around the anterior end of the trunk. In all the other genera the ectodermal vesicles branch off a dorsal and a ventral pair of tissue strands that trail posteriorly through the larval test, one strand on each side of the dorsal and ventral mid-lines, respectively.

Aplidium is the most diverse of the genera, and is common in tropical and temperate waters of all the oceans. *Synoicum* is moderately diverse and commonly encountered in Australian waters. Both *Aplidiopsis* and *Polyclinum* are cosmopolitan. *Polyclinum* contains species with wide geographical ranges, but *Aplidiopsis* and *Morchellium* species are seldom recorded and most are known from restricted locations in temperate waters (see below). *Sidneioides* is known only from two species, one from Japanese and the other from Australian waters.

Key to genera of Polyclinidae

1. Stomach wall longitudinally folded .. *Aplidium*
Stomach wall not longitudinally folded 2

2. Branchial lobes 8 .... *Morchellium*
Branchial lobes 6 3

3. Ovary in the thorax .... *Sidneioides*
Ovary not in the thorax 4

4. Constriction present between abdomen and posterior abdomen 5
Constriction not present between abdomen and posterior abdomen .... *Synoicum*

5. Gut loop voluminous, not twisted and always vertical; branchial papillae never present .... *Aplidiopsis*
Gut loop small, twisted and usually horizontal; branchial papillae usually present . ... *Polyclinum*

Genus **Polyclinum** Savigny, 1816

Type species: *Polyclinum constellatum* Savigny, 1816

The test is usually soft in preservative. Sand, though embedded in the surface layer in some species, is seldom present internally. The atrial lip is often long and muscular. It usually arises separately from the body wall anterior to the anteriorly directed opening, which has a distinct sphincter muscle. However, in some species the lip is produced from the anterior rim of the aperture. The body musculature consists of fine longitudinal bands that fade out on the posterior half of the thorax and do not extend onto the abdomen and posterior abdomen. Transverse muscle bands are in the transverse branchial vessels between the rows of stigmata, but no other transverse muscles are present. Branchial papillae are present on the transverse vessels, although in a few species they are present only in juvenile zooids. The thorax is always longer than the abdomen, usually with from 10 to 20 rows of stigmata, and the atrial cavity is relatively large. The oesophagus curves ventrally to enter the smooth-walled stomach along its short dorsal margin. The whole gut loop is bent horizontally from the oesophagus, and at the same time twisted so that the descending limb is anterior (or ventral) and the ascending limb posterior (or dorsal). The distal tip of the loop is also curved to the left and dorsally. The stomach is small and smooth-walled.

The gonads are in a sac-like posterior abdomen constricted off from the abdomen by a narrow neck. The vas deferens has a complicated course, joining the abdomen in the concavity on the left side of the centre of the pole of the gut loop. It then curves around the ventral border of the descending limb of the gut loop (the mid-intestine) and continues around on the right side of the gut, following its bend at the pole before extending anteriorly on the inside of the rectum to the atrial cavity. The male opening is at about mid-thoracic level near the bilabiate anus. The small ovary is usually surrounded by male follicles. The course of the oviduct has not been determined.

In many species there is degree of polymorphism in the shape of the posterior abdomen which is related to the reproductive condition of the zooid. In zooids reproducing sexually it is short and sac-like, joined to the left side of the gut loop by a narrow neck. It contains bunched testis follicles, a small ovary, and (in the posterior end) the V-shaped heart. In zooids in the vegetative phase the posterior abdomen is long and strap-like. It is horizontally divided into buds that develop into replicated zooids. These long posterior abdomina often occur on zooids around the outer margin of colonies where growth is taking place, while in other parts of the same colony the posterior abdomina are short sacs. One or 2 moderately long, narrow vascular stolons extend out into the test behind the posterior abdomen.

Embryos are incubated either in the peribranchial cavity, or in a brood pouch constricted off from it at mid-thoracic level, near the anus. Larvae are small (the trunk length usually 0.6mm or less — only *P. glabrum* has a trunk more than 1mm long). They are unusually conservative throughout the genus, with 4 pairs of lateral ampullae, usually 4 median ampullae alternating with the 3 median adhesive organs, and clusters of epidermal vesicles along each side of the dorsal and ventral mid-lines. On each side, the dorsal vesicles are on terminal branches of a long strand of epidermal tissue extending back through the test from a point near the dorsal ampulla. Clusters of vesicles on each side of the trunk near the base of the tail are on the terminal branches of similar strands extending posteriorly on each side of the mid-ventral line, from about halfway along the ventral surface. Columnar epidermal cells form a cap on the tip of the ampullae, and sometimes on the outer wall of the epidermal vesicles (see *P. vasculosum*). The adhesive organs in this genus have long, narrow stalks and shallow epidermal cups and axial cones.

The branchial papillae are said to be the relicts of the papillae that support internal longitudinal vessels in the Cionidae, Diazonidae, and Phlebobranchia. Sometimes they are present in the younger zooids of a species but are not present in the larger, older ones (see *P. vasculosum* below).

Systems are either large with complex branching canals or they are simple and circular. Generally in this genus, sand (when it is present) is either embedded throughout the test, or it forms a sandy coating in the surface layer of test completely enveloping the colony. Naked areas on the upper surface over the zooid systems, such as occur in many *Aplidium* species, are known only in a few species (e.g. *P. festum* Hartmeyer, 1905 from Mauritius and *P. solum* nom.nov.).

Problems in defining the species of this genus result from a high degree of intrageneric conservatism in both larval and zooid morphology, as well as changes that occur with growth such as polymorphism in the posterior abdomen and changes (e.g. loss of papillae) in the branchial sac. The present studies suggest that wrong assignation of specimens on the basis of zooid similarities has resulted in apparent intraspecific variability in the presence of sand in the colony. The presence or absence of sand, and the form of the systems, together with the number of rows of stigmata and the number per row, and occasionally the shape of the posterior abdomen, constitute the principal means of distinguishing species.

The colonies of species of this genus often grow large, forming gelatinous masses up to 20cm long, and this may also contribute to confusion in species definitions.

Species of *Polyclinum* usually have a wide geographic range. The genus is well represented in Australia being especially diverse in temperate waters where there are some common indigenous species (Table 5).

Key to species of *Polyclinum* recorded from Australia

1. Sand embedded in surface test 2
   Sand not embedded in surface test 10

2. Branchial sac wide with 18 or more stigmata per row 3
   Branchial sac narrow with fewer than 18 stigmata per row 5

3. Stigmata in more than 15 rows 4
Stigmata in not more than 15 rows .... *P. saturnium*

4. Zooids in a single circular system per colony lobe; brood pouch not present .... *P. orbitum* n.sp.
Zooids not in a single circular system per colony lobe; brood pouch present .... *P. tsutsuii*

5. Atrial lip from upper border of the aperture. 6
Atrial lip from body wall anterior to the aperture 7

6. Colony with thin keel-like base .... *P. terranum* n.sp.
Colony without thin keel-like base .... *P. tenuatum* n.sp.

7. Systems conspicuously circular .... *P. incrustatum*
Systems not conspicuously circular 8

8. Stigmata up to 17 per row; with brood pouch .... *P. marsupiale*
Stigmata up to 12 per row; without brood pouch 9

9. Stigmata in 14 or more rows .... *P. solum* nom. nov.
Stigmata in fewer than 14 rows ..... *P. fungosum*

10. Atrial lip from upper border of the opening .... *P. nudum* n.sp.
Atrial lip from the body wall anterior to the opening 11

11. Living colonies with translucent test; branchial papillae present .... *P. glabrum*
Living colonies with opaque test; branchial papillae not present .... *P. vasculosum*

Species recorded from waters adjacent to Australia

Polyclinum circulatum Sluiter, 1909 from Indonesia is a flat, circular plate, sometimes with a short stalk. Three to 5 circular systems, each with 5 to 8 zooids are in each colony. Zooids have about 10 rows of 10 stigmata. Branchial papillae are not recorded. Stalks sometimes have sand but heads are naked.

Polyclinum complanatum Herdman, 1899 (> *P. depressum* Herdman, 1899) appears not properly assigned. It has a long abdomen distinguishing it from genera of Polyclinidae. It is said to have incubatory pouches packed with embryos (Herdman, 1899). It could be a species of *Pseudodistoma*, no other known genus having a brood pouch as well as both a long abdomen and a posterior abdomen, although brood pouches of *Pseudodistoma* cannot be said to be 'packed with embryos'. The number of rows of stigmata is not known.

Polyclinum constellatum Savigny, 1816 from Mauritius, has flat-topped colonies attached by a small part of the basal surface. They are without sand, and have branching double rows of zooids radiating from circular common cloacal apertures. *Polyclinum festum*: Kott and Goodbody, 1982, from Hong Kong, with large potato-shaped colonies, blue-green when living, and crowded stellate systems of zooids, may be a synonym of *P. constellatum*. The loaf-like *P. constellatum*; Michaelsen, 1923 from Hong Kong and other specimens from Hong Kong, Mozambique and St. Helena, all with radiating rows of zooids are probably also conspecific with *P. constellatum*, as Michaelsen (1923) thought them to be. The branchial sacs are relatively wide with 18 to 22 (16 to 18: Kott and Goodbody 1982) stigmata. Small papillae are present on the transverse vessels. Further probably conspecific populations are from the Atlantic (Florida, the West Indies and possibly south to Rio de Janiero), and the West Indian Ocean to Ceylon (Michaelsen 1923).

Polyclinum constellatum: Tokioka, 1967 has indistinct systems. Although the zooids, like those of *P. constellatum*, have 14 to 18 rows of stigmata with 15 to 20 stigmata per row (more in specimens from the Palau Is), and distinct branchial papillae, the sandy coating on all Tokioka's examined specimens suggests they are not *P. constellatum*.

Polyclinum crater Sluiter, 1909 has simple circular systems, each with the branchial apertures surrounding a central cloacal aperture in a surface depression. The body wall has strong muscles. About 9 rows of 6 to 8 stigmata are present. The outer surface of the test is smooth and slippery.

Polyclinum festum Hartmeyer, 1905 (see also Millar 1975) from Mauritius has flat-topped colonies with circular systems. Sand is present externally (around the base and outer border, and sometimes along radii across the upper surface) as in *Aplidiopsis amoyensis* and related species (see below).

Polyclinum hospitale Sluiter, 1895, from Thursday I. is smooth on the upper surface, with debris and sand on the under surface. Sluiter did not see either cloacal openings or systems, but both are likely to be present — the atrial opening having the usual pointed lip associated with a cloacal system. The body wall is muscular — an unusual condition for *Polyclinum*. The gut loop (including the oesophagus) is shorter than usual for this genus, and is not twisted. There are no branchial papillae. It is probable that the colony is an *Aplidium* species.

Polyclinum gelidus (Monniot, 1987) from New Caledonia, with a brownish-yellow colony resembles *P. vasculosum*, having no branchial papillae. Monniot (1987) assigned the species to the genus *Aplidiopsis*,

TABLE 5. Summary of characters of species of *Polyclinum* recorded from Australia

Species	Biogeographic range[1]	Range anticlockwise around Australia	Surface	Systems	Atrial lip[2]	Stigmata: no. rows; max no./row	Branchial papillae	Larval trunk median length (mm)	Other
P. solum. nom. nov	WP,tr	Hervey Bay. to Heron I	sandy	circular to double rows	S	14–18;14	none	—	long, posterior abdomen
P. fungosum	A,te	Bass Strait to NSW	"	"	"	12–13;14	small, pointed	0.55	
P. incrustatum	A,te	South Australia	"	"	"	15;14	"	0.6	
P. saturnium	IWP,tr	Heron I.	"	"	"	8–12;20	"	0.45	
P. marsupiale	A,te	South Australia, Tasmania	"	"	"	16–13;17	tongue-shaped	0.5	brood pouch
P. tsutsuii	WP,tr	NW Australia	"	circular	"	14–16;20	"	0.5	"
P. terranum	A,te	Cockburn Sd	"	"	R	16;15	pointed	0.7	"
P. tenuatum n.sp.	A,te	Southern Australia	"	"	"	13;12	"	--	sand relatively sparse
P. orbitum n.sp.	A,te	Bass Strait	"	"	"	18–20;24	"	0.45	1 system/lobe
P. nudum n.sp.	A,te	Coffs Harbour	naked	circular to double row	" "	14–16;18	shallow rounded	0.5	soft, gelatinous test
P. glabrum	WP,tr	Heron I. to Lizard I.	"	branched	S	12–13;19	"	1.2	"
P.vasculosum	P,tr	Bass Strait	"	"		12–14;16	none	0.55	firm, gelatinous test

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[1] A, indigenous; P, Pacific ocean; WP, Western Pacific; IWP, Indo-West Pacific; te, temperate, tr, tropical. [2] S, separate from rim of aperture; R, part of rim of aperture.

however its abdomen is characteristic of the genus *Polyclinum*.

? *Polyclinum nigrum* Herdman, 1906, from Sri Lanka, has a smooth shiny surface, and circular depressions in the surface, which may have contained zooids, although these are not present. There is no evidence of the genus of this colony.
The type specimen of this species from Port Jackson (AM U33, *Polyclinum nigrum* Herdman, 1899) and another (MV F59436) from the same locality have been re-examined and found to be *Sigillina* (see *S. nigra*: Kott 1990). The zooids are contracted, possibly causing Herdman to misinterpret the length of the oesophagus.

Polyclinum sundaicum (Sluiter, 1909), from the western Pacific (Fiji, Indonesia and Hong Kong: see Kott 1981, Kott and Goodbody 1982) are small stalked or sessile sandy colonies each containing one or more circular systems. They are distinguished from *P. fungosum* and *P. solum* nom. nov. by their large branchial papillae.

Polyclinum tralatica Sluiter, 1913 from Aru I. is an irregularly lobed, cylindrical, gelatinous mass along a bryozoan or gorgonian stalk. Its outer surface grey with a pale violet hue. The body wall is moderately muscular. The species resembles *P. vasculosum* in the absence of branchial papillae and in its 10 rows of about 10 to 12 stigmata

Polyclinum fungosum Herdman, 1886
(Fig. 25)

Polyclinum fungosum Herdman, 1886, p.190.
Polyclinum marsupiale: Kott, 1976, p.60.
Synoicum hypurgon: Kott, 1976, p.62.

DISTRIBUTION

NEW RECORD: Victoria (Bass Strait, QM G12748).
PREVIOUSLY RECORDED: Victoria (Westernport — MV F59365 F59431–2 Kott 1976), New South Wales (Port Jackson — Herdman 1886).

DESCRIPTION

EXTERNAL APPEARANCE: The small (about 5mm diameter) newly recorded specimen from Bass Strait is mutilated, possibly stalked, mushroom-shaped, with a firm, translucent test, an external layer of sand, and some sand internally. The zooids are crowded, obscuring the form of the systems. Larger (to 4cm diameter) colonies (MV F59431) are soft, mushroom-shaped, fixed by a small part of base or with a small stalk. In preservative they are collapsed, with a wrinkled, furrowed surface. Sand encrusts the sides and under surface, is in patches on the upper surface, and is sparse internally.

INTERNAL STRUCTURE: Zooids are about 3 to 4mm long, with a narrow thorax, small horizontal

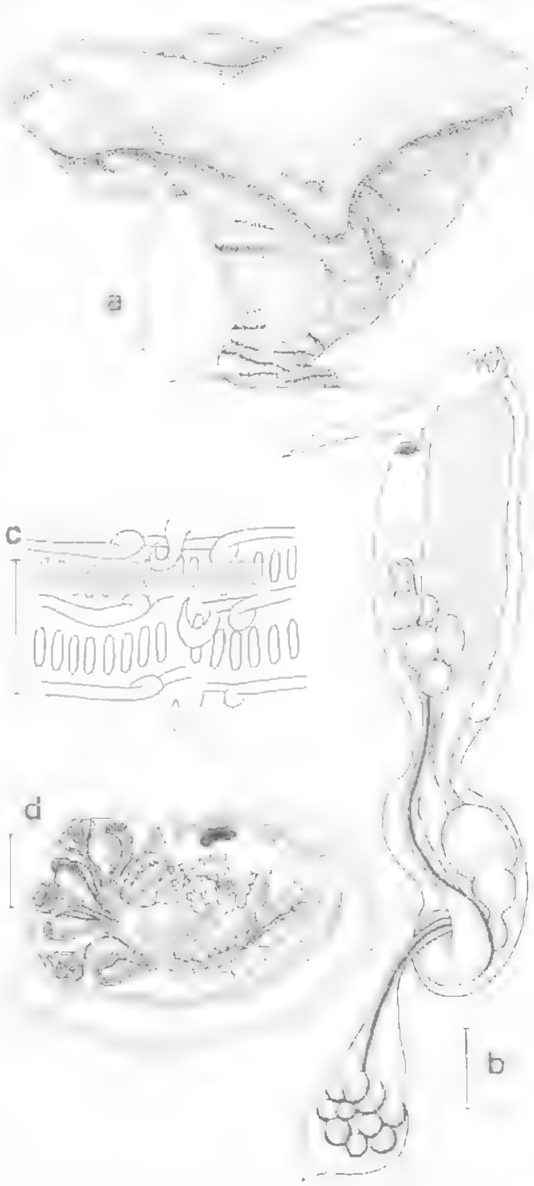


FIG. 25: *Polyclinum fungosum* — a, colony (MV F59431); b, zooid with embryos in atrial cavity (MV F59431); c, dorsal part of portion of branchial sac showing kink in transverse vessels (MV F59431); d, larva (QM G12748). Scales: a, 1cm; b, 0.5mm; c, 0.2mm; d, 0.1mm.

gut loop, and sac-like posterior abdomen. The branchial lobes are triangular and pointed, and the atrial lip is long and narrow. Six to 10 fine longitudinal muscles are present on the anterior half of the thorax. Fine circular muscles are present in the transverse vessels between the rows of stigmata. The branchial sac is narrow, with 12 or 13 rows of 12 to 14 short oval stigmata. A short expansion of the transverse vessels on each side of the dorsal languets in some of the zooids could have resulted from contraction of the transverse muscle fibres in the vessels. The branchial papillae on the margin of the transverse vessels are small, shallow, triangular protrusions about one to every one and a half stigmata.

The gut forms the usual small, horizontal loop with a smooth-walled stomach, a long duodenal area and an oval posterior stomach. The sac-like posterior abdomen has a short neck and is pointed posteriorly. Male follicles are clustered behind and to the side of a relatively large ovary, which has up to 5 relatively large eggs and some small ones.

The Bass Strait specimen contains about 12 embryos in the right peribranchial cavity. Larvae have a row of median ampullae alternating with the adhesive organs and 4 lateral ampullae along each side. A ventral pair of rows of large epidermal vesicles expands into a postero-ventral cluster on each side beneath the tail. Corresponding rows are present on each side of the mid-dorsal line. The larval trunk is 0.4 to 0.5mm long, and the broad tail barely reaches its anterior end. Each of the ampullae has a terminal cap of columnar cells, although these are more conspicuous on the long, narrow median ampullae than on the rounded lateral ones.

REMARKS

The type specimen of this species (Herdman 1886) is a circular, dome-shaped cushion, 1.6cm high, 3.3cm in maximum dimension. It has a hard sandy external coating. Zooids are crowded in the colony, and systems were not determined. Long, narrow stigmata are in 10 to 12 rows of about 12. Herdman did not observe any branchial papillae. The gut loop is small, with a smooth stomach, and although Herdman did not observe it to be horizontal, it has the short oesophagus and short mid-intestinal region that is characteristic of *Polyclinum*, and it also has a polyclinid, stalked, sac-like posterior abdomen with the ovary surrounded by male follicles. The species apparently is assigned to the correct genus rather than belonging to *Synoicum* as Millar (1982) suggested.

Some of the zooids of the holotype contained larvae. Although the exact number present is not recorded it appears that there were more than one or 2 and that they were in the atrial cavity, as a brood pouch is not mentioned.

The crowded zooids, the narrow thorax, the number of rows of stigmata, and the form of the colony of the holotype and the newly assigned and recorded specimens are all identical. The only point of difference is the presence of small inconspicuous branchial papillae in the Victorian specimen. Herdman may have overlooked these as they are difficult to detect.

Tropical sandy species such as *P. tsutsuii* and *P. saturnium* have broader branchial sacs with more stigmata per row. *Polyclinum incrustatum* n.sp. is distinguished from the present species by its slightly more stigmata per row (14) and more rows (15), and by its large tongue-like branchial papillae. The sympatric *P. marsupiale* also has larger branchial papillae, more rows of stigmata and more stigmata per row, and thinner more irregular colonies than the mushroom-like ones of the present species. It also has a brood pouch.

Polyclinum glabrum Sluiter, 1895
(Fig. 26)

Polyclinum glabrum Sluiter, 1895, p. 168; 1913, p. 71.

DISTRIBUTION

NEW RECORDS: Western Australia (Montebello Is, QM GH5507), Queensland (Capricorn Group, QM GH5038–41 GH5563; Townsville Harbour, QM GH2094; Lizard I, QM GH319 GH5024 GH5036–7 GH5042).

PREVIOUSLY RECORDED: Indonesia (Sluiter 1895, 1913).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies from shallow reefal habitats are irregular cushions, or robust, spreading sheets, up to 1cm thick and 6cm in maximum dimension, with soft, transparent test entirely free of sand, and orange zooids. Collector's notes describe them as 'soft orange' and 'chinese orange' (Ridgeway 1886). In preservative these colonies are transparent and yellowish to a translucent, soft grey or beige colour. Common cloacal apertures are relatively crowded, especially around the borders of the colony. Some protrude from the surface on conical prominences, but others are sessile, irregular and extensive openings. Atrial lips of zooids are in the test around the rim of the cloacal openings. In some preserved zooids, the tips of the atrial lips contain dark pigment. Cloacal systems are crowded, and zooids also are crowded along each side of the canals that radiate from the cloacal apertures.

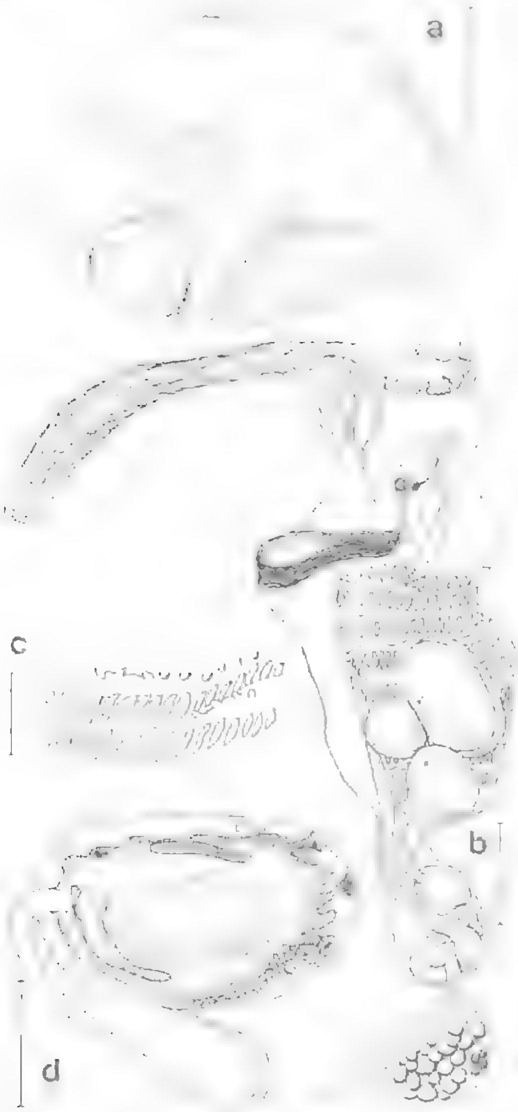


FIG. 26: *Polyclinum glabrum* — **a**, colony (QM GH319); **b**, zooid relaxed with embryos in atrial cavity, anterior rows of stigmata obscured (QM GH319); **c**, portion of branchial sac showing dorsal languets and branchial papillae on the transverse vessels (QM GH319); **d**, larva (QM GH5563). Scales: **a**, 2cm; **b**, 0.5mm; **c**, 0.2mm; **d**, 0.4mm.

The colony from the Montebello Is is a large (maximum dimension 4cm) flattened slab which, with a light coating of sand on one side, appears to have been lying on its side when collected. Originally it probably stood upright, attached to pebbles by its narrow base. Systems open on both sides of the colony, which has an irregularly subdivided surface.

INTERNAL STRUCTURE: The zooids are about 4mm long, with a large thorax, a small horizontal gut loop, and a spherical to tapering (QM GH2094) posterior abdomen. The atrial lip is long and moderately broad, and contains fine longitudinal muscles. It extends along the roof of the cloacal canal toward the cloacal aperture and ends in a single point or a fringe of up to 6 minute papillae. A small median papilla projects from the body wall just behind the atrial aperture. Fine longitudinal muscles are present over the anterior part of the thorax. There are 12 or 13 rows of up to 19 oval stigmata with the maximum number in rows 2 to 6. Rounded branchial papillae are on the transverse vessels, about one and a half per stigma. The gut loop is small and horizontal. The posterior abdomen is attached to it by a relatively long neck. The posterior abdomen is either sac-like or (sometimes) it tapers to a short vascular stolon that projects from its posterior end behind the heart.

Three embryos are in the posterior end of the atrial cavity of specimens from the Capricorn Group collected in December, Lizard I. specimens collected in July, and 6 in those from Montebello Is collected in August. Larvae have a long (1.2mm) trunk with median and lateral ampullae anteriorly, and dorsal and ventral clusters of ectodermal vesicles along each side of the mid-line.

REMARKS

Sluiter (1895) described the type specimen as a large naked cushion, less than 1cm thick, with a smooth surface, without conspicuous systems, and with conspicuous branchial papillae. Although he believed this colony to be juvenile, both male and female gonads are present. The cloacal systems in the present specimens are so crowded that they are hard to distinguish, and in view of the similarities in the branchial sac, and the smooth-surfaced colonies without sand, they seem to be conspecific with the Indonesian species.

The irregular shape and soft consistency of the colony distinguishes it from the more regular and robust *P. constellatum*. The branchial papillae, the more numerous stigmata per row, and the transparent test of the living specimens distinguish it from *P. vasculosum*. The larval trunk is unusually long for this genus.

Sluiter's specimen from Ambon (1895) was grey in preservative with a reddish-violet glimmer, but this does not occur in other known colonies.

Polyclinum incrustatum Michaelsen, 1930
(Fig. 27, Plate 6a,b)

Polyclinum neptunium: Michaelsen, 1930, p.542 f. incrustatum. Kott, 1963, p.83 (part, South Australian specimen).

DISTRIBUTION

NEW RECORDS: South Australia (Golden I., SAM E2145 *QM GH4185*; Hopkins I., QM GH4192; Margaret Brock Reef, SAM E2531; Perforated I., QM GH4141; The Gap, QM GH4163; Cathedral Rock, QM GH4145 GH5209; Nuyts Arch., SAM E2528), Victoria (Portland Harbour, MV 59434 F59437).

PREVIOUSLY RECORDED: Western Australia (Bunbury, Albany — Michaelsen 1930). South Australia (Reevesby I. — Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are thick sheets, sometimes with swellings, high convoluted ridges and irregularities on the surface. The common cloacal apertures are sessile or on small raised prominences about 5mm apart. The zooids open all around the ridges and irregularities, as well as on the flat part of the colony. Sand is present in a single layer in the surface test. Sometimes it is interrupted by the prominences raising the cloacal apertures above the surface, but in other specimens these are also covered with sand. Embedded sand is only sparse in the internal test between the zooids, but the grains are moderately crowded between the zooid systems. Cloacal cavities are small, circular, and are confined to the area beneath the cloacal aperture. The zooids are arranged around these cavities. The atrial lip of each zooid in the system extends across the roof of the cavity and is inserted into the test around the rim of the cloacal aperture. The branchial apertures open in a small surface depression surrounding each cloacal prominence.

INTERNAL STRUCTURE: Zooids are about 8mm long, with the narrow thorax about three-quarters of the total length. A small horizontally oriented gut loop has an almost spherical to long, cylindrical posterior abdomen connected to it by a short narrow neck. There is a narrow vascular stolon from the posterior end of the posterior abdomen.

The atrial lip is long and narrow. It has denticulations on its free tip. The usual muscular atrial siphon projects forward to open into the base of the cloacal cavity around its outer margin.

The anterior part of the zooid, including the branchial lobes and atrial lip, contains black pigment. Fine longitudinal muscles (about 8) extend from the branchial siphon to about halfway down the thorax. Fifteen rows of 13 or 14 longish-oval stigmata have transverse vessels with flat tongue-shaped papillae along the margin, about one to every stigma. These are delicate and hard to see without staining.

The oesophagus is short, and curved ventrally to the small, smooth-walled, horizontal stomach. The distal end of the gut loop is bent to the left. The narrow neck connecting the posterior abdomen is attached in the pole of the gut loop in the concavity of this distal bend of the loop. It appears to have been drawn up onto this side of the gut loop, as the vas deferens moves to the outer curve of loop and follows the curve of the rectum where it lies adjacent to the duodenum, stomach and oesophagus. The rectum terminates in a 2-lipped anus halfway up the branchial sac.

Up to 20 male follicles surround the ovary in the sexual posterior abdomen. The long (3mm) vegetative posterior abdomen is in colonies collected in April from Perforated I. (QM GH4141) and in February from Franklin I. (SAM E2528).

Up to 7 embryos are clumped together in the atrial cavity of zooids from Portland Harbour (MV F59434) but the collection date is not recorded. Larvae have a trunk nearly 0.6mm long, with median and lateral ampullae, and postero-ventral and antero-dorsal vesicles.

REMARKS

Zooids of this species are relatively large and that, together with their distinct circular systems helps to distinguish them from other species.

Michaelsen (1930) believed specimens from Western Australia with embedded sand throughout to be a form of *P. neptunium* Hartmeyer, 1912 for which the type locality is South Africa. Hartmeyer's species has a more or less spherical stalked head, and, with the exception of one specimen (which has sand in the lower half of the colony), is without sand either on the surface or embedded (see also Millar 1962). The abdomen is clavate when mature, and long and cylindrical when immature, the zooids are in circular to double-row systems, and have conspicuous branchial

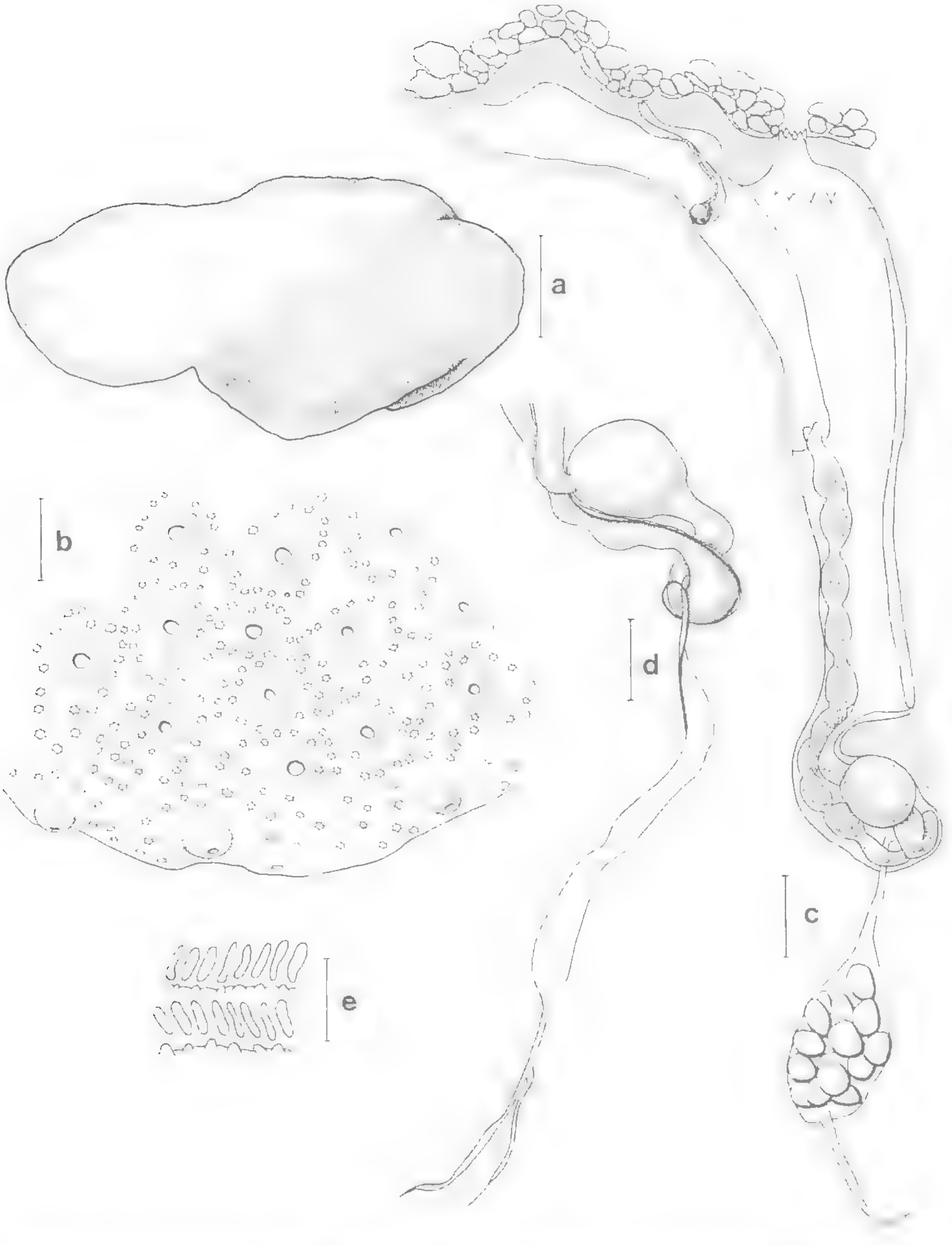


FIG. 27: *Polyclinum incrustatum* — **a**, general view of colony (QM GH4185); **b**, close-up view of surface of colony with common cloacal apertures surrounded by branchial apertures (MV F59434); **c**, zooid in colony showing atrial lip in test above cloacal cavity, and branchial aperture amongst sand adhering to outer surface (QM GH4185); **d**, abdomen and vegetative posterior abdomen (QM GH4141); **e**, portion of branchial sac showing branchial papillae (QM GH4141). Scales: **a**, 2cm; **b**, 2mm; **c–e**, 0.5mm.

papillae. Michaelsen (1930) and Kott (1963) assigned the western and southern Australian material to this species largely on the basis of the long vegetative abdomen, which now is known to occur in other species of this genus.

Michaelsen identified 2 forms, *Polyclinum neptunium* f. typicum being the form in which sand is absent altogether or present only in the basal layer; and *P. neptunium* f. incrustatum with sand throughout. The present sessile specimens from South Australia, with moderate amounts of embedded sand between the systems, with an almost continuous layer on the surface, and with strictly circular systems and raised cloacal apertures, appear to be conspecific with *P. neptunium*: Michaelsen, 1930 f. incrustatum recorded from Bunbury and Albany, but not with the stalked South African species. The stalked specimen from Western Australia (Kott 1963), does have characters in common with the South African species, but is distinguished by the flattened upper surface. It resembles *Polyclinum circulatum* Sluiter, 1909, and may be a synonym. There is insufficient data available for the Shark Bay specimens of *P. neptunium* f. typicum (see Michaelsen 1930) with double rows systems and sand in the lower half of the colony to assign it to a species.

Polyclinum marsupiale Kott, 1963
(Fig. 28a–c. Plate 6c,d)

Polyclinum marsupiale Kott, 1963, p.83 (part, not specimen from Heron I.? < *P. saturnium*). Not Kott 1976, p.60 (< *P. fungosum*).

? *Polyclinum macrophyllum*: Kott, 1963, p. 82 (part, specimen from Rottnest I.).

DISTRIBUTION

NEW RECORDS: Western Australia (Albany, QM GH5059). South Australia (Kingston, QM G10138). Victoria (Deal I., QM G10175; Portland, MVF 59433).

PREVIOUSLY RECORDED: Western Australia (Rottnest I. — AM Y1330 Kott 1963). South Australia (Victor Harbour — Kott 1963); Tasmania (Hunter I. — Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are soft, rather irregular sheets, up to 4cm in maximum extent, investing weed; to upright structures to 1m high with vertical flattened ribs (QM G10175). The zooids are in circular systems. The branchial apertures open to the surface between the sand grains that form an otherwise continuous coat over the outer surface. Sand also is sparsely distributed in the soft, transparent internal test that forms thin partitions between the crowded zooids. Dark pigment in the anterior part of the zooid can be seen where the branchial apertures open to the surface. Common cloacal apertures protrude from the surface.

The colonies from Albany (sea grass beds) are small (less than 1cm in diameter) sessile and upright, covered with a layer of sand, and with characteristic zooids in circular systems.

INTERNAL STRUCTURE: The zooids are small, 3 to 4mm long, with a relatively large conspicuous thorax more than half the total length. Longitudinal muscles are fine and extend only over the anterior part of the thorax (about the first 3 rows of stigmata). The branchial lobes are triangular. The tongue-shaped, moderately muscular atrial lip, undivided to tridentate terminally, projects in front of the atrial aperture.

Stigmata are oval, and are in 12 or 13 rows with a maximum of 16 or 17 per row. The branchial papillae, on the transverse vessels are well-defined, tongue-shaped, and about one per stigma. The gut loop is small, horizontal with the pole of the loop curved to the left and the short neck of the posterior abdominal sac attached to the dorsal (concave) side of the gut loop.

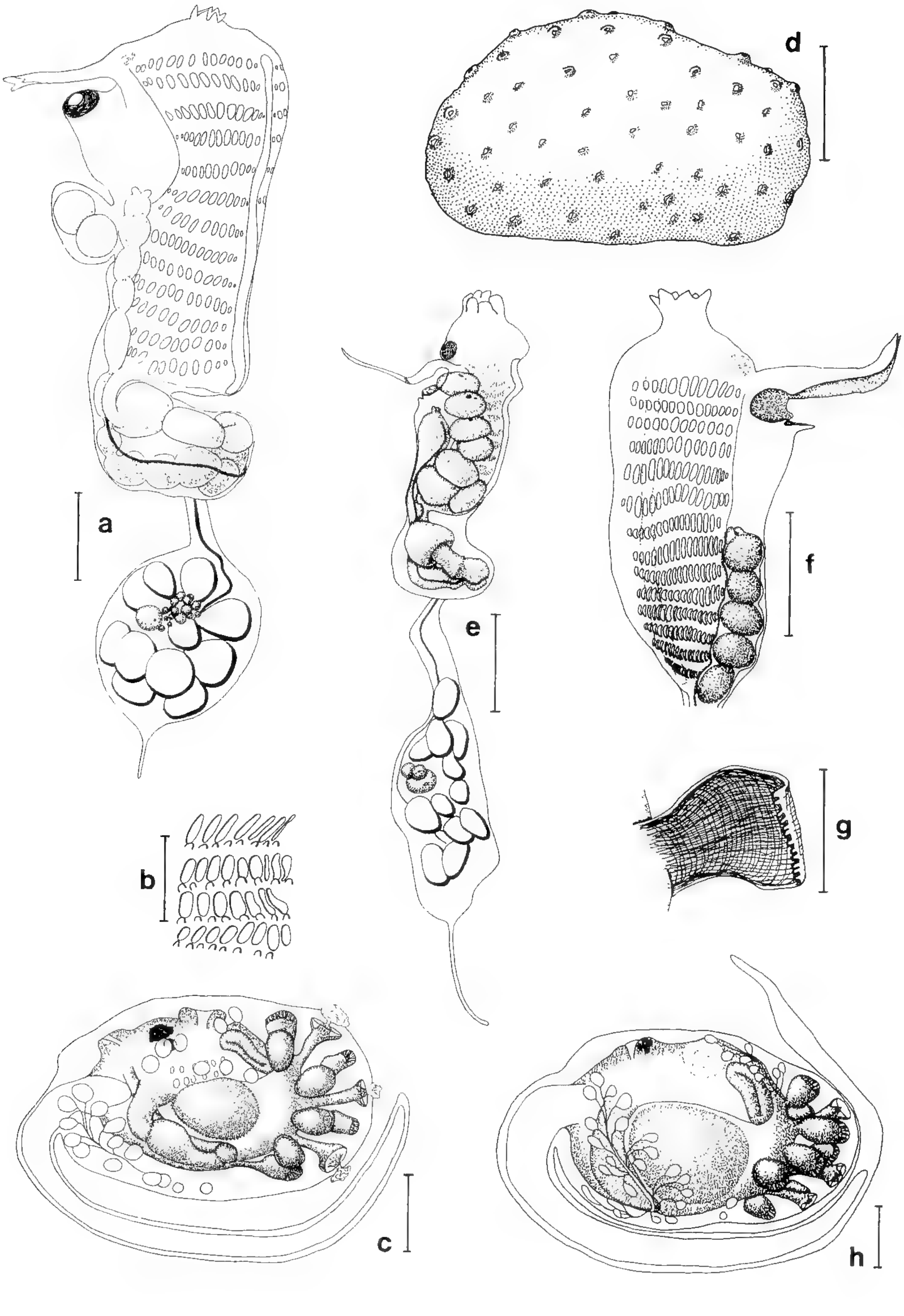
The newly recorded specimen collected in September has 2 or 3 well developed embryos in the brood pouch which projects from the thorax about halfway up the thorax (opposite the sixth row of stigmata).

The larval trunk is 0.5mm long. It has the usual median and lateral ampullae and postero-ventral and antero-dorsal bunches of numerous ectodermal vesicles. The vesicles continue anteriorly in a row along each side of the median line. The tail is wound halfway around the trunk. The caps of columnar cells are more conspicuous on the narrow median ampullae than the rounded lateral ones.

REMARKS

Polyclinum marsupiale is a temperate species,

FIG. 28: *Polyclinum marsupiale* (QM G10138) — a, zooid with embryos in brood pouch; b, branchial sac showing papillae; c, larva. *Polyclinum nudum* — d, colony (QM GH5388); e, zooid with embryos in atrial cavity and ovary surrounded by male follicles in posterior abdomen (QM GH5387); f, thorax (holotype QM GH5391); g, atrial lip (holotype QM GH5391); h, larva (holotype QM GH5391). Scales: a, f, 0.5mm; b, 0.25mm; c, 0.2mm; d, 2cm; e, g, 1mm; h, 0.1mm.


a
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characterised by the layer of sand in the surface test, black pigment in the zooids, soft internal test, and crowded circular systems of small zooids. The tropical *P. saturnium* also has small zooids, and they have a similar pharynx with 8 to 12 rows of 18 to 20 stigmata per row. However they lack the brood pouch of the present species.

The small colony from Rottnest I. assigned to *P. macrophyllum* : Kott, 1963 is similar to the newly recorded one from Albany and may be a specimen of the present species.

Kott (1963) reported an incipient brood pouch in a specimen from Heron I. she assigned to *P. marsupiale*. This has not been confirmed, and that specimen is possibly one of *P. saturnium*.

The other temperate sandy species with dark pigment in the zooids, *P. incrustatum*, has firmer colonies, larger zooids, more conspicuous circular systems, more rows of stigmata, and fewer per row.

Polyclinum nudum n.sp.
(Fig. 28d–f. Plate 6e–g)

DISTRIBUTION

TYPE LOCALITY: New South Wales (Coffs Harbour, old jetty piles, 0.5m, coll. AIMS Bioactivity Group 18.2.88, holotype QM GH5391; 16.2.88, paratype QM GH5387.

FURTHER RECORDS: New South Wales (Coffs Harbour, QM GH5388 GH5390).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are cushion- or dome-shaped, to about 9cm in diameter and up to 1.5cm thick. The test is soft and gelatinous, translucent internally, but with an opaque layer where the anterior ends of the zooids are crowded together at right angles to the surface.

Colonies are dark, black in preservative, and black immediately after removal from the substrate. The photograph of a colony *in situ*, however, shows it to be whitish green (QM GH5387) or yellow (QM GH5388), or brownish red with yellow zooids (QM GH5390). Zooids are in irregularly branching relatively short double rows, one row along each side of canals that converge to common cloacal apertures about 5mm apart. These apertures are sometimes sessile in the preserved colonies, but in the living colony they protrude from the surface on conical elevations. Occasionally there are a few patches of sand adhering to the surface test, but most of the surface is naked, and there is no embedded sand.

INTERNAL STRUCTURE: The zooids are large, about 1cm long, of which the thorax and abdomen together are about half, and the stalked posterior abdomen the other half. Only very fine longitudinal muscles extend over the anterior part of the thorax, including an extensive prestigmatal area.

The branchial siphon is long, with large lobes around the aperture and a long, prebranchial area. The atrial tongue is long, extending out from the upper rim of a large opening. Its tip is variable, sometimes being a single point, or with up to 12 minute papillae along a straight edge. The muscles in the atrial lip form a fine, irregular meshwork. A small, median dorsal papilla is present just posterior to the atrial opening.

There are 14 to 16 rows of up to 18 relatively short, oval stigmata. Small branchial papillae (about one per stigma) are on the transverse vessels. The gut forms the usual small, horizontal loop characteristic of this genus. The vas deferens also makes the characteristic loop around the outside of the bend of the gut loop before extending around onto the other side.

The long, club-shaped posterior abdomen has a long narrow neck, joining it to the abdomen. It contains up to 24, loosely bunched, large pear-shaped male follicles. A small ovary is from one third to half the distance down the posterior abdomen, surrounded by male follicles. A long vascular stolon extends back from the tip of the posterior abdomen.

Up to 7 embryos at a time are crowded in the posterior half of the right peribranchial cavity of the holotype. They are progressively advanced postero-ventrally in the postero-dorsal quarter of the atrial cavity, then anteriorly and dorsally in the postero-ventral quarter.

A tailed larva has a trunk 0.5mm long, with the tail wound about three-quarters of the way around it. A large otolith and ocellus are in the atrial cavity. A lateral ampulla is on each side of each of the 3 median adhesive organs. Also there is a median dorsal and a median ventral ampulla. Patches of epidermal vesicles are antero-dorsal and postero-ventral.

REMARKS

The present species is unusual in having the atrial tongue arising from the upper rim of the atrial aperture (as in *Polyclinum orbitum* n.sp. and *P. tenuatum* n.sp.). Like *P. orbitum* n.sp., the larvae lack median ampullae.

The long club-shaped posterior abdomen is unique. It differs from that of those *Polyclinum* spp. which have a long posterior abdomen only in the vegetative phase. The long posterior abdomen of the present species has mature sexual organs in it, and in that it resembles *P. solum* nom. nov. However, although the latter species has similar colonies, it is distinguished from the present one by its smaller zooids, relatively small posterior abdomen with fewer and smaller male follicles, fewer stigmata in each row (i.e. a narrower thorax), and its lack of branchial papillae.

The colonies resemble some more fleshy ones of *P. vasculosum*. However, the cloacal canals of the present species do not branch as much, the atrial tongue is not separate from the opening, it has branchial papillae, and it has a long posterior abdomen in its sexual phase.

Polyclinum orbitum n.sp.

(Fig. 29)

DISTRIBUTION

TYPE LOCALITY: Victoria (Ninety Mile Beach, 10 km SW Seaspray, 560 m offshore calcenarite reef, 12m depth, fast currents, coll. J.E. Watson August 1977, holotype QM G12730, paratype QM G12731).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are a number of trumpet-shaped lobes up to 1cm diameter at the wide, free end, and 2cm long, narrowing basally to a common stalk. The outer surface is covered with sand, but there is no sand in the soft internal test. Zooids form a single circular system of up to 8 zooids in each lobe. Branchial apertures, around the outer rim of the upper free border are directed laterally. The test is raised into a rounded swelling over the anterior end of each zooid, around the margin of the upper, free end of each lobe. A protuberant cloacal aperture is in the centre of the upper surface.

INTERNAL STRUCTURE: Zooids are up to 1cm long, of which the thorax and abdomen together comprise less than half the length. The abdomen is small, and there is a particularly long, narrow neck, about half the length of the posterior abdominal sac, attaching it to the gut loop. Thus, posterior abdomina lie in the basal common stalk of the colony.

The branchial lobes are well defined. The atrial lip is large and pointed, rising from the anterior rim of the anteriorly directed atrial aperture. Eighteen to 20 rows of stigmata each have 22 to 24 stigmata. Transverse vessels have conspicuous rounded papillae (about one to every 1.5 stigmata).

The particularly small gut loop is horizontal. The ovary is surrounded by and mixed with male follicles in the tear-drop-shaped to long fusiform posterior abdomen.

One or two embryos are in the peribranchial cavity of the type specimens. The larval trunk is 0.45mm long, and the tail is wound three-quarters of the way around it. The 3 median adhesive organs are wide and shallow with thick stalks and wide, shallow axial cones. Four lateral ampullae with enlarged ectodermal cells over the tip of each are present along each side of the adhesive organs. Median ampullae are not present. A row of ectodermal vesicles are present along each side of the mid-ventral and mid-dorsal lines, but a postero-ventral clump was not detected. The otolith is larger than usual, and in one larva 3 otoliths are present (QM G12731).

REMARKS

The species is distinguished by its simple circular systems, the shape of the colonies, the long neck connecting the posterior abdomen to the gut loop, and the large branchial sac. Millar (1977) described a similar *Polyclinum* from the Brazilian Shelf which, however, has a narrow branchial sac with only half the stigmata of the present species.

The species is unusual in having the atrial lip continuous with the anterior rim of the opening. The larvae are unusual in the genus in the absence of median ampullae, and in having fewer ectodermal vesicles than usual. These larvae are also amongst the smallest known in this genus.

The colonies resemble those of *Synoicum stewartense* (Michaelsen, 1924) from New Zealand (see Millar 1982). Generic characters, including the absence of branchial papillae, as well as its purple colour, distinguish the New Zealand species.

Polyclinum saturnium Savigny, 1816

(Fig. 30)

Polyclinum saturnium Savigny, 1816, p.190. Hartmeyer, 1915, p.424. Michaelsen, 1920, p.9. Not Tokioka, 1962, p.260 (< *P. tsutsuii*). Not Rho, 1966, p.212; 1971, p.108; 1975, p.126 (< *P. tsutsuii*).

Polyclinum vasculosum: Tokioka, 1967, p.51 (part, specimen from Baliwasan, Philippines).

Polyclinum marsupiale: Kott, 1963, p.83 (part, Heron I. specimen).

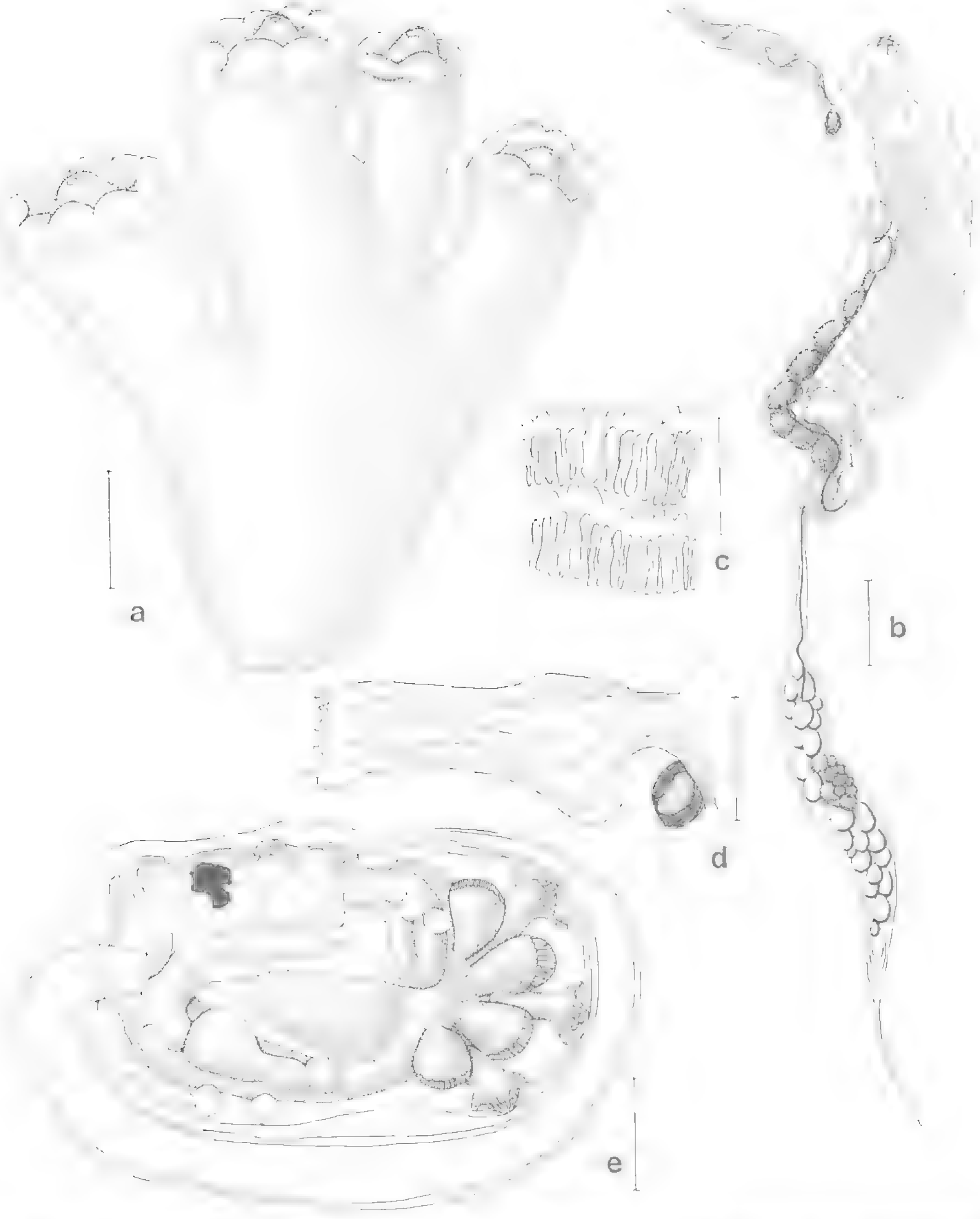


FIG. 29: *Polyclinum orbitum* n.sp. — **a**, colony (paratype QM G12731); **b**, zooid with 2 small embryos in atrial cavity (paratype QM G12731); **c**, portion of branchial sac showing branchial papillae on transverse vessels (holotype QM G12730); **d**, atrial opening with lip (holotype QM G12730); **e**, larva (paratype QM G12731). Scales: **a**, 5mm; **b**, 0.5mm; **c**, **d**, 0.25mm; **e**, 0.1mm.

? *Polyclinum tsutsuii*: Tokioka, 1967, p.47 (part, specimen from Baliwasan, Philippines).

DISTRIBUTION

NEW RECORDS: Western Australia (Dongara, WAM 280.83). Queensland (Heron I., QM GH5034–5 GH5260 GH5568).

PREVIOUSLY RECORDED: Suez, Red Sea (Savigny 1816, Hartmeyer 1915, Michaelsen 1920). Philippines (Baliwasan — USNM 11648 Tokioka 1967).

DESCRIPTION

EXTERNAL APPEARANCE: The re-examined colonies from the Philippines as well as the Heron I. colony are cushions up to 1.0cm in diameter, with a layer of sand externally. The internal test is soft and transparent. Zooids are arranged in circular systems, and the surface layer of sand is interrupted where they open to the surface. Sometimes the zooids extend along each side of short canals that radiate from the apertures to form stellate systems. The zooids are yellow in freshly preserved material with purple in the test above them. In the living specimens the zooids are 'burnt amber' or 'aster purple' and the test translucent. One juvenile colony is recorded as having bright red pigment in the zooids and the test.

INTERNAL STRUCTURE: Zooids are about 4mm long, with a moderately long neck joining the posterior abdomen to the abdomen. The atrial lip

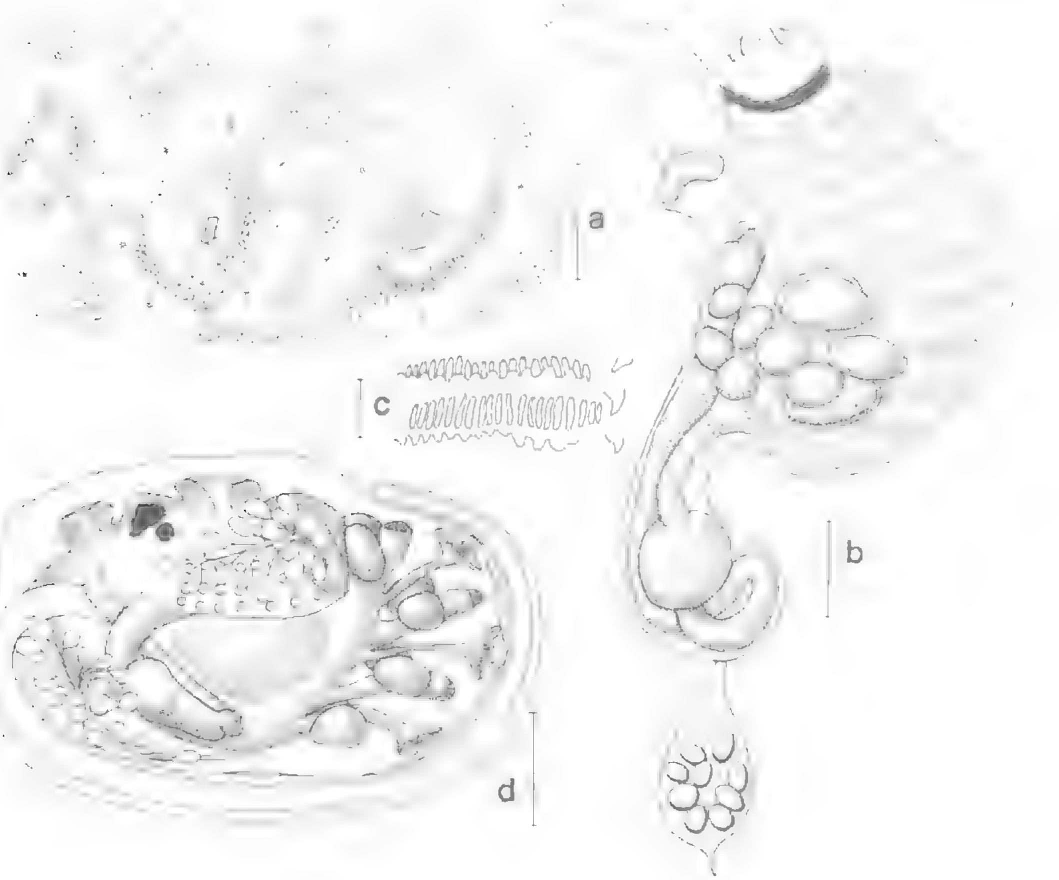


FIG. 30: *Polyclinum saturnium* — **a**, sandy surface of colony with large common cloacal apertures surrounded by branchial apertures (QM GH5034); **b**, zooid with 9 embryos in atrial cavity, abdomen twisted (QM GH5034); **c**, portion of branchial sac showing transverse vessels with papillae and dorsal languets (QM GH5035); **d**, larva (QM GH5035). Scales: **a**, 2mm; **b**, 0.5mm; **c**, 0.25mm; **d**, 0.1mm.

is moderately long and narrow with about 6 pointed denticulations on its terminal (straight) edge. Zooids have 8 to 12 rows of about 20 short, oval stigmata and about the same number of conspicuous, flat, tongue-shaped branchial papillae on the transverse vessels. These papillae are even more conspicuous anteriorly than posteriorly.

The gut forms the usual twisted loop. The bilabiate anus is halfway up the thorax. A group of about 8 large male follicles are clustered in a more or less spherical mass around the ova in the posterior end of the posterior abdomen.

About 5 embryos are scattered in the right peribranchial cavity of specimens collected from Bahiwasan (Philippines) in January (USNM 11540). Up to 10 embryos are present in the postero-dorsal quarter of the atrial cavity in specimens from Heron I. collected in May (QM GH5035). Tailed larvae have a trunk of 0.4 to 0.5mm, with the tail wound about three-quarters of the way around it. Median and lateral ectodermal ampullae have terminal caps of enlarged ectodermal cells. Paired rows of vesicles are antero-dorsal and postero-ventral.

REMARKS

The absence of the brood pouch distinguishes these specimens from *P. tsutsuii* (tropical) and *P. marsupiale* (temperate) which are also sandy, and have broad branchial sacs and circular or stellate systems. *Polyclinum incrustatum* and *P. solum* nom. nov. are also sandy species but they have narrower branchial sacs. The larvae have fewer ampullary vesicles than most other species of the genus.

The small specimen with only 8 rows of stigmata from Baliwasan assigned to *P. tsutsuii* by Tokioka (1967) seems more likely to be a specimen of the present species in which branchial sacs generally are shorter than in *P. tsutsuii*. The other small specimen (*P. vasculosum*: Tokioka, 1967 < *P. saturnium*) from Baliwasan has 10 to 12 rows of stigmata, as do the present colonies from Heron I. while *P. tsutsuii* has 14 to 16.

Polyclinum solum nom. nov.
(Fig. 31)

Polyclinum sabulosum Sluiter, 1909, p. 96

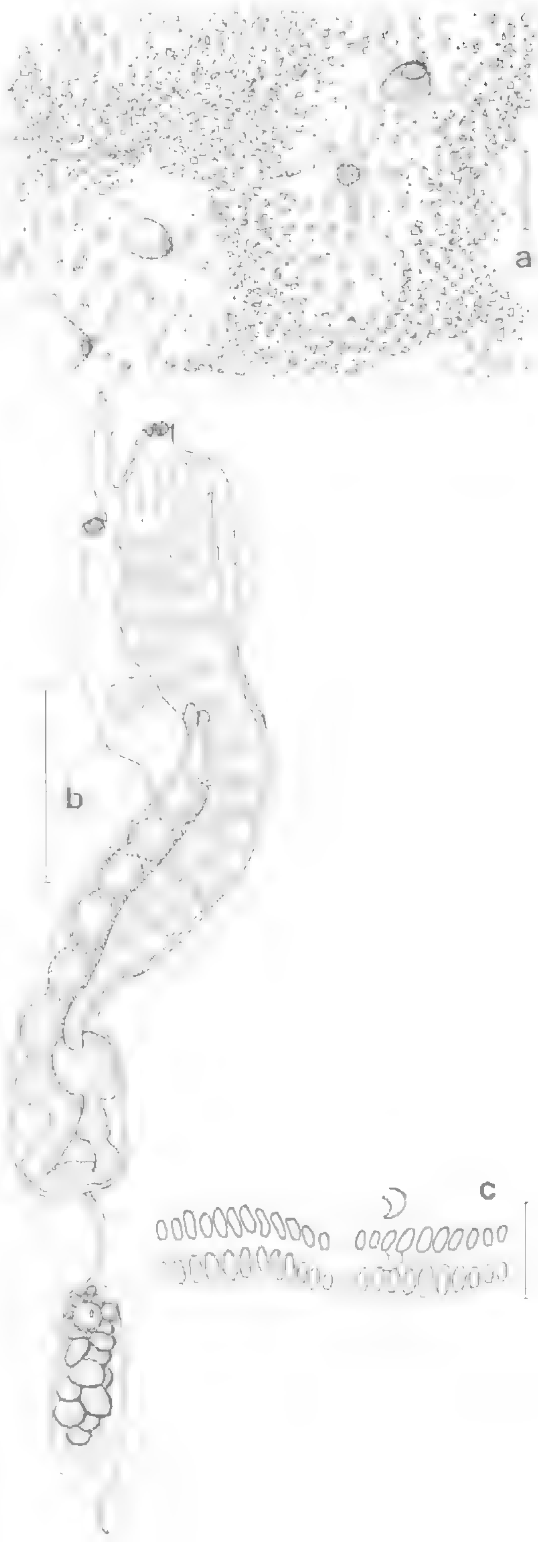


FIG. 31: *Polyclinum solum* nom. nov. — a, sandy surface of colony with protuberant common cloacal apertures surrounded by crowded branchial apertures (QM GH5023); b, zooid with single embryo in atrial cavity (QM G9293); c, portion of branchial sac (QM GH9293). Scales: a, 2mm; b, 1mm; c, 0.25mm.

DISTRIBUTION

NEW RECORDS: Queensland (Pt. Lookout, QM GH5273; Hervey Bay, QM G9293 G9295 GH4978–80; Tannum Sands S. of Gladstone, QM GH4977; Wistari Reef, QM GH5023; Heron I., QM GH5202 GH5273).

PREVIOUSLY RECORDED: Indonesia (Sluiter 1909).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are rounded cushions to 4cm in greatest extent and up to 1cm high. They have a single layer of sand grains adhering to the surface. Sometimes this is absent from the test over the systems, although it is present between and around them (QM GH5023). The internal test is very soft, transparent and free of sand. The cloacal apertures are on wart-like prominences about 3mm apart in the naked areas on the upper surface. Crowded zooids, some in short double rows, surround the cloacal apertures, and converge to them. Thoraces and abdomina are in the upper half of the colony and posterior abdomina in the lower half. There is no pigment in the test of the preserved specimens.

INTERNAL STRUCTURE: The zooids are slender, 6mm long, of which the thorax is about half. The abdomen is relatively short, but the loop is vertical rather than bending horizontally. The posterior abdomen is narrow and relatively long, more or less club-shaped, its posterior half slightly expanded. A fine vascular stolon extends from the tip of the posterior abdomen. Zooids contain minute dark pigment cells scattered through the body wall.

The 6 branchial lobes are triangular and pointed. A long, narrow atrial tongue extends from the body wall anterior to the muscular, forward-projecting atrial siphon. Six fine longitudinal muscles from the branchial siphon fade out on the anterior part of the thorax.

Fourteen to 18 rows of oval stigmata have 10 to 12 stigmata on the right and 12 to 14 on the left. There are some fine muscles in the branchial vessels, but there are no branchial papillae. The small smooth-walled stomach is halfway down the abdomen, with a moderately long duodenal area behind it. The vertical gut loop is twisted slightly so that the descending limb is ventral to the ascending limb, and the distal part of the loop is flexed slightly to the left. The rectum extends halfway up the thorax and the anal border is bilabiate.

Six to 10 male follicles are bunched or in an irregular double row in the posterior half of the long posterior abdomen, which is about twice the length of the abdomen. As they develop, they fill the whole of the posterior abdomen. The ovary is just anterior to them.

Colonies collected in November (QM GH4980) are in an active vegetative condition, those collected in May (QM GH4977) have mature male follicles.

REMARKS

Characteristics of the present species are the single layer of sand externally, the conical protuberant cloacal apertures, the narrow zooids with relatively few stigmata per row but numerous rows, the long narrow posterior abdomen with the gonads in its posterior half, testis follicles in an irregular double row, and the absence of branchial papillae. The holotype, from Indonesia, has a small tear-drop shaped posterior abdomen, like one of the juvenile colonies in the present collection (QM G9295). The Indonesian colony was stalked, and conical protruding cloacal apertures are not reported. However there is little else to separate the newly recorded specimens from it.

Polyclinum tenuatum n.sp. has similar (but smaller) crowded circular systems to the present species, but its zooids are smaller, branchial papillae are present, and the thorax is shorter. *Polyclinum constellatum*: Tokioka, 1967, has sand in the surface test, as does the present species. However, it has very numerous stigmata per row (15 to 20 and 40) and conspicuous branchial papillae. *Polyclinum saturnium* has similar colonies with prominent cloacal apertures and an external layer of sand. However it has a wide branchial sac with conspicuous papillae, relatively few rows of stigmata, and it lacks the narrow posterior abdomen of the present species.

Polyclinum solum nom. nov. replaces the name *P. sabulosum* Sluiter, 1909 for the present tropical species. The latter name is preoccupied by *Polyclinum sabulosum* (Lahille, 1890), which is a junior synonym of the northern hemisphere *Polyclinum aurantium* Milne Edwards, 1842.

Polyclinum tenuatum n.sp.

(Fig. 32, Plate 7a)

Synoicum papilliferum: Kott, 1963, p. 87.

DISTRIBUTION

TYPE LOCALITY: Western Australia (Shelly Beach, Nornalup, 29.1.39, holotype AM Y2261; paratypes AM Y1356)

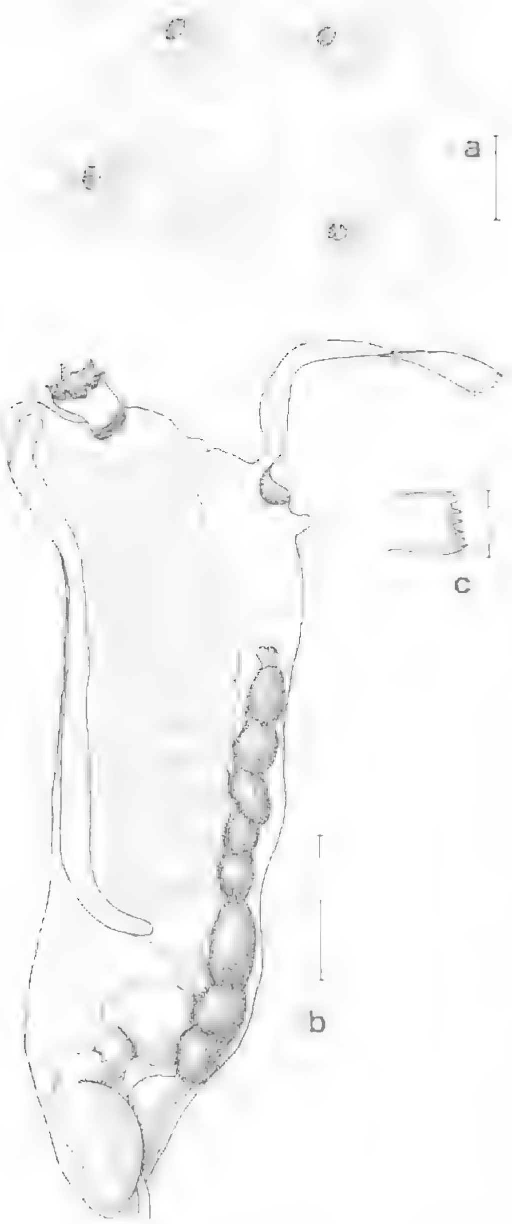


FIG. 32: *Polyclinum tenuatum* n.sp. — **a**, surface of colony showing zooids in circular systems with central common cloacal apertures (paratype AM Y1356); **b**, thorax and abdomen (QM GH5444); tip of atrial tongue (paratype AM Y1356). Scales: **a**, 1mm; **b**, 0.5mm; **c**, 0.1mm.

FURTHER RECORD: South Australia (Cape Jaffa, QM GH5444).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are fleshy sheets, up to 5mm thick, to 5cm in maximum extent, with an irregular outline, rounded borders, and a flat and even upper surface which has a light dusting of sand. The colonies are fixed to the substrate by irregular processes from the whole of the undersurface. Sand is sparse internally. Circular systems of 10 to 12 zooids have slightly protuberant common cloacal apertures in the centre of each system. Cloacal apertures are 2 to 3mm apart.

INTERNAL STRUCTURE: The thorax and abdomen are together about 3mm long. The posterior abdomen is short and sac-like or lengthened to a club-shape. Fine longitudinal muscles are confined to the anterior part of the zooid. The strap-like atrial tongue is produced forwards from the upper rim of the atrial siphon, which protrudes from the body wall. Five minute pointed papillae form a fringe along the straight tip of the atrial lip. A medial dorsal papilla projects from the body wall posterior to the base of the atrial siphon.

Thirteen rows of up to 12 relatively short, oval stigmata are separated by transverse vessels with about one conspicuous conical branchial papilla per stigma. The small, horizontal gut loop is twisted and the distal part of the loop curves forwards as is characteristic for the genus. The posterior abdomen, a short sac in its sexual phase, but long and club-shaped in the vegetative phase (QM GH5444), is attached by a narrow neck to the concavity of the distal curve of the gut loop.

REMARKS

Kott (1963), overlooking the branchial papillae and other characteristic polyclinid features (including the flexure of the gut loop and the constriction between abdomen and posterior abdomen), assigned these 3 colonies to *Synoicum papilliferum* on the basis of the dorsal papilla. This structure has since been found in many *Polyclinum* as well as *Synoicum* species.

The present species has a layer of sand on the upper surface, crowded circular systems, and the atrial lip from the upper rim of the aperture like *P. solum* from the central Queensland coast. However *P. solum* has a longer thorax with more rows of fewer stigmata, and lacks branchial papillae altogether. *Polyclinum terranum* n.sp. has similar branchial papillae and atrial lip, but its zooids are larger, and its colonies have a keel-like structure anchoring them to the substrate.

Polyclinum terranum n.sp.

(Fig. 33. Plate 7b,c)

DISTRIBUTION

TYPE LOCALITY: Western Australia (Rockingham, 32°15.7S 115°37.1E, 15m, coll. AIMS Bioactivity Group 21.3.89, holotype QM GH5460).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony consists of extensive hard, robust zooid-bearing lamellae up to 1cm thick, 3cm across the upper surface and 6cm along its length, standing vertically above the substrate. Along the upper edge the thick zooid-bearing part curves over to form a round margin. Along the underside of the zooid bearing part, the colony abruptly changes to a keel-like flange (up to 0.5cm thick, 5cm deep) which is hard, brittle and stiff with embedded sand. This flange appears to have been embedded in sand, although here and there it suddenly increases in thickness to accommodate zooids, and it may have been above the surface of the substrate in those places.

The colony is complex, branched and folded so that lamellae lie in parallel against one other. Sometimes there are 2 basal keels attached to the one zooid-bearing part of the colony. Zooids are arranged in circular systems, about 3mm diameter, opening on the upper surface of the zooid-bearing part of the colony. Common cloacal apertures protrude from the surface. Patches of sand are present on the upper surface of the zooid-bearing part of the colony, and some is present internally, but it is sparse. The test is tough and zooids, tightly enclosed in it, are hard to remove. The atrial lip is inserted into the rim of the cloacal aperture and is particularly difficult to remove entire. In preservative the test is transparent, purple, but living specimens are a dark purple-brown, and opaque.

INTERNAL STRUCTURE: The thorax and abdomen together are about 4mm long, of which the abdomen is only about one quarter. Body wall musculature consists of about 6 fine longitudinal bands extending halfway down the thorax. Branchial apertures are small, with 6 pointed lobes. The atrial lip is long, moderately muscular with dorsal muscle bands extending along each side and transversely across the lip. The lip usually is pointed, terminating in 2 or 3 small papillae. The anterior part of the circular sphincter muscle of the atrial aperture is in the base of the atrial lip, and the lip is thus associated with the anterior rim of the aperture. A median dorsal papilla is behind the atrial aperture.

Sixteen rows of oval to rectangular stigmata with 15 in the middle rows are separated by transverse vessels containing the usual groups of transverse muscles. An extensive imperforate area of branchial wall is along each side of the endostyle. The transverse vessels have conspicuous, almost triangular branchial papillae, about one per stigma. The dorsal languets are small, only about twice the length of the branchial papillae.

The small gut loop has the usual twist distally, a smooth-walled stomach, long duodenum, and complicated course for the vas deferens. The bilabiate anus is halfway up the branchial sac. The posterior abdomen is tear-drop-shaped with a narrow neck attaching it to the abdomen. It contains mature gonads in the holoytpe colony, consisting of about 15 male follicles and 2 or 3 large eggs. Up to 2 embryos are in a brood pouch attached to the thorax by a narrow stalk, at the level of the anus.

Larvae have a trunk 0.7mm long with 2 median ampullae in each interspace between adjacent adhesive organs, 4 lateral epidermal ampullae on each side, and large postero-ventral and antero-dorsal clusters of epidermal vesicles on each side. Conspicuous caps of enlarged ectodermal cells are on the tips of the ampullae.

REMARKS

The present species, known only from its type locality off Rockhampton, resembles the southern Australian *P. incrustatum* and *P. tenuatum* in its circular systems. The latter species also has large branchial papillae and its atrial lip directly associated with the aperture.

Quite apart from the unique colony with its flat, brittle, keel-like extension projecting down into the substrate, *P. terranum* has more rows of stigmata and more stigmata per row than *P. tenuatum*. Although it has a similar number of stigmata to *P. incrustatum*, the latter species does not have a brood pouch. The brood pouch in the present species resembles that of *P. marsupiale* which, however, does not have the regular circular systems of the present species, and has fewer rows of stigmata and a slightly smaller (0.5mm trunk) larva.

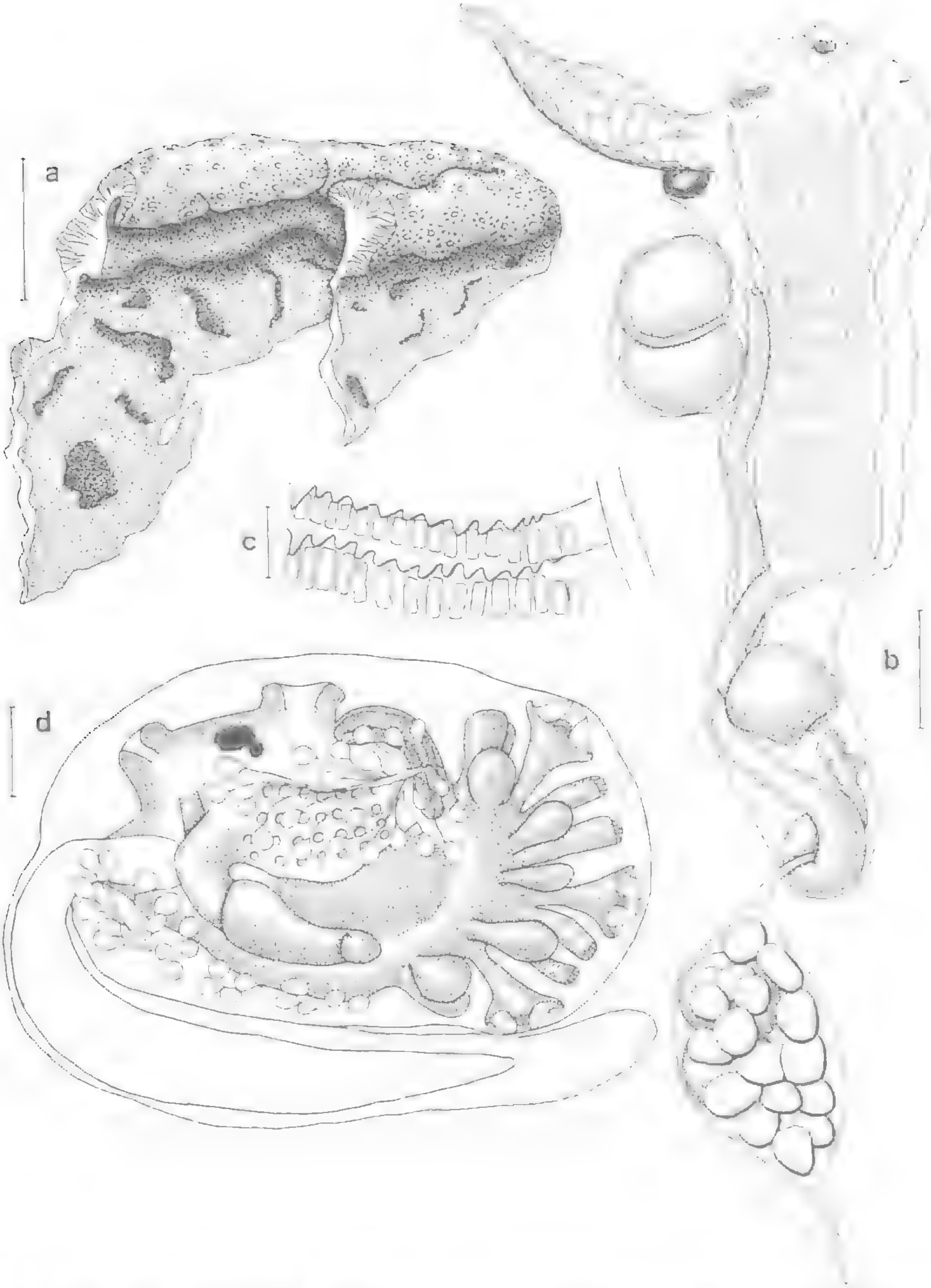


FIG. 33: *Polyclinum terranum* n.sp. (holotype QM GH5460) — **a**, portion of colony showing orientation of zooids in section at each end; **b**, zooid with 2 embryos in brood pouch; **c**, portion of branchial sac showing branchial papillae. **d**, larva. Scales: **a**, 2cm; **b**, 0.5mm; **c**, 0.2mm; **d**, 0.1mm.

Polyclinum tsutsuii Tokioka, 1954
(Fig. 34)

Polyclinum tsutsuii Tokioka, 1954a, p.240; 1967, p.47.
Polyclinum saturnium: Tokioka, 1962, p.260. Rho, 1966, p.212; 1971, p.108; 1975, p.126.
Polyclinum vasculosum: Tokioka, 1967, p.51 (part, specimen from Marianas Is).
Polyclinum pute: Monniot and Monniot, 1987, p.84. Monniot, 1987, p.514.
? *Polyclinum laxum* Van Name, 1945, p.71.

DISTRIBUTION

NEW RECORDS: Western Australia (W. of Cervantes. WAM475.91 476.91, Queensland (Heron I., QM GH5609).

PREVIOUSLY RECORDED: Moorea, Tahiti (Monniot and Monniot 1987). New Caledonia (Monniot 1987). Japan (Tokhara Is — Tokioka 1954a; Osaka, Sagami Bay — Tokioka 1962). Marianas Is (USNM 11540 Tokioka, 1967). Korea (Rho 1971, 1975). ? Eastern Pacific (Gulf of California — Van Name 1945).

The species has a wide longitudinal as well as latitudinal range in the Pacific Ocean.

DESCRIPTION

EXTERNAL APPEARANCE: Some colonies (WAM475.91) are sessile, rounded to wedge-shaped lobes, the borders sometimes spreading out in sheets over the substrate, other colonies are sheet-like and investing (USNM 11540). The external sandy coating often is light and interrupted on the upper surface leaving bare patches. Sand grains are sparse in the internal test. The zooids are in a crowded layer around the outside of the colony. The external layer of sand is interrupted where the zooids open to the surface, and the darkly pigmented anterior ends of the zooids are seen, evenly spaced over the surface. Zooids are difficult to remove from the test.

The actual arrangement of zooids is difficult to determine in some colonies, but in others they are seen to be arranged in crowded circular systems with the atrial lip inserted around the rim of the central common cloaca. However, it is possible that some cloacal canals with zooids along each side, radiate from the apertures.

INTERNAL STRUCTURE: Zooids are about 3mm long, including the short, tear-drop shaped posterior abdomen with a short neck attaching it to the abdomen. There is a posterior vascular stolon from the posterior end of the posterior abdomen.

FIG. 34: *Polyclinum tsutsuii* — a, zooid with 3 embryos in atrial cavity (WAM 475.91); b, larva (WAM 476.91). Scales: a, 0.5mm; b, 0.1mm.

The atrial aperture is well anterior and the body wall projects dorsally so that the aperture is directed anteriorly. The atrial tongue is moderately long and fleshy, and sometimes has a serrated tip. Eight short, fine muscle bands on each side radiate from the branchial aperture over the anterior part of the body but they become finer posteriorly and only occasionally can be distinguished extending the whole length of the thorax. The branchial sac has 14 to 16 rows of about 18 to 20 stigmata per row. The transverse vessels have about one tongue-shaped papilla per stigma.

The gut loop is horizontal, lying close behind the thorax, with the distal part of the loop turned to the left. About 8 relatively large male follicles surround the ovary in the posterior abdomen.

Colonies taken in April have 3 embryos are in a brood pouch which projects from the dorsal part of the peribranchial cavity at about the level of the sixth row of stigmata. The larval trunk is 0.5mm long, with lateral and median ampullae alternating with the shallow, stalked, median adhesive organs. Ectodermal vesicles continue anteriorly in a row along each side of the median line from postero-ventral and antero-dorsal clumps. There is an otolith and ocellus. The tail is wound almost three quarters of the way around the trunk. The tips of the ampullae have caps of enlarged ectodermal cells.

REMARKS

The species is distinguished from *P. incrustatum*, which also has sand confined to the outer layer of test, by its wide branchial sac with 18 to 20 stigmata per row (instead of about 13), and its large larvae in a brood pouch rather than free in the atrial cavity. *Polyclinum incrustatum* has small, distinct circular systems with conspicuous projecting cloacal apertures which also distinguish it from the present species.

The sandy *P. solum* from the northeastern coast of Australia and Indonesia lacks branchial papillae; and has a long posterior abdomen with gonads in its posterior half, and a narrow branchial sac with only 8 to 10 stigmata per row.

Polyclinum saturnium, another sandy species is separated from the present one by the absence of a brood pouch, but has many other characters in common including a moderately long posterior abdominal neck and a broad branchial sac with about 20 stigmata per row. Specimens assigned to *P. saturnium* from Korea and Japan (see Tokioka 1962; Rho 1966, 1971, 1975) have the brood pouch characteristic of *P. tsutsuii*.

Polyclinum laxum Van Name, 1945, from the Gulf of California has potato-shaped colonies. Van Name thought this species could be a synonym of *P. saturnium* Savigny, 1816 (from the Gulf of Suez). However, embryos in *P. laxum* are probably in a brood pouch (see Van Name 1945) as they are in the present species but not in *P. saturnium*. The only difference evident between the Western Australian and the eastern Pacific specimens are that the latter have a longer oesophageal neck and the zooids do not seem to be so crowded.

Although Tokioka thought them to be unique, the short longitudinal thoracic muscles do occur in other species of this genus.

Polyclinum vasculosum Pizon, 1908
(Fig. 35)

Polyclinum vasculosum Pizon, 1908, p.223. Tokioka, 1967, p.51 (part, specimens from Hawaii).

Polyclinum macrophyllum Michaelsen, 1919, p.82; 1930, p.546 subsp. *phortax*. Hastings, 1931, p.105 subsp. *phortax*. Kott, 1963, p.82.

? *Polyclinum festum*: Van Name, 1918, p.162.

DISTRIBUTION

NEW RECORDS: Western Australia (Broome, WAM1023.83). New South Wales (Arrawarra, QM GH4986). Queensland (Pt Lookout, QM GH4981 GH4984; Myora, QM GH4985 GH4990 GH5027; Bribie I, QM G10124; Kawana Waters, QM GH4989, Noosa, QM GH1496; Pt Vernon, QM GH4991 GH4993 GH5028; Bargara, QM GH4983; Gladstone, QM GH4988; Capricorn Group, QM GH4992 GH4994–5018 GH5023–33 GH5185 GH5279; Lizard I., QM GH4982 GH5017 GH5025 GH5261–2 GH5268; off Cairns, QM GH4987).

PREVIOUSLY RECORDED: Western Australia (Shark Bay — Michaelsen 1930). Queensland (Capricorn Group — Kott 1963; Sarina, Mackay — Kott 1963; Low Is — Hastings 1931). ? Philippines (Van Name 1918). Indonesia (Pizon 1908). Hawaii (USNM 11755 Tokioka 1967). West Indian Ocean (Michaelsen 1919).

The species apparently is a tropical one.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are naked, fleshy, extensive investing sheets or cushions to about 2cm thick. In life thinner sheets are brown, yellowish brown and beige internally. Thicker specimens are greenish-black, to black, often with some yellow, and 'mummy brown' (Ridgeway 1886) internally. In preservative they are brown, red-brown to pink. The test is firm and gelatinous, and does not have embedded sand.

Zooids are arranged in rows along each side of branching canals that radiate from the cloacal apertures. In relatively thin colonies with thin surface test the cloacal apertures are completely sessile, sometimes opening out along the top of the parts of the cloacal canals adjacent to them. They have denticulate borders which contain the tips of the long atrial lips of the zooids in their vicinity. Zooids further away have their atrial lips stretched out with their tips inserted into the test above the canals. The atrial lips contain brown pigment making them very conspicuous through the surface test, outlining not only the cloacal apertures, but also the branching canals, which, when they are crowded, often appear to form a network.

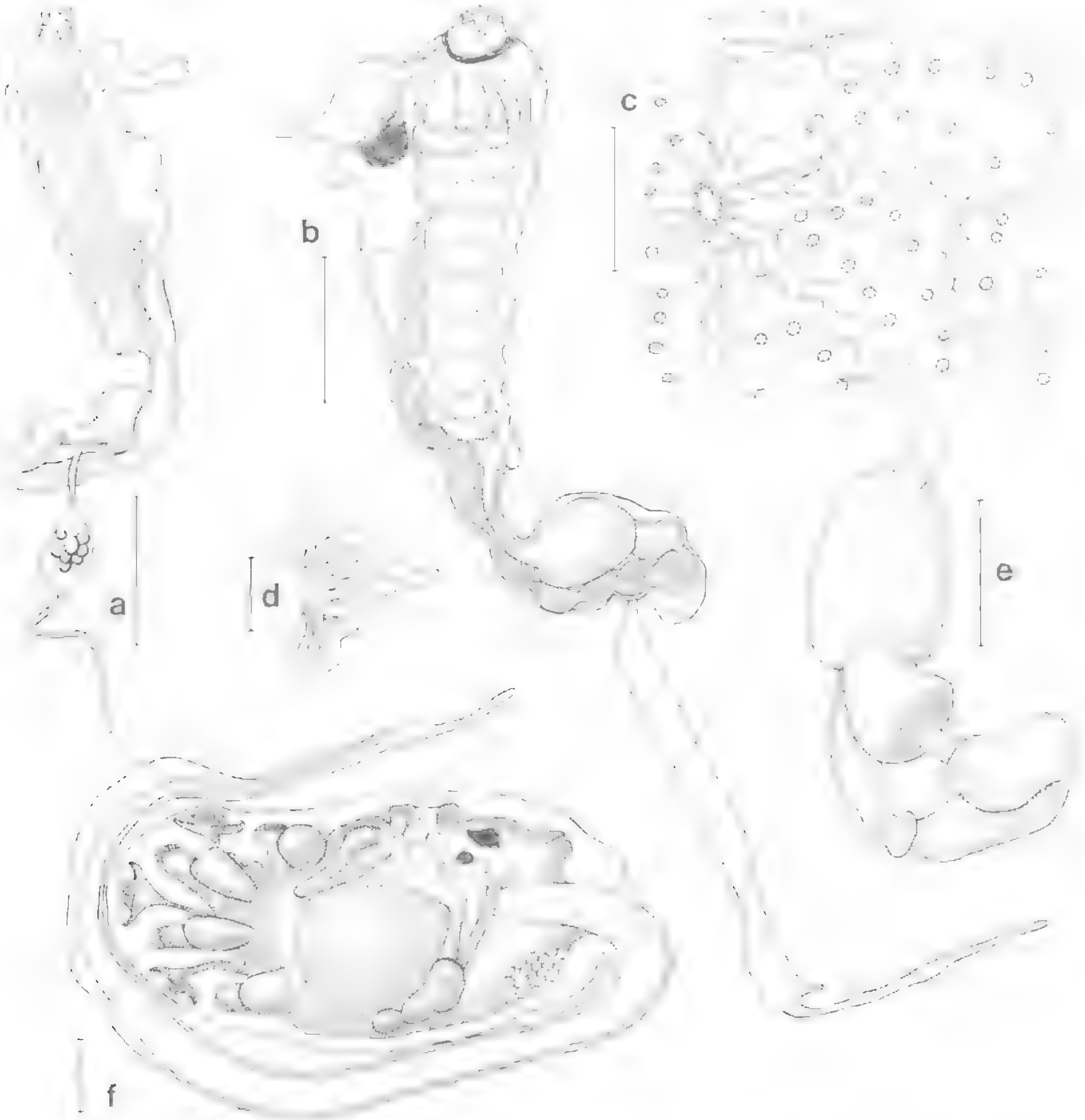


FIG. 35: *Polyclinum vasculosum* — **a**, **b**, zooids (**a**, QM GH1496 with sexual posterior abdomen; **b**, QM GH4984 with vegetative posterior abdomen); **c**, colony showing atrial lips along each side of cloacal canals that converge to common cloacal apertures (QM GH4982); **d**, atrial lip (QM GH4984); **e**, gut loop (QM GH4984); **f**, larva (QM GH4985). Scales: **a**, **b**, 1mm; **c**, 2mm; **d**, **e**, 0.5mm; **f**, 0.1mm.

Thicker colonies, which are recorded from mainland rather than coralline habitats, have less conspicuous systems, and cloacal and zooid apertures. The thick surface test obscures the openings, the denticulations around them, the insertion of the tips of the atrial apertures into the test and the position of the zooids relative to cloacal canals. Sometimes common cloacal apertures are raised on slight conical prominences about 1cm apart and are evenly distributed over the surface. In other specimens each branchial and cloacal aperture is depressed into the surface. In some colonies zooid-free areas of test separate the systems, which have cloacal apertures about 5mm apart. In others, the cloacal systems are contiguous and the only zooid-free parts of the test are those between the rows of zooids.

Vesicles (about 0.04mm in diameter) are evenly scattered in the surface test, about 0.3mm apart, amongst zooid openings, although they often are obscured by zooids and pigment.

INTERNAL STRUCTURE: Zooids in the thinner colonies are more easily removed from the test than those in the thicker ones, which have the atrial lips embedded in thicker, firmer test. The thorax is large and roomy (up to 3mm long). Usually the smaller abdomen (about 2mm long) is bent at right angles to the thorax. The posterior abdomen varies from the short, sac-like sexual organ to the long (up to 3mm) strap-like vegetative one. A delicate, sometimes branched, vascular stolon extends into the test from the end of the posterior abdomen.

The branchial lobes are well-formed and triangular. The atrial lip is long and broad, and usually constricted at the base. Its shape is variable, being tongue-shaped or short and broad with up to 7 denticulations on its outer edge, or leaf-shaped, tapering to a single point. It contains longitudinal muscle bands that extend into it from the dorsal side of the branchial siphon. These divide into separate fibres toward the sides and tip of the lip. The atrial aperture surrounded with circular muscles protrudes forwards on a short siphon, beneath the atrial lip. There is a median dorsal papilla protruding from the body wall posterior to the atrial siphon. About 10 to 15 fine longitudinal thoracic muscles extend from the branchial siphon to about one third of way down the thorax. There are 12 to 14 rows of short oval to rectangular stigmata, the latter being in larger, mature zooids. The dorsal languets are to the left of the mid line, and there are 2 more stigmata on the left than on the right side of the zooid. Stigmata vary from 8 on the right side posteriorly to 16 on the left side anteriorly.

In some colonies (possibly with juvenile zooids) the stigmata are small and oval and rounded papillae are on the transverse vessels (Gladstone QM GH4988). However, this is rare, and papillae were not usually detected.

The oesophagus is relatively long and distally it bends before entering the smooth, oval horizontal stomach, which lies anterior to a horizontal part of the rectum in the ascending limb of the gut loop. The distal end of the loop curves to the left and dorsally and the short neck connecting it to the posterior abdomen is on its dorsal side. The rectum extends anteriorly to halfway up the branchial sac and ends in a 2-lipped anus.

The sexual posterior abdomina are short, teardrop-shaped containing male follicles and ovary. These lengthen to comma shaped organs and subsequently to long and strap-like vegetative posterior abdomina. The latter are found on vegetative zooids around the actively growing borders of the colony. Comma-shaped posterior abdomina with the V-shaped heart posteriorly and a few male follicles and small ovary in the middle or anteriorly, occur as the zooid changes from its sexual to vegetative phase.

Two or 3 embryos are found in the unusually large atrial cavity of zooids collected in May in Moreton Bay, August (but not in March) from the Capricorn Group and in June from Lizard I. The embryos are few and small, especially in relation to the thorax and its roomy peribranchial cavity. It is possible that the species compensates for this by a long reproductive period (producing offspring over much of the year), and by having large long-lived colonies with numerous zooids.

The larval trunks are 0.5 to 0.6mm long. They have 3 shallow, narrow-stalked adhesive organs anteriorly, alternating with median and lateral ampulla, and a postero-ventral and mid-dorsal clump of ectodermal vesicles. The ampullae have conspicuous caps of enlarged epidermal cells, and similar enlarged ectodermal cells are present in the outer walls of the ectodermal vesicles.

REMARKS

Polyclinum vasculosum Pizon, 1908 from Indonesia was described from a small, single system colony. The zooids in branching double rows radiate from the common cloaca. The zooids have 12 rows of stigmata with up to 15 stigmata per row, and no branchial papillae were detected on the transverse vessels. Specimens from Hawaii, the Philippine and Marianas Is., some sandy and others naked, were assigned to this species (Tokioka 1967), but the naked ones (from the Hawaiian Islands) are the only ones correctly assigned. They have branching double rows of zooids radiating from large cloacal apertures with denticulate borders (like those of *P. constellatum*: see colonies from St. Helena, Michaelsen 1930), dark pigment (yellowish-brown) in the zooids, and colonies that are extensive sheets up to 2.5cm thick. The narrow thoraces, dark pigment, long atrial languets and large cloacal apertures resemble *Polyclinum macrophyllum* which appears to be a synonym of *P. vasculosum*. *Polyclinum festum* Van Name, 1918 from the Philippines, which has large investing colonies, is probably also a synonym of *P. vasculosum*, although the colonies are too mutilated to be sure.

Polyclinum macrophyllum Michaelsen, 1919 from Malagasy, and Western Australia (Michaelsen 1930), with its large muscular atrial lip, narrow thorax, 12 to 14 rows of 10 or 11 stigmata and branchial papillae sometimes on the transverse vessels, cannot be separated from *P. vasculosum*, especially from colonies from the Hawaiian islands (Tokioka 1967). Michaelsen distinguished *Polyclinum macrophyllum phortax* Michaelsen 1930 (from Shark Bay, Western Australia) from the West Indian Ocean *P. macrophyllum typicum* by its almost rough (rather than smooth and slippery) upper surface, the tighter insertion of the atrial tongue into the surface layer of test, and more delicate atrial musculature. However, these distinctions fall within the range of variation of the Australian populations and there well may be a continuous distribution around the Indian Ocean. Thus, assuming the synonymy of *P. macrophyllum* with *P. vasculosum* Pizon, 1908 is valid, *P. vasculosum* has a range from the West Indian Ocean into the Western Pacific to Hawaii (see Tokioka, 1967).

Polyclinum festum Hartmeyer, 1905 from Mauritius has a long, narrow atrial lip and probably does not belong to this species. Although its surface is smooth, sand is present on the base and sides of the colony and sometimes on the surface (see Millar 1975).

The large (6mm) investing colonies, *Polyclinum festum*: Van Name, 1918, from the Philippines, although so mutilated that systems could not be discerned, probably are synonyms of the present species. Van Name (1945) believed that these specimens, as well as *P. festum* from the type locality to be synonyms of *P. constellatum* which also has its type locality in Mauritius. However, all 3 species appear to be distinct. Michaelsen (1930) believed that *P. constellatum* could be distinguished by its branching double row systems while in *P. macrophyllum* (< *P. vasculosum*) branching canals formed a network. However, the complicated branching cloacal canals with a row of zooids along each side, that converge to the cloacal apertures, occur in both species. The primary difference between them appears to be the shape of the colony, viz. a capitate cushion attached by a small area of the base in *P. constellatum*, and in the present species an extensive sheet fixed by the whole of the basal surface. Usually the absence of branchial papillae also is indicative of *P. vasculosum*.

Genus **Aplidiopsis** Lahille, 1890

Type species: *Macroclinum vitreum* Lahille, 1887

Species of this genus resemble those of *Polyclinum*. The zooids differ mainly in the absence of branchial papillae, the relatively large and vertical gut loop, and in some species a ventral band of muscles continuing onto the abdomen and posterior abdomen. As in *Polyclinum* the posterior abdomen is connected to the abdomen by a narrow neck, and the vas deferens takes the characteristic polyclinid course from the left to the right side of the gut loop. As in *Polyclinum*, *Synoicum* and *Sidneioides* the oesophagus curves ventrally to enter the stomach along its dorsal border. A long atrial lip sometimes extends out from the upper rim of the opening as in *Synoicum* spp. and some *Polyclinum* spp. (e.g. *P. orbitum*). In other species the atrial lip arises from the body wall anterior to the opening and closes down over the anteriorly oriented atrial aperture, as in most *Polyclinum* spp. and some *Synoicum* spp. Zooids are arranged in circular or stellate systems.

Generally *Aplidiopsis* zooids are about 1cm long while those of *Polyclinum* are about 5mm or less. Other differences between *Polyclinum* and *Aplidiopsis* are discussed above (see Polyclinidae). The relatively large, vertical gut loop and the larger zooids of *Aplidiopsis* are very often the only reliable characters to distinguish it from *Polyclinum*. Although the posterior abdomen and testis are longer than in *Polyclinum*, the gut loop is vertical rather than horizontal, and the characteristic twist found in *Polyclinum* does not occur in this genus, a relationship to *Polyclinum* is indicated by the ocurse of the vas deferens.

Aplidiopsis is not diverse. In addition to the type species from the Mediterranean, the known species are *A. pannosa* (Ritter) from Alaska (see Nishikawa 1990) and the related *A. helenae* Redikorzev (see Van Name 1945), *A. atlantica* Monniot, 1974 from the Azores (at 600m), *A. stellata* Monniot and Monniot, 1984 from Guadaloupe, *A. pyriformis* (Herdman, 1886), *A. amoyense* Tokioka, 1967 from China, *A. tokaraensis* Tokioka, 1954a from the Tokhara Is, *A. discoveryi* Millar, 1960 from the North I. (New Zealand), and 3 new Australian species (see below). *Aplidiopsis pannosa, A. atlantica, A. stellata* and *A. helenae*, *A. confluata* n.sp., and *A. mammillata* n.sp., have delicate muscles confined to the anterior part of the thorax, in contrast to the other known species, which have the thoracic longitudinal muscles converging to a ventral band that extends the length of the zooid. *Aplidiopsis stellata* is known to have a brood pouch at the posterior end of the thorax rather than halfway up as in *Polyclinum*. The 3 species recorded from Australia are from temperate waters.

Key to species of *Aplidiopsis* recorded from Australia

1. Longitudinal muscles extend the length of the zooid; systems circular .... *A. sabulosa* n.sp.

   Longitudinal muscles do not extend the length of the zooid; systems not circular 2

2. Colony sandy; common cloacal apertures protrude .... *A. mammillata* n.sp.

   Colony not sandy; common cloacal apertures sessile .... *A. confluata* n.sp

Species recorded from waters adjacent to Australia

Aplidiopsis amoyense Tokioka, 1967 from Hsia-men has stellate systems that resemble those of *A. mammillata* n.sp. (see below).

Aplidiopsis discoveryi Millar, 1960 from New Zealand, unlike *A. sabulosa* n.sp., lacks sand altogether. The zooids, arranged in circular systems, can be seen through the transparent test.

Aplidiopsis tokaraensis Tokioka, 1954a from the Tokhara Is have an external layer of sand obscuring the systems. About 10 longitudinal thoracic muscles converge to form a ventral abdominal band. Monniot (1974) believed this species to be a member of the genus *Sidnyum*, with 8 branchial lobes. However, its smooth stomach wall shape of the posterior abdomen preclude that view.

Aplidiopsis confluata n.sp.
(Fig. 36)

DISTRIBUTION

TYPE LOCALITY: Tasmania (Ninepin Point, 5m coll. P. Last 19.7.82, holotype QM G115514).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a soft, almost spherical, naked head, about 2.5cm in diameter, attached by a short, thick, wrinkled stalk which narrows toward the base, and has some sand adhering to it. Double rows of zooids converge to large, sessile common cloacal apertures which are scattered randomly over the head. The test is soft and translucent internally, though the surface layer is opaque. Zooids are crowded, and cross one another in the centre of the colony and down into the stalk. The test, although it is soft, is tough and the zooids, tightly enclosed in it, are difficult to free from the colony.

INTERNAL STRUCTURE: Zooids are at least 1cm long, of which the thorax is about 2mm the abdomen about 1mm, the posterior abdomen occupying most of the zooid length. The branchial aperture has 6 small, pointed lobes. There is a long, flat, strap-like tongue from the body near the anterior edge of the first row of stigmata. The atrial aperture, with a sphincter muscle, is opposite the second row. About 8 fine longitudinal muscles on each side radiate from the branchial aperture and fade out halfway down the thorax. A median dorsal papilla is posterior to the atrial aperture. There are 16 rows of up to 14 stigmata, the ventral ones progressively reduced in length. The gut loop is vertical, although the oesophagus curves ventrally to enter the smooth-walled stomach. The duodenum expands in diameter to its junction with the short proximal part of the mid-intestine, and an oval posterior stomach is in the descending limb of the gut loop.

The posterior abdomen is particularly long, extending into the centre of the colony and down into the stalk. It is joined to the left (or ventral) side of the pole of the gut loop by a short narrow neck, but distal to the neck it abruptly increases in diameter and the greater part of the posterior abdomen is of even diameter. Anteriorly gonads are absent from 5mm or more of its length. They occupy about 2mm of the middle part of the posterior abdomen. They consist of a small ovary anteriorly, and a long cluster of almost spherical testis follicles. These are of various sizes, randomly distributed in the cluster, and they are not in regular longitudinal series. The vas deferens curves around the gut loop onto the other (right or dorsal) side to extend anteriorly to the atrial cavity between the oesophagus and rectum. There are no embryos in this specimen.

REMARKS

The species is unique in its soft sand-free test, crowded zooids and their long posterior abdomina each with a long bunch of testis follicles about half way down. It resembles the other Australian species *Aplidiopsis mammillata* n.sp. in its long longitudinal muscles confined to the anterior part of the long, delicate thorax, and the absence of branchial papillae. The long, strap-like atrial tongue is more conspicuous, there are more stigmata per row but fewer rows, and the posterior abdomen is longer than in either of the other 2 Australian species assigned to this genus. *Aplidiopsis discoveryi* Millar, 1960, from New Zealand has circular systems and a spindle-shaped posterior abdomen distinguishing it from the present species.

Aplidiopsis mammillata n.sp.

(Fig. 37. Plate 7d)

DISTRIBUTION

TYPE LOCALITY: South Australia (Cathedral Rock, near Thistle I., Spencer Gulf, coll. W.H. Sasse 6.4.87, slide 19, holotype QM GH4168).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The holotype is a large cushion 4cm in diameter and 1cm thick. The upper surface is depressed and divided into 3 naked areas by raised sandy elevations continuous with the raised rim around the margin. There are one or 2 systems in each naked area. Each system has sandy strips extending along radii from the peripheral sandy elevated rim to the central protuberant common cloacal aperture. Three or 4 double rows of zooids extend out between the radial strips of sand. Sand is confined to the surface test, however, and never is found internally. Zooids are tightly enclosed in the soft test and are difficult to remove.

INTERNAL STRUCTURE: The zooids are large, 7mm long, the thorax being more than half of the total length. The branchial aperture is small with

FIG. 36: *Aplidiopsis confluata* n.sp. (holotype QM GH5514) — a, colony; b, zooid. Scales: a, 2cm; b, 0.5mm.

6 pointed lobes. The small anteriorly directed atrial aperture is near the anterior end of the zooid.

Fine and inconspicuous longitudinal muscles were detected in the anterior part of each zooid. The atrial lip is long and narrow, arising from the body wall, and is difficult to remove from the test. There are 18 rows of stigmata with about 10 per row. The gut loop is vertical and relatively short. The stomach wall is smooth.

A long, almost cylindrical posterior abdomen, with a narrow neck attaching it to the left side of the gut loop, contains crowded male follicles and a small ovary surrounded by the male follicles.

REMARKS

Aplidiopsis amoyense Tokioka, 1967 from Hsia-men has stellate systems that resemble those of this new South Australian species. Zooids are also similar, with only very delicate muscles, however the Australian species has a larger branchial sac with about 18 rows of stigmata (the Chinese species having 12), and sand adheres to the external test.

Aplidiopsis pannosa is also in this group of species, with delicate muscles, and a smaller gut loop than usual. However, it lacks the characteristic radiating double row systems of *A. amoyense* and the present species.

Aplidiopsis sabulosa n.sp.

(Fig. 38, Plate 7e)

DISTRIBUTION

TYPE LOCALITY: South Australia (Price I., Avoid Bay 15–20m, coll: W.H. Sasse 9.4.87, holotype QM GH4153).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The holotype is a large cushion 10cm in diameter up to 3cm thick and with sand embedded throughout, absent only from the surface around the branchial and common cloacal apertures. The surface is even, without depressions or ridges. The cushion is fixed by a small area of the flat basal surface. Zooids open onto the rounded borders of the colony as well as its upper surface and much of the basal surface as well. Zooids are arranged in circular systems around sessile conspicuously naked common cloacal apertures about 5mm apart.

INTERNAL STRUCTURE: Zooids are about 1.3cm long of which the thorax and abdomen are of equal length and together are about half the total zooid length. Six strong longitudinal muscles from the branchial aperture, with some from the intersiphonal space, extend to the posterior end of the thorax where they join into a single ventral band that extends to the end of the zooid. The atrial lip is a tongue-shaped muscular extension of the upper border of the opening. It is forked at the tip. The atrial opening is anteriorly directed.

There are 20 rows of about 6 stigmata. The gut loop is voluminous. The oesophagus curves into the stomach which has a short dorsal border and a long, curved ventral margin. The duodenum is long and there is an oval posterior stomach at the bottom of the descending limb of the loop. The rectum extends to about halfway up the thorax.

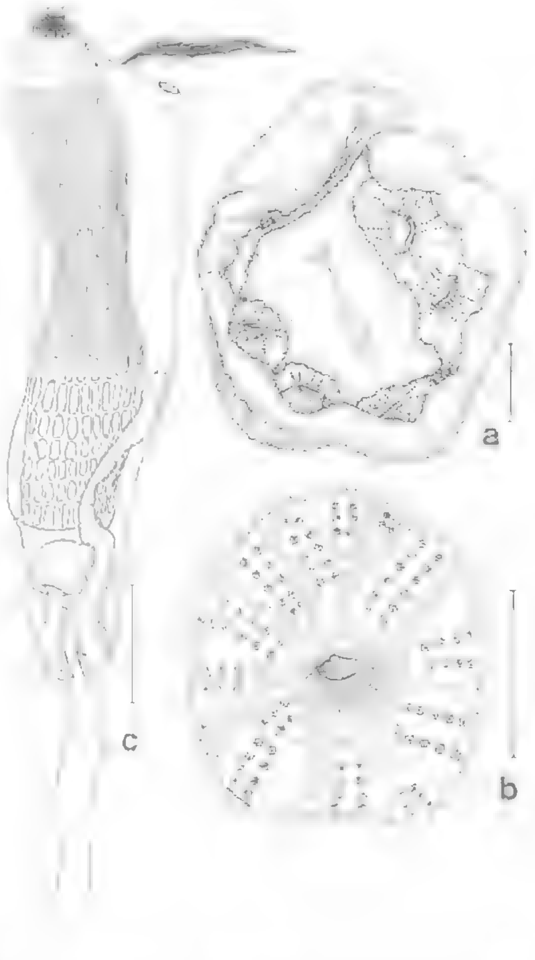


FIG. 37: *Aplidiopsis mammillata* n.sp. (holotype QM GH4168) — **a**, colony from above; **b**, single system with central protuberant cloacal aperture and double rows of zooids converging to it; **c**, zooid. Scales: **a**, 1cm; **b**, 5mm; **c**, 1mm.

terminating in a bilabiate anus. The stomach wall has internal circular patches of glandular epithelium giving a mulberry-like pattern.

The posterior abdomen is long, with a narrow neck anteriorly joining it to the left side of the pole of the gut loop. This neck portion gradually expands to the posterior gonad-bearing half. Male follicles are small and bunched and the large 2-egg ovary is surrounded by them. At its posterior end, the posterior abdomen tapers to a vascular stolon. The vas deferens curves around the ventral side of the posterior stomach from the left (or ventral) side of the loop and extends along the right side of the curve and inner side of the rectum to open at the level of the anus.

Two or 3 early embryos crowded in a longitudinal series are in the posterior part of the atrial cavity of the holotype (collected in April). Tailed larvae were not present.

REMARKS

Aplidiopsis mammillata has about the same number of rows of stigmata as the present species, but slightly more per row. It is also distinguished by its delicate musculature, smaller gut loop, smooth stomach wall, short and cylindrical posterior abdomen and its radial double-row systems.

Aplidiopsis sabulosa has circular systems like *A. discoveryi*, and *A. confluata*, and is distinguished by its embedded sand, and small number of stigmata in each row.

Aplidiopsis tokaraensis has sand on the outer surface, but not embedded in the test. The zooids have 18-20 stigmata and 12 rows, clearly distinguishing them from zooids of the present species.

Genus **Sidneioides** Kesteven, 1909

Type species: *Sidneioides tamaramae* Kesteven, 1909.

The genus resembles *Polyclinum* in its short longitudinal muscles, large muscular atrial lip that arises from the body wall anterior to the opening and its smooth-walled and bilaterally symmetrical stomach. It differs in having a relatively large ovary. The position of the ovary at mid-thoracic level, and a relatively large vertical gut loop. A median dorsal papilla projects from

FIG. 38: *Aplidiopsis sabulosa* n.sp. (holotype QM GH4153) — **a**, colony from above; **b**, thorax and abdomen with 2 embryos in atrial cavity; **c**, posterior abdomen. Scales: a, 2cm; b, 1mm; c, 2mm.

the body wall behind the atrial aperture as in many species of *Polyclinum* and *Synoicum*. The vas deferens passes around the ventral side of the descending gut loop to lie on the right side of the rectum as in *Polyclinum*. The voluminous vertical gut loop, absence of branchial papillae, and long posterior abdomen are more like *Aplidiopsis* than *Polyclinum*.

The larvae are small, sometimes smaller than those of *Polyclinum*. Although they have similar lateral ampullae and ectodermal vesicles, median ampullae are not present.

Three species of this genus are known. One is indigenous, with a wide range (from Westernport to Gladstone) on the eastern coast of Australia. The other known species are recorded from Japan (see Tokioka 1953):

Sidneioides japonense Redikorzev, 1913, recorded from Japan and Indonesia (Tokioka 1953, Millar 1975, Nishikawa 1990) forms a flat cushion with irregular furrows and protruding cloacal apertures on the upper surface. As in *S. tamaramae* a layer of sand adheres to the surface test, but sand is not present internally. The species are distinguished by their colony shape, and by the longer rows of stigmata and longer larval trunk of *S. japonense* (see Tokioka 1953).

Sidneioides snamoti (Oka, 1927) is distinguished by its systems which resemble those of *Polyclinum vasculosum*, with branching cloacal canals converging to protuberant cloacal apertures. The zooids differ from those of other species in having more rows of stigmata (17 to 19), as well as a large number of perforations in each row (see also Tokioka 1953, Nishikawa 1990).

Sidneioides tamaramae Kesteven, 1909
(Fig. 39, Plate 7f)

Sidneioides tamaramae Kesteven, 1909, p.277. Kott, 1957, p.104; 1976, p.63.

DISTRIBUTION

NEW RECORDS: New South Wales (Ulladulla, QM G11859; Twofold Bay, AM Y2151; Merewether, MV). Queensland (Gladstone Harbour, QM G9808).

PREVIOUSLY RECORDED: Victoria (Western Port — Kott 1976). New South Wales (Tamaramae Bay — Kesteven 1909; Merewether — AM Y1318–9 U3831 Kott 1957).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies consist of upright mushroom-shaped lobes widest across their free ends where often they are subdivided into separate shallow lobes, each with a central protruding cloacal aperture. Branchial openings are inside a ridge around the outer margin of each subdivision. The colony lobes narrow toward the base where they are continuous with the basal common test. The small colonies from Gladstone are separate lobes, without the basal common test (QM G9808). The diameter across the free end of each terminal branch is about 1cm, and the rounded subdivisions each containing a single circular system, are about 0.3mm in diameter. The free terminal part of each lobe is nearly 1cm long, and the overall height of the colony is up to 3cm. The whole outer surface is covered with a thick layer of sand. Sand is not present internally. Although the test is rather tough, the whole colony is soft, flaccid, and colourless in preservative. The outer free ends of all the lobes are level with one another and crowded together, and the upper surface has a cauliflower-like appearance. The large, muscular atrial lip of each zooid is extended into the central of the colony lobe and is inserted into the test around the cloacal aperture.

INTERNAL STRUCTURE: The zooids are about 6mm long including the posterior abdomen, which is attached to the abdomen by a long, narrow neck. The thorax is about two-thirds of the length of the abdomen. Six to 10 fine longitudinal muscle bands are on the anterior half of the thorax. The atrial aperture is projected forwards, and the anterior atrial lip, containing longitudinal and fine transverse muscles arises from the body wall anterior to the aperture. Twelve to 14 rows of stigmata, each with about 12 stigmata, are separated from one another by plain-edged transverse vessels each containing a narrow band of muscles.

The voluminous gut loop is vertical and the stomach smooth-walled. The posterior abdomen, joined to the abdomen by a narrow neck, is short, tear-drop-shaped to long and almost cylindrical or elliptical and is packed with male follicles. The relatively large ovary, with up to 18 eggs of various sizes, is in the thorax just on the right side of the anal opening, half way up the thorax. The colony from Gladstone collected in April has up to 8 embryos in the anterior half of the right peribranchial cavity.

The larval trunk is 0.4mm long (one of the smaller viviparous larvae known in the Ascidiacea). The tail is wound almost the whole way around it. Four lateral ampullae are present each side of the adhesive organs, and there are clumps of postero-ventral ectodermal vesicles each side of the base of the tail, and a row of about 6 ectodermal vesicles along each side of the mid-dorsal line.

REMARKS

The colony closely resembles that of *Polyclinum orbitum*. The shape and consistency of the colonial lobes are the same, and both zooids and larvae are very similar in size in these two species. The larvae of the present species, also resemble those of *P. orbitum* in the absence of median ampullae. *Sidneioides tamaramae* can be distinguished by the absence of branchial papillae, the position of the ovary, and the atrial lip, which in *P. orbitum* extends out from the upper rim of the aperture (as it does in *Aplidiopsis*, but seldom in other species of *Polyclinum*). The present species also has fewer rows of stigmata, fewer stigmata per row, and a larger and more vertical gut loop than *P. orbitum*.

The thickness of the basal common test varies, the type specimens having a basal plate (Kesteven 1909) rather than the upright stalk of the newly recorded colonies from Ulladulla (QM G11859).

Genus **Synoicum** Phipps, 1774

Type species: *Synoicum turgens* Phipps, 1774.

Zooids are small, and form circular or double-row systems. Colonies are sessile cushions, or investing sheets, or stalked heads. Despite the small size of the zooids there are 4 to 20 rows of

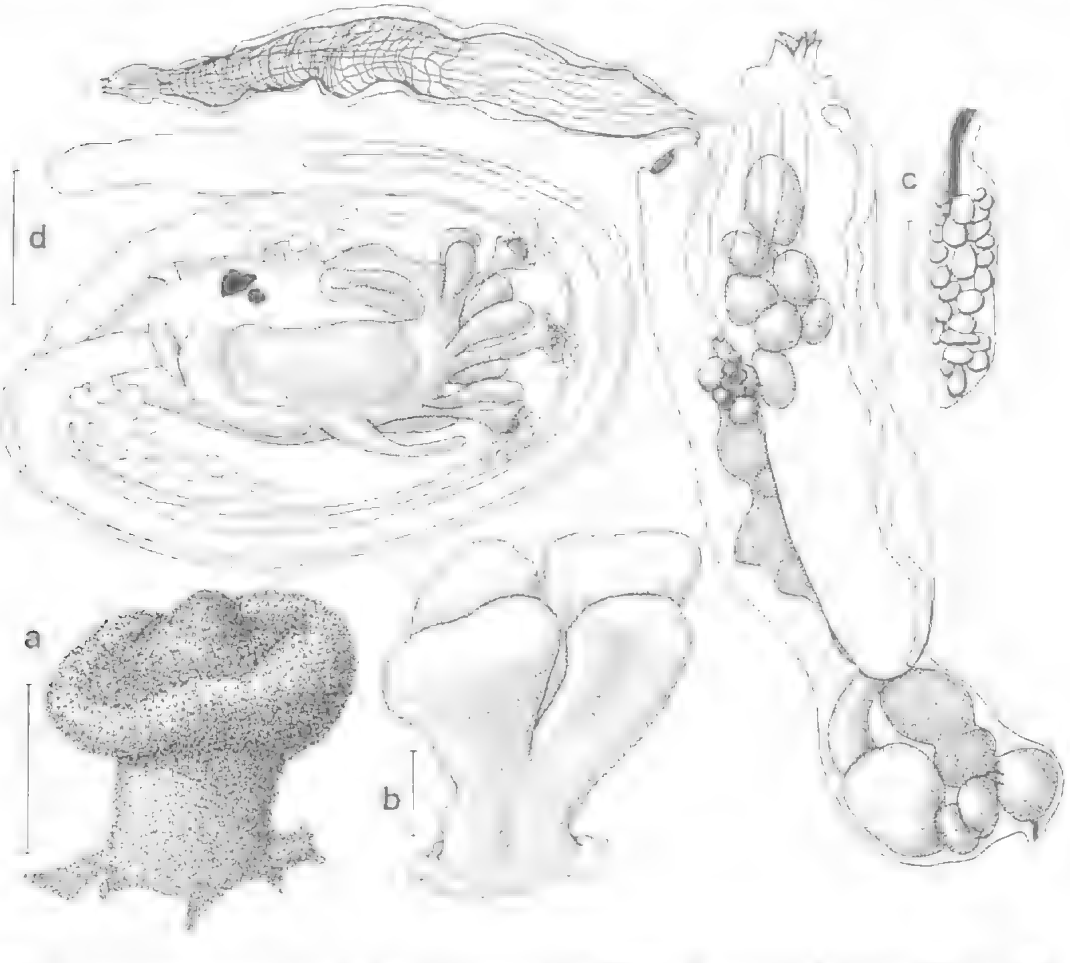


FIG. 39: *Sidneioides tamaramae* — **a**, lobe of a colony (QM G9808); **b**, portion of a colony (QM G11859), **c**, zooid with ovary to right of the distal part of the rectum and embryos in atrial cavity (QM G9808); **d**, larva (AM Y1318). Scales: **a**, **b**, 5mm; **c**, 0.5mm; **d**, 0.1mm.

stigmata and up to 20 stigmata per row. Longitudinal muscles form a wide band along each side of the abdomen and posterior abdomen. Gonads are in the long, narrow posterior abdomen which is continuous with, and not constricted off from, the abdomen. The oesophagus is curved to enter the bilaterally symmetrical stomach a short way along its dorsal border. The stomach wall is smooth or it has circular mulberry-like swellings. Sometimes it is quadrate in section but it never has true longitudinal folds. The gut loop is narrow and vertical, not being twisted or horizontal as in *Polyclinum*. The male follicles are in longitudinal series (rather than being bunched) with the ovary anterior to them.

The atrial aperture is large, and often produced dorsally on a roomy siphon. The rim of the opening often has minute pointed teeth except anteriorly where it is produced into a lip. *Synoicum macroglossum* is the only species with the lip separated from the aperture. The dorso-median papilla on the body wall just behind the atrial aperture, often actually on the atrial siphon itself, occurs in most species, as it does also in *Aplidiopsis*, *Sydneioides* and in many *Polyclinum* spp. It is not a species character as Michaelsen (1930) thought it was.

Embryos usually are incubated in the postero-dorsal half of the atrial cavity, sometimes (when large) occupying the whole of the cavity. In a few species (e.g. *S. sacculum* n.sp.) the embryos are incubated in a brood pouch constricted off from the postero-dorsal corner of the thorax (rather than half-way up as in *Polyclinum*).

Larvae have median and lateral ectodermal ampullae, each with columnar ectodermal cells forming a cap over the terminal end like those of *Polyclinum*. Dorsal and ventral vesicles resemble those of *Polyclinum*, branching off epidermal strands that trail posteriorly on each side of the mid-dorsal and mid-ventral lines. In other species the vesicles are median rather than lateral and the median stems from which they branch are shorter than the lateral ones of *Polyclinum* — dorsal as well as ventral vesicles being anterior, just behind the ampullae.

In many species the branchial lobes are relatively shallow and inconspicuous (e.g. *S. bowerbanki*). In *Synoicum papilliferum* and *S. macroglossum* the atrial lips are produced from the body wall anterior to the aperture (as in the majority of *Polyclinum*). However, in other species of the genus the atrial opening is relatively primitive, with the atrial lip represented by a simple expansion of the the upper rim of the opening (as in *Polyclinum orbitum* and *Aplidiopsis*). Two or 3 lobes are on the tip of the atrial lip and other small lobes are present on the posterior rim of the opening. The condition is reminiscent of the *angolanum* group of species in *Eudistoma* (see Kott 1990) in which rudimentary cloacal systems consist of zooids arranged around shallow rudimentary cloacal cavities that are little more than depressions in the surface test (see Kott 1990). Thus the atrial aperture generally present in *Synoicum* may be a relict of an early stage in the evolution of cloacal cavities.

The presence or absence of mulberry-like swellings of the stomach wall are reliable species characters. Although these swellings are sometimes inconspicuous in small zooids, Berrill's (1950) view that the stomach is smooth in small zooids but mulberry-like in large ones is not confirmed in the present study. In certain species the stomach is large, falling into horizontal folds. Such a stomach, known from *Synoicum concavitum* n.sp. and *S. atopogaster*, resembles the stomach of *Morchellium pannosum* n.sp. and *M. albidum* n.sp. It was formerly the characteristic of the genus *Atopogaster* by which it was separated from *Synoicum*.

The curved oesophagus of *Synoicum* which usually (but not always) enters the stomach along its dorsal border, resembles that of *Polyclinum* and the Holozoinae rather than the barrel shaped, vertical and more or less radially symmetrical stomach of Diazonidae, Polycitoridae, *Ritterella* and *Aplidium*.

Synoicum rubrum (Abbott and Trason, 1968), initially assigned to *Ritterella*, apparently has closer affinities with the present genus as, despite its lack of zooid systems, it has a characteristic mulberry-like stomach with the oesophagus entering its dorsal surface.

Synoicum is cosmopolitan, known from both northern and southern hemispheres, especially in polar waters. It is well represented in Australia by indigenous species, of which the majority are temperate, although some are tropical (Table 6). It is most diverse in New Zealand waters (see Millar 1982).

Key to species of *Synoicum* recorded from Australia

1. Stigmata in 4 rows .... *S. bowerbanki*
   Stigmata in more than 4 rows 2
2. Colony long, narrow, cylindrical stalks with zooids opening onto terminal head 3

Colony not long, narrow, cylindrical stalks with zooids opening onto terminal head 5

3. Stigmata in 9 rows; more than one system per lobe; tropical .... *S. buccinum* n. sp.
Stigmata in more than 9 rows; one system per lobe; temperate 4

4. Stomach wall mulberry like; system stellate .... *S. angustum* n.sp.
Stomach wall not mulberry-like; system circular .... *S. arenaceum*

5. Stomach wall mulberry-like 6
Stomach wall not mulberry-like 8

6. Colony separate flat-topped lobes on sandy base .... *S. sacculum* n. sp.
Colony not separate flat-topped lobes on sandy base 7

7. Colony a flat irregular sheet; surface raised into dome-like swellings over each system .... *S. intercedens*
Colony not a flat irregular sheet; surface not raised into dome-like swellings over each system .... *S. erectum* n. sp.

8. Atrial lip separate from aperture 9
Atrial lip not separate from aperture 10

9. Sand in layer externally; temperate .... *S. papilliferum*
Sand not in layer externally, tropical .... *S. macroglossum*

10. Parastigmatic vessels present .. *S. atopogaster*
Parastigmatic vessels not present 11

11. Zooids arranged in conspicuous longitudinal double row systems ...... *S. longistriatum* n.sp.
Zooids not arranged in conspicuous longitudinal double row systems 12

13. Cloacal cavities beneath deep depressions in surface 13
Cloacal cavities not beneath deep depressions in surface 16

13. Cloacal canals surround elevated zooid-free areas .... *S. chrysanthemum* n.sp.
Cloacal canals do not surround elevated zooid-free areas 14

14. Conspicuous elevated ridges around depressions in surface .... *S. castellatum* n.sp.
Conspicuous elevated ridges not present around depressions in surface 15

15. Stigmata up to 18 per row .... *S. concavitum* n.sp.
Stigmata up to 12 per row .... *S. tropicum*

16. Colony of numerous lobes on sandy base 17
Colony not numerous lobes on sandy base ..19

17. Colony lobes sandy 18
Colony lobes naked .... *S. suarenum* n.sp.

18. Systems more than one per lobe .... *S. durum* n.sp.
Systems one per lobe .... *S. obscurum* n.sp.

19. Colony, flat-topped .... *S. galei* n.sp.
Colony not flat-topped 20

20. Thorax long and narrow, about 16 rows of stigmata .... *S. prunum*
Thorax not long and narrow, about 8 rows of stigmata .... *S. citrum* n.sp.

Species recorded from waters adjacent to Australia

Synoicum apectetum Millar, 1982, from the northern tip of the North I. of New Zealand, has colonies resembling those of *S. buccinum* n. sp. However the New Zealand species has only one or 2 systems per colony lobe, and its atrial lip is separate from the aperture, as in *S. papilliferum.*

Synoicum haurakiensis Brewin, 1951 from the Hauraki Gulf, has a mulberry-like stomach, and the atrial lip apparently from the upper rim of the aperture. The colony is stalked and the systems are circular. The species is distinguished from *S. sacculum* n. sp. by its stalked colony.

Synoicum herdmani Brewin, 1956 from Chatham I., New Zealand has stalked lobes with circular systems. Zooids have a smooth stomach. The atrial lip appears to be independent of the aperture. The flat-topped colony may be distinctive (see below, *S. arenaceum*).

Synoicum hypurgon Michaelsen, 1924 from Hauraki Gulf, New Zealand, is not conspecific with the specimens from Fremantle which Michaelsen (1930) assigned to *S. hypurgon* as forma galei. The New Zealand colonies are club- or pear-shaped, with obscure systems, faecal pellets in the test, naked upper surface and sandy base, smooth stomach wall, atrial lip from the upper rim of the opening and a brood pouch constricted off from the body wall like *S. sacculum* n. sp. It resembles the tropical Australian *S. suarenum* n. sp., although the latter lacks a brood pouch, and has a dorsal papilla.

Synoicum kuranui Brewin, 1950b, from Great Barrier I., New Zealand, has flat-topped, sandy lobes up to 1.5cm high, reducing in diameter toward the base. The zooids, in round or oval systems, have mulberry-like stomachs. It is distinguished from *S. sacculum* n. sp. by the shape of the colonies, with their narrow sandy basal stalks. Kott (1963) assigned specimens

TABLE 6. Summary of characters of species of *Synocium* recorded from Australia

Species	Biogeographical Range[1]	Range anticlockwise around Australia	Colony	Systems	Stigmata: no. rows; no./row	Atrial lip[2]	Dorsal papilla[3]	Stomach wall[4]	Embryos: number;larval trunk median length (mm)	Other
S. bowerbanki	A,te	Fremantle – Vic.	sessile, upright with or without sand	circular	4;15	R	N	S	5;0.75	small branchial lobes
S. buccinum n.sp.	A,tr	Capricorn Gp – Coral Sea	long sandy stalks	"	9;20	"	"	"	2; 0.65	barrel-shaped stomach
S. arenaceum	Tasman Sea, te	Victoria – New Zealand	"	circular one/lobe	>13;?	"	"	"	?	
S. chrysanthemum n.sp.	A,tr	WA	stalked heads, with sand	canals circular	10;10	S	"	"	?	
S. papilliferum	A,te	Bunbury – Vic.	"	?	16–17; 9–10	"	P	"	?	
S. macroglossum	A,tr	Heron I. – NW Aust.	"	circular	18; 12–14	"	"	"	?	
S. intercedens	WP,tr	Capricorn Gp	"	"	14–17; 12–14	R	"	M	2;	
S. angustum n.sp.	A,te	Bass St	"	canals converging to terminal apertures; one/lobe	14; 20	"	"	"	?; ?	
S. erectum n.sp.	A,te	SA – Vic.	upright, sand externally	circular	12;8	"	"	"	2; 0.70	stomach areolations internal
S. sacculum n.sp.	A,te	SA – Tas	flat-topped lobes naked; sandy base	"	10;8	"	"	"	3; 0.4	brood pouch
S. obscurum n.sp.	A,te	Vic. to NSW	short, sandy lobes	circular one\lobe	20;20	"	"	I	5; 0.6	
S. suarenum n.sp.	A,tr	Capricorn Gp	flat-topped lobes naked; sandy base	circular	16;10	"	"	S	3; 0.6	
S. durum n.sp.	A,tr	Heron I.	short, sandy lobes	"	10;15	"	"	"	2; 0.45	
S. longistriatum n.sp.	A,te	Cockburn Sd	upright, sandy	canals converging to terminal apertures	16;16	R	N	S	?; ?	
S. atopogaster	A,te	WA	"	circular	17;10	"	"	"	1; 1.3	
S. tropicum	WP,tr	NW Aust.	massive, naked	circular; depressed into surface	12;8–10	"	"	"	?	
S. concavitum n.sp.	A,te	WA	"	"	15;18	"	"	"	?	
S. castellatum	A,tr	NE Aust.	"	"	22;30	"	"	I	3; 1.3	protuberant common cloacal aperture
S. prunum	A,te	NSW – Qld	"	circular, not depressed into surface	15;8	"	P	"	2; 0.56	
S. galei n.sp.	A,te	Fremantle	extensive sheets naked on upper surface	"	?	"	N	"	2;?	brood pouch
S. citrum n.sp.	A,te	SA – Tas	naked cushions	"	8; 20	"	"	"	?	

[1] A, indigenous; WP, Western Pacific; tr, tropical; te, temperate. [2] S, separate from atrial siphon; R, from rim of atrial siphon. [3] P, present; N, not present. [4] S, smooth; M, mulberry-like; I, irregular.

from Heron I. to this species, but re-examination has shown them not to be conspecific (see *Synoicum durum* n. sp.). Other colonies assigned to this species from Fiji (Kott 1981) and Indonesia (*S.? clavatum*: Millar, 1975) appear to be colonies of *S. suarenum* n. sp.

Other species from the South I. of New Zealand (see Millar 1982) not likely to occur in Australia, are *S. stewartense* (Michaelsen, 1924), *S. pererratum* (Sluiter, 1912), *S. otagoensis* Millar, 1982 and *S. occidentalis* Millar, 1982.

Synoicum angustum n.sp.

(Fig. 40a,b)

DISTRIBUTION

TYPE LOCALITY: Tasmania (45 nautical mls NNE of East Sister Is, 39°00'S 148°25'E, 92m sandy bottom, epibenthic seed CSIRO *Soela* Statn 22, coll. W. Zeidler 14.10.84, holotype SAM E2570, paratypes SAM E2572 E2573.

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are almost spherical heads (about 1cm diameter) on the terminal free ends of narrow branching sandy stalks about 6cm long and 0.5cm diameter. Zooids are in double rows along the sides of the head converging to a terminal, sessile common cloacal aperture. Sand adheres to the head to form a light covering but a thick coat of sand is crowded on the stalk. Sand is not embedded internally.

In preservative the zooids are reddish, and these, showing through the translucent test and the light covering of sand, make the head appear as brownish-red. The colour of the living colony is not known.

INTERNAL STRUCTURE: Zooids are robust when contracted, but only about 4mm long, the thorax and abdomen of equal length and together about half the length of the zooid. When extended it is probable that they are thread-like and extend down into the stalk. The rim of the branchial aperture is divided into 6 rounded lobes, and the atrial aperture has a moderately long, pointed, fleshy lip from the upper border of the opening. A median dorsal papilla behind the lower rim of the atrial aperture is a flat tongue-like projection or flap bent anteriorly or posteriorly against the zooid. Ten longitudinal muscles are on the thorax and extend down the rest of the zooids as a ventral band. About 14 rows of stigmata have 20 or more stigmata per row. These could not be counted accurately owing to the contracted thorax. The oesophagus and post-pyloric part of the gut loop are long. The stomach has rounded swellings in its wall to give a mulberry-like appearance.

The posterior abdomen has a moderately long sometimes branched terminal vascular appendix. Neither mature gonads nor embryos are present in this type material.

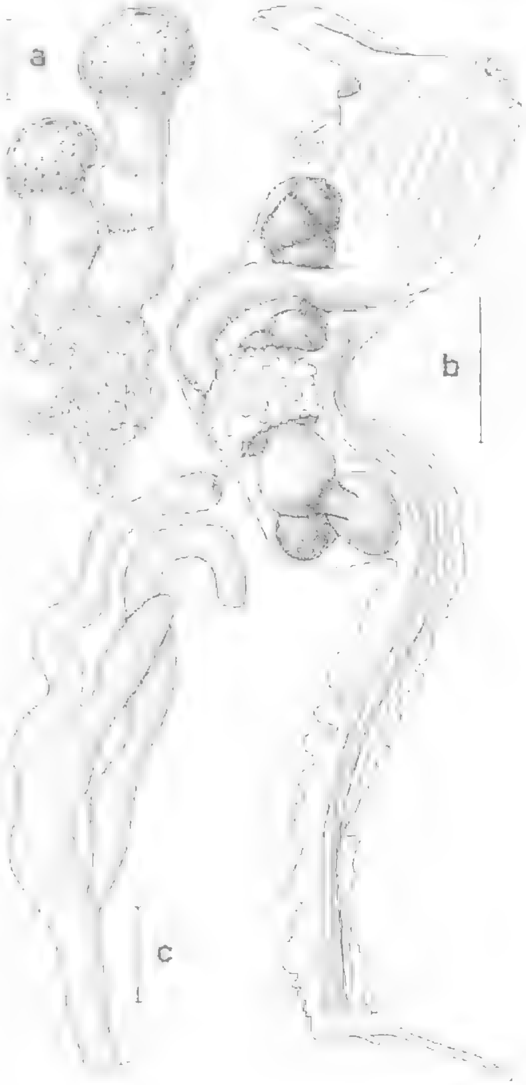


FIG. 40: *Synoicum angustum* n.sp. — **a**, colony (paratype SAM E2572); **b**, zooid (holotype SAM E2570). *Synoicum arenaceum* — **c**, colony (MV F58686). Scales: **a**, 5mm; **b**, 1mm; **c**, 1cm.

REMARKS

This species has the same mulberry-like stomach and the same temperate ranges as *S. sacculum* n.sp., from which it is distinguished by the long, narrow branching stalks of its small but distinctive colonies and its long posterior abdomen. The colonies of other stalked species of this genus, viz. the tropical *S. buccinum* n.sp., and the temperate *S. arenaceum* are distinguished by their circular (rather than radiating double-row) systems and smooth stomach walls. *Synoicum erectum* n.sp. also has a mulberry-like stomach and naked heads on a sandy base. However a number of circular systems opening on the upper surface of *S. erectum* and narrower thoraces with only about 8 stigmata per row distinguishes it from the present species. The flap-like dorsal papilla is also unique, distinguishing *S. angustum* from all others is this genus.

Synoicum arenaceum (Michaelsen, 1924)
(Fig. 40c)

Macroclinum arenaceum Michaelsen, 1924, p.406,
Synoicum arenaceum: Millar, 1960, p.361; 1982, p.21.

DISTRIBUTION

NEW RECORD: Victoria (off Cape Howe, MV F58686).
PREVIOUSLY RECORDED: ? Victoria (Port Phillip Bay — Millar 1960), New Zealand, Stewart I. (Michaelsen 1924). The new record is from 274m.

DESCRIPTION

EXTERNAL APPEARANCE: The newly recorded specimen is a narrow, cylindrical branching stalk, branching twice, and about 6cm long overall. The terminal branches are about 4mm diameter. Each branch occupies about one third of the total length. The tip of each terminal branch is naked, about the same diameter as the rest of the stalk, with a central sessile cloacal aperture around which the zooids appear to be arranged. The remainder of the colony is covered with sand, and also sand is embedded internally.

INTERNAL STRUCTURE: The zooids in this specimen are muscular and very contracted and few details of their morphology can be determined. The atrial lip is produced from the rim of the atrial aperture. There are at least 13 rows of stigmata. The large smooth-walled stomach is halfway down the abdomen. Gonads are not mature.

REMARKS

The identification of this specimen is based on the form of the colony. However the free end of the head is expanded and flat in the type specimen, but not in the present specimen. Millar (1966) did not describe the specimen he recorded from Port Phillip Bay. Kott (1969) thought this species to be synonymous with the sub-antarctic *A. recumbens*; and Millar (1982) referred to proposals that *S. arenaceum*, *S. herdmani* and *S. kuranui* are conspecific. Generally the relationships of these species are unresolved, although *S. kuranui* unlike the others has a mulberry-like stomach, and appears to be different. Further, colonies of the present species have long cylindrical branching stalks different from the tapering ones of *S. kuranui*. At this stage the New Zealand populations require review, and more Australian material is needed to establish the status of this species and its populations on both sides of the Tasman Sea.

Synoicum atopogaster Kott, 1963
(Fig. 41)

Synoicum atopogaster Kott, 1963, p.89.

DISTRIBUTION

NEW RECORDS: None.
PREVIOUSLY RECORDED: Western Australia (W of the Abrolhos — AM U3927 holotype Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a thick, cylindrical upright lobe, 5cm high and 2.5cm in diameter. A few smaller lobes are present around the base. The test of the lower half of the colony is firm, while that of the upper half is soft. A crowded layer of sand adheres to the surface test of the lower half, and some is on the upper surface between bare patches.

Zooids extend out to occupy the whole length of the colony, but when contracted they are found either near the top, or withdrawn down into the base. They are arranged in 4 or 5 systems opening around the upper surface. Each common cloacal aperture appears to be surrounded by a circle of zooids, with their branchial apertures protected by a ridge of surface test.

The holotype colony is wrinkled transversely and its head is displaced laterally.

INTERNAL STRUCTURE: The zooids are large, the thorax and abdomen of contracted zooids being at least 4mm long. They have about 30 longitudinal muscle bands on the thorax and these continue as a wide band along the ventral surface of the abdomen and posterior abdomen. When contracted, this muscle band draws up the posterior abdomen alongside the abdomen. The branchial aperture is on a short, narrow siphon with the rim divided into 6 lobes. The 2 ventral lobes are slightly enlarged and dorsally-directed. The atrial aperture has a fleshy lip from the anterior rim and a few irregular lobes on the posterior rim.

Each of the 17 rows of up to 10 stigmata is crossed by a parastigmatic vessel, and both primary transverse and parastigmatic vessels have a dorsal languet. Transverse vessels contain muscle fibres. The oesophagus is long, the stomach voluminous, collapsed into transverse folds. The duodenum and mid-intestine are relatively long and narrow and the oval posterior stomach large.

The gonads consist of a clump of male follicles about halfway down the posterior abdomen, with a small ovary anterior to them. The vasa efferentia join to form the vas deferens about halfway up the side of the male follicles, rather than each follicle separately joining the vas deferens as it passes up the length of the posterior abdomen.

A single embryo is present in the atrial cavity of zooids of the holotype colony. The larval trunk is 1.3mm long. A median ampulla with 2 or 3 branches is in each interspace between the median adhesive organs. Minute epidermal vesicles branch off the epidermis and lie in the thin layer of test that surrounds the large trunk. The yolk mass is large, the developing adult organs are crowded into the posterior end of the trunk.

REMARKS

The zooids of this species are, in some respects,

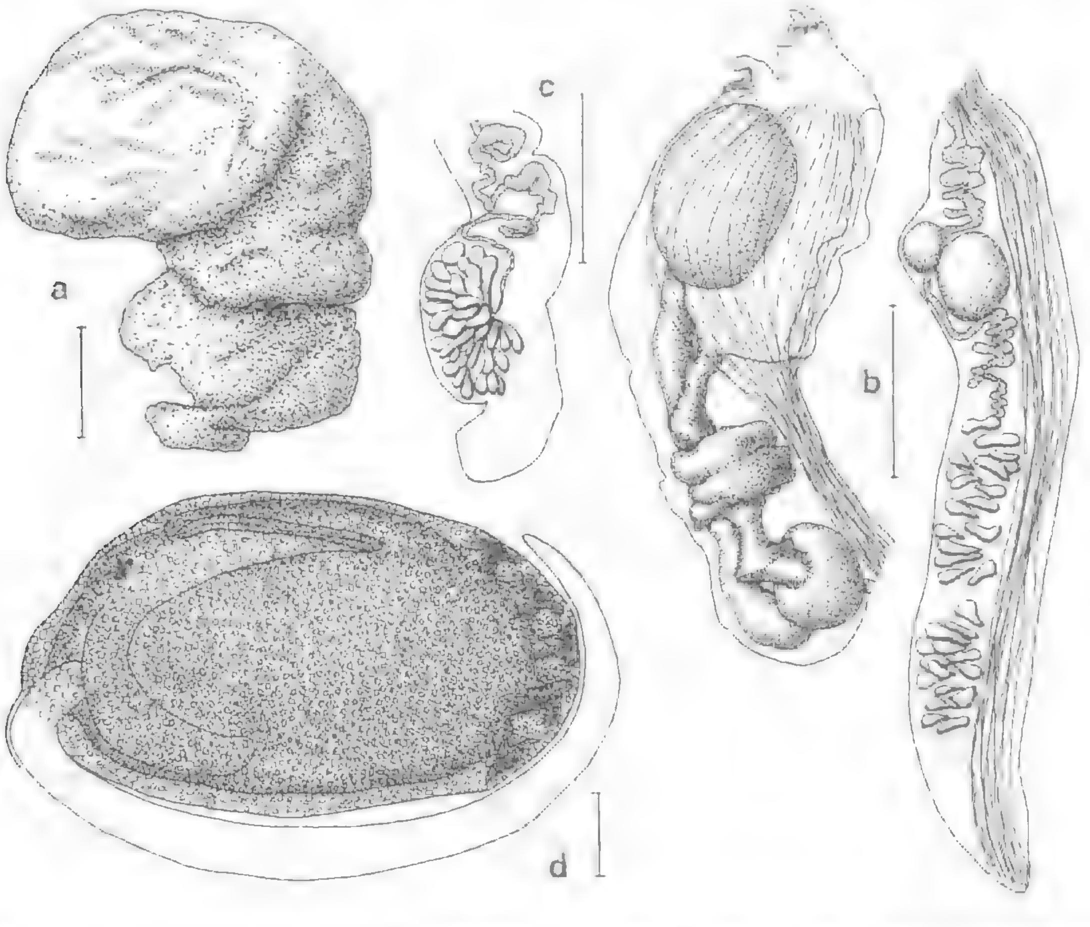


FIG. 41: *Synoicum atopogaster* (holotype AM U3927) — **a**, colony; **b**, zooid; **c**, contracted posterior abdomen; **d**, larva. The epidermal vesicles in the test around the sides of the larval trunk are not shown. Scales: **a**, 1cm; **b**, **c**, 1mm; **d**, 0.2mm.

like those of *S. concavitum* n.sp., having a similar large stomach, a strong ventral muscle, and conspicuous transverse muscles in the branchial sac. However, *S. concavitum* n.sp., has a flat rather than upright colony with more numerous, but smaller systems in firm, naked, gelatinous test.

The relationship of the species to *Morchellium pannosum* n.sp. is discussed below. The course of the vas deferens resembles that of *Pseudodistoma candens* n.sp., but a phylogenetic relationship between these taxa is not implied.

Synoicum bowerbanki Millar, 1963
(Fig. 42. Plate 8a)

Synoicum bowerbanki Millar, 1963, p.697.

DISTRIBUTION

NEW RECORDS: Victoria (Portland, QM GH38, SAM E2551, MV F59372).

PREVIOUSLY RECORDED: Western Australia (Fremantle — Millar 1963). Millar (1963) records a further specimen from an unknown Australian locality.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are upright and club-shaped (to 6cm high) to almost spherical (to 5cm in diameter). A short stalk from the under surface reduces in diameter toward the substrate, although in some specimens it is divided into branched roots. Several of the newly recorded specimens (SAM E2551, QM GH38) have a single layer of sand grains attached to the surface test, interrupted over the zooid openings. Several upright, club-shaped colonies (MV F59372), however, are naked with basal sandy roots. Sand is not present internally.

Zooids are arranged in evenly spaced circular cloacal systems of about 6 zooids around a central cloacal aperture. Each system is about 5mm in diameter.

The red test of living colonies becomes transparent and pink in preservative, although this is obscured by the surface layer of dark grey sand grains. The naked colonies are opaque purple on the surface, but transparent internally. The test is gelatinous and firm, but soft.

INTERNAL STRUCTURE: Zooids are long (to 1cm) and thread-like. When contracted, the thorax and abdomen together are about one third of the total length. The terminal branchial aperture is almost smooth-rimmed, the 6 branchial lobes being almost completely suppressed. The atrial aperture is on a relatively long siphon, with its anterior border produced into a lip with its tip divided into 3 rounded lobes which are inserted into the rim of the cloacal aperture. Apart from the sphincter muscles around the apertures, thoracic musculature is limited to about 14 fine longitudinal and oblique muscles. These extend in a band along each side of the abdomen and posterior abdomen. There are 4 rows of stigmata with up to 15 per row. The oesophagus is curved, the stomach wall is smooth. The duodenal part of the gut is long and the mid-intestine is expanded before opening into an oval posterior stomach in the bend of the gut loop. The anal opening is about one-third of the way up the thorax.

A group of 3 or 4 oocytes are posterior to a gonad-free part of the posterior abdomen behind the gut loop. Behind the ovary are testis follicles in a single longitudinal series sometimes occupying most of the length of the posterior abdomen. The testis follicles are spent in the colonies with embryos being incubated. The species may be protandrous.

Zooids of colonies collected in July (QM GH38) have up to 5 embryos at a time in the atrial cavity. They are at different stages of development, and perhaps were fertilised in the oviduct. Larvae have a trunk 0.7mm long. Small adhesive organs on slender stalks alternate with conical median ampullae. There also are 4 rounded lateral ampullae on each side. Ampullary vesicles develop on a posteriorly projecting median stalk both ventrally and dorsally. The larval tail reaches to the anterior end of the trunk.

REMARKS

The holotype of this species from Fremantle (Millar 1963) and the specimens Millar described at the same time, from an unknown locality, are fleshy naked masses, up to 9cm in maximum extent, and 3cm thick. Most of the newly recorded specimens have a single layer of sand adhering to the surface test, although some club-shaped ones from Portland (MV F59372) are naked, but with sandy basal root-like projections of the test. However, all known specimens have an almost smooth branchial aperture, a conspicuous atrial siphon with a tridentate tip on the anterior lip, smooth stomach wall, a single row of male follicles, 4 rows of up to 15 stigmata, and a similar larva. Although the cloacal systems of the type specimens are not described, the unusual almost smooth branchial apertures together with the reduced branchial sac support the view that the newly recorded material from south-eastern Australia (in which there is some variability in shape and in the presence of a surface layer of sand) is conspecific with the type specimens (Millar 1963).

The oesophagus of *Synoicum* spp. is characteristically longer than in most other genera of the Polyclinidae, and its curve is also characteristic of the genus. However, the oesophagus of the type specimen of *S. bowerbanki* figured by Millar (1963, p.697) is unusually long in relation to the total length of the gut loop, the stomach being in the posterior third of the abdomen rather than half way down it as is more usual.

Synoicum buccinum n. sp.
(Fig. 43. Plate 8b)

DISTRIBUTION

TYPE LOCALITY: Coral Sea (Marion Reef, cave, 8m, coll. N. Coleman 24.8.77 AMPI 209, holotype QM GH5045). Queensland (Heron I., rubble zone, sandy substrate, coll. P. Kott 26.2.84, paratypes QM GH5046; W. reef crest, W. Wistari Reef, coll. P. Kott 12.9.84, paratypes QM GH5047; NW corner Wistari Reef, coll. P. Kott 3.11.86, paratypes QM GH5048).

FURTHER RECORDS: Queensland (Capricorn Group, QM GH5049–52 GH5585).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are slender, sandy, cylindrical, irregularly bent, branching stalks. The terminal branches are about 1cm long and 3mm in diameter expanding toward the free end into a rounded to flat-topped or flattened mushroom-like naked head up to 1.5cm in diameter onto which the zooids open. Each terminal

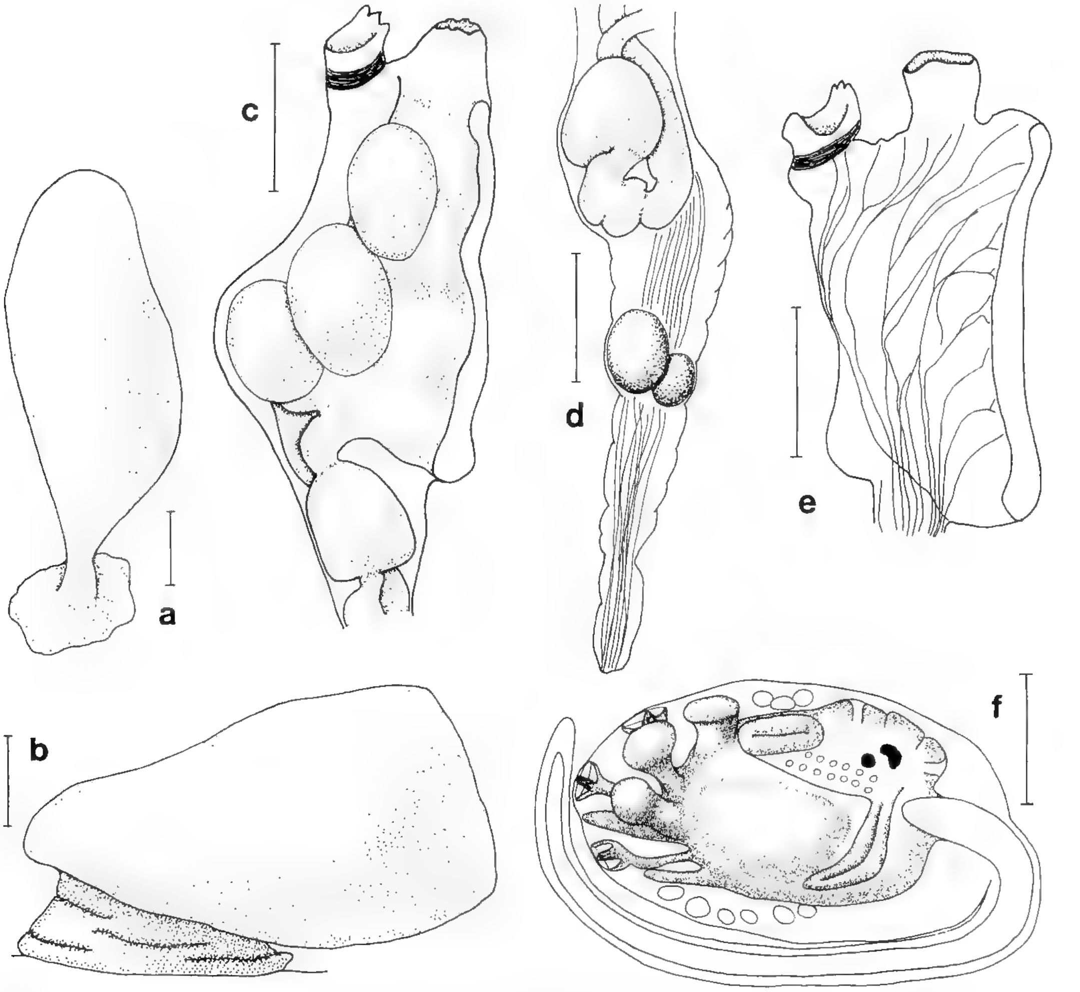


FIG. 42: *Synoicum bowerbanki* — **a**, **b**, outline of colonies (MV F59372, QM GH38); **c–e**, parts of zooids (QM GH38); **f**, larva (QM GH38). Scales: **a**, **b**, 1cm; **c–e**, 0.5mm; **f**, 0.2mm.

FIG. 43: *Synoicum buccinum* n.sp. — a, b, colonies (a, detail of systems, paratype QM GH5048; b, outline of holotype QM GH5045); c, thorax and abdomen (QM GH5299); d, larva (paratype QM GH5047). Scales: a, 2mm; b, 1cm; c, 0.5mm; d, 0.2mm.

stalk contains from one to 5 or 6 circular to long systems of 6 or more zooids around large, sessile common cloacal apertures. The systems often are separated from one another by deep furrows in the surface test.

Sand is on the external surface of, and embedded through, the stalk, making it hard, but not brittle. The sand sometimes projects up into the centre of the head and forms partitions around the systems. It is always absent from around the zooids in the soft, upper layer of translucent test, through which the zooids can be seen perpendicular to the terminal surface. Sometimes green algal cells are embedded in the surface test together with a scattering of sand particles.

In life the head is 'orange buff' or 'orange rufus' with zooids 'orange chrome' (Ridgeway 1886), but the sandy stalk has no colour and usually is embedded in the substrate.

INTERNAL STRUCTURE: Zooids are moderately small, the thorax and abdomen together being about 2mm long. The posterior abdomen is very long, projecting down into the stalk. One or 2 stolonic vessels are at the posterior end of the posterior abdomen. About 6 fine longitudinal muscle bands extend the whole length of the zooid. The atrial apertures are wide and sessile, with a frilled margin. Muscles are present around the sides and posterior rim of the aperture, and the outside ones loop back across the postero-dorsal surface of the body. The atrial aperture can probably be closed by contraction of the muscles around it, but in most of the zooids examined the dorsal border of the zooid is contracted and concave, partially occluding the aperture. The anterior rim of the atrial aperture is produced into one to 3 long, pointed lips. Nine rows of stigmata are in the pharynx, with 16 per row posteriorly, and 20 per row anteriorly. The gut loop is vertical, and the oesophagus relatively straight. The smooth-walled stomach is quadrate in section and sometimes appears to have 4 folds. These are not true folds. The duodenal area is moderately long, and a posterior stomach is in the bend of the gut loop.

Two rows of male follicles are in the posterior half of the posterior abdomen of the holotype and a small ovary is anterior to the male follicles. A single embryo is in the atrial cavity of this specimen lot (collected in August). Two embryos, one an advanced tailed larva, are present in specimens collected in September. Larvae have an almost spherical trunk about 0.65mm long with the tail wound about three quarters of the way around it. There are median and lateral ampullae, but epidermal vesicles were not detected in the larval test. Both otolith and ocellus are present.

REMARKS

The straight oesophagus and more or less barrel-shaped stomach of this species approach the condition found in *Aplidium* spp. However, stomach folds, when they occasionally are found, do not appear to be structural and the stomach generally is smooth, justifying its position as a species of *Synoicum*.

The colonies resemble those of *S. arenaceum* Michaelsen, 1924 and *S. apectetum* Millar, 1982, from temperate New Zealand waters. The species is distinguished from both by the numerous systems in each head, and further distinguished from Millar's species by the origin of the atrial lip from the rim of the aperture (rather than separately from the body wall anterior to the opening), and by the length of the larval trunk (only 0.5mm in Millar's species). *Synoicum arenaceum* is also distinguished by its more numerous rows of stigmata.

Synoicum castellatum n.sp.

(Fig. 44, Plate 8c–e)

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I, North Point, 5m, coll. D. Parry 4.11.86, holotype QM GH5160, coll. R. Day 4.7.73, paratypes QM GH5163).

FURTHER RECORDS: Western Australia (Exmouth Gulf, QM GH5401). Queensland (Capricorn Group, QM GH5161–2 GH5164–5 GH5512 GH5587 GH5590; Swain Reefs, AM Roche ZQ 326; Broadhurst Reef, QM GH5351 GH5503; Whitsunday Is, QM GH5508; Hook and Hardy Reefs Channel QM GH5376 GH5509; Lizard I., QM GH5332; Raine I., QM GH5627). Northern Territory (Gulf of Carpentaria, AM Y1062).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are robust, usually massive cushions to 10cm diameter and about 2cm high. The upper surface has raised rounded ridges that surround more or less circular to irregularly shaped, or stellate depressions. A conical cloacal aperture protrudes from the centre of each depression rising above the level of the rounded ridges. The branchial apertures are around each depression at the base of the raised ridges. A shallow but extensive cloacal cavity surrounded by the zooids is beneath each depressed area. The test is translucent, firm and gelatinous. In life colonies are 'fleshy' coloured, with 'isabella' colour (Ridgeway 1886) in the centre of the ridges. In preservative the flesh colour becomes beige, some darker grey along the ridges and in the margins of the colony, and minute dark pigment cells in the test.

The zooids are in rigid compartments in the firm test. They are large and not crowded. Neither embedded nor adherent sand is present.

INTERNAL STRUCTURE: Zooids are large and robust, the thorax and abdomen together about 1cm, even in contracted zooids. The posterior abdomen is at least twice that length. Each branchial aperture has 6 large triangular lobes and a strong sphincter muscle behind the branchial lobes. The atrial tongue is fleshy, sometimes long and pointed, sometimes contracted and blunt and occasionally divided into 2 lobes. Five small pointed papillae are evenly spaced around the rim of the atrial aperture posterior to the atrial tongue, which extends out from the anterior rim of the opening. About 30 longitudinal muscles are in the parietal wall of the thorax, and these continue along the length of the zooid. Transverse muscles are in the transverse vessels of the branchial sac. Short stumpy connecting branches from the muscles in each transverse vessel cross the atrial cavity in connecting vessels about one third of the distance from the dorsal mid-line. These muscles break into terminal branches which join with the eighth to tenth longitudinal muscles on each side of the pharynx. The connecting vessels with their contained muscles effectively divide the atrial cavity into a dorsal chamber (containing faeces and embryos) and a ventral chamber on each side of the pharynx.

The branchial sac is long and wide with 18 to 22 rows of stigmata. In the centre of the sac about 30 stigmata are in each row but the rows dramatically reduce in length posteriorly.

The stomach is large, and its shape sometimes is obscured by horizontal folds when contracted. The stomach wall is smooth externally in the relaxed zooid, but with some variability in its internal lining. Occasionally vertical divisions separate the glandular lining into 4 to 8 ribbon-like bands. In other specimens these bands become irregular patches of glandular epithelium interrupted by branching internal ridges which may be parallel to one another toward the posterior end of the stomach. The remainder of the descending limb of the gut loop has the usual duodenum, proximal part of the mid-intestine, small posterior stomach, and the distal part of the mid-intestine which opens into the rectum at the base of the ascending limb of the gut loop. The anus is trumpet-shaped and circular. It is not divided into 2 lips. A few relatively large oocytes are anterior to 2 irregular, crowded series of more or less club-shaped testis follicles, in the posterior half of the long, cylindrical posterior abdomen.

One to 3 large embryos are being incubated in the dorsal peribranchial cavity of zooids collected at Heron I. in June and July, but not in August, September or November. Larvae have a trunk 1.0mm long, with the tail wound three-quarters of the distance around it. Median ampullae alternate with the 3 narrow-stalked, shallow adhesive organs. Bands of crowded epidermal vesicles are crowded across the dorsal and ventral mid-lines behind the adhesive organs and extend anteriorly along each side of the mid-line.

REMARKS

These large, robust, naked colonies with their zooid systems opening into large depressed areas separated by high rounded ridges of naked test, superficially resemble both *Lissoclinum patella* (Didemnidae: see Kott 1980) and *Aplidium crateriferum* (see below). The large, protuberant

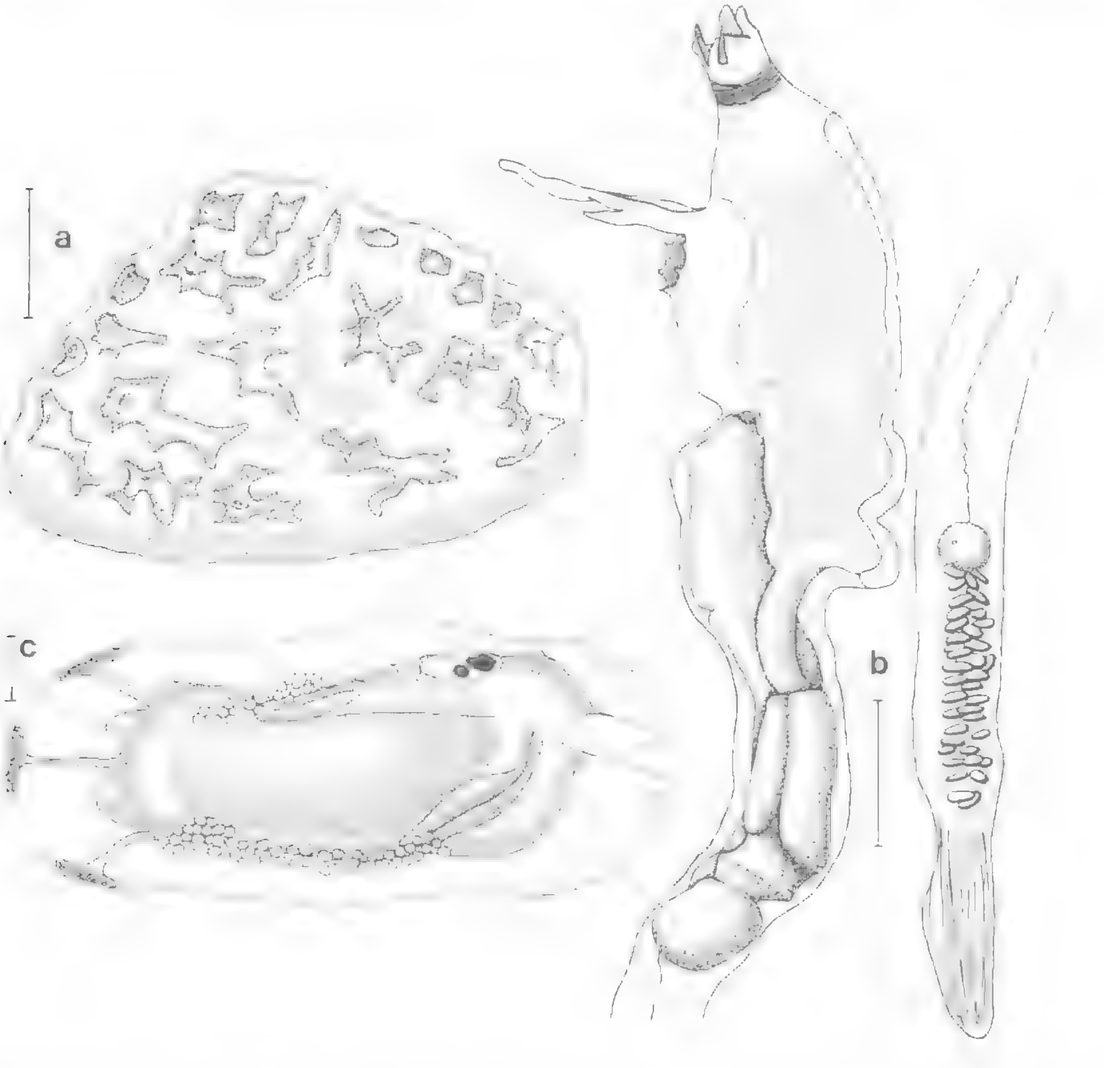


FIG. 44: *Synoicum castellatum* n.sp. — a, colony (holoytpe QM GH5160); b, zooid (QM GH5164); c, larva (QM GH5163). Scales: a, 2cm; b, 1mm; c, 0.1mm.

common cloacal apertures of the latter also resemble those of the present species. In addition to the differences in its stomach wall, *A. crateriferum* systems open into depressions that are long, slightly curved with excentric cloacal apertures rather than the more circular to stellate depressions with central common cloacal that occur in the present species. *Aplidium crateriferum* also has a differently shaped zooid from that of the present species, with the atrial lip separated from the aperture and a narrow thorax with only 8 (rather than the present 30 stigmata).

Aplidium clivosum n.sp. has a similar robust colony, but the zooids are in double rows along cloacal canals that converge to the common cloacal apertures.

Synoicum chrysanthemum n. sp.

(Fig. 45)

DISTRIBUTION

TYPE LOCALITY: Western Australia (NW Bluff Point 27°40'S 113°03'E, 130m, CSIRO 22.8.63, holotype WAM 1031.83; paratype 21.8.63 WAM 1032.83; 80km W of Dongara 64m, MV Sprightly 19.2.76, paratype WAM 850.83 *QM GH2115*).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are mushroom-like consisting of a spherical to conical head to 5cm in diameter, on a thick, cylindrical stalk 3 to 4cm long and 1cm in diameter. Basally the stalk divides into 2 or 3 short thick roots.

The preserved colonies are opaque and white. Sand is crowded in the surface layer of test, but becomes less so internally. The surface of the head is covered with circular zooid-free areas (about 5mm in diameter) which swell out from the surface a little. These are surrounded by cloacal canals which lie beneath depressions or creases in the surface test. The layer of test over the cloacal canals is thin but opaque with sand embedded. Common cloacal cavities are where several of the circular canals meet beneath a large common cloacal aperture. Cloacal canals are rigid with sand and in the examined colonies the branchial sacs are exposed directly to them through the large atrial apertures.

INTERNAL STRUCTURE: The thorax and abdomen together are about 3mm long, with the thorax longer than the abdomen. The posterior abdomen

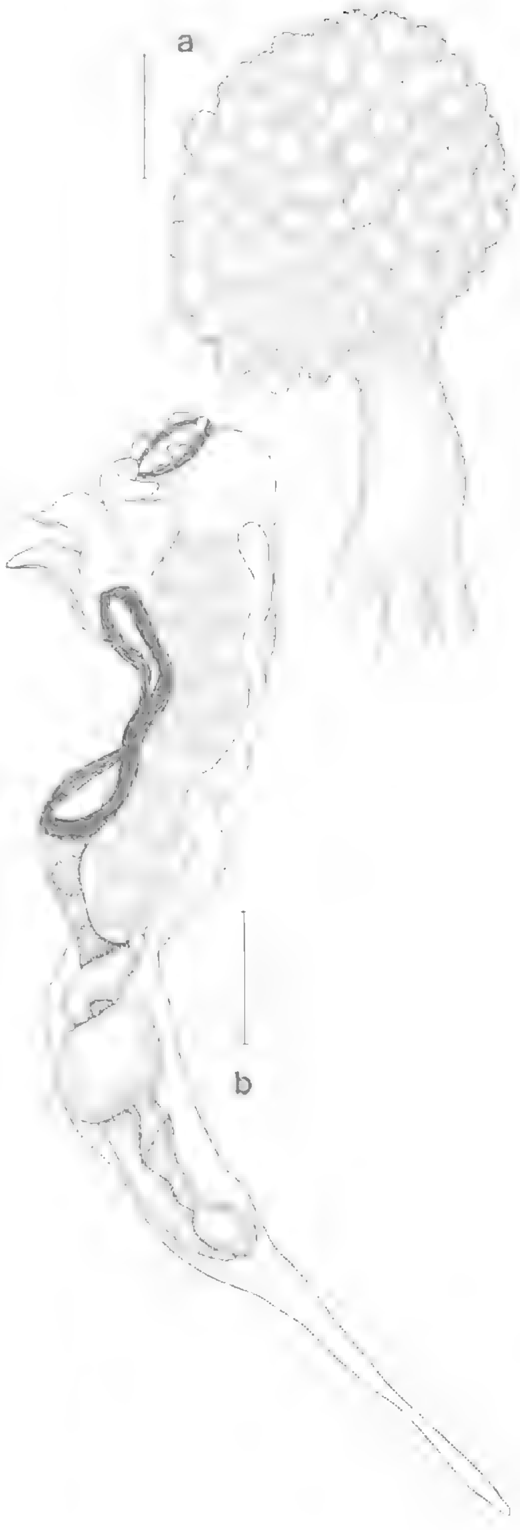


FIG. 45: *Synoicum chrysanthemum* n.sp. (paratype QM GH2115) — **a**, colony; **b**, relaxed zooid with wide open atrial aperture. Scales: a, 2cm; **b**, 0.5mm.

is particularly long, extending into the centre of the head and down into the stalk.

One to 3 shallow to pointed, fleshy atrial lips are produced from the body wall just anterior to the atrial sphincters. The atrial aperture is open for about the middle two-thirds of the length of the thorax. No dorsal papilla was seen, although its presence could have been obscured by the wide open atrial aperture. About 10 rows of 10 long narrow stigmata are in the branchial sac. The stomach is smooth, and quadrate in section. Gonads were not observed in the examined material.

REMARKS

The organisation of the cloacal systems, with zooids in double rows, one row along each side of the narrow canals that surround the raised circular areas on the surface, resembles some *Aplidium* species (e.g. *A. tabascum* n.sp., *A. cellis* Monniot, 1987) from the tropical western Pacific. The present species is stalked, unlike the sessile sheets of these *Aplidium* spp. It is further distinguished by the sand which is crowded throughout the test.

Synoicum citrum n. sp.

(Fig. 46. Plate 8f)

DISTRIBUTION

TYPE LOCALITY: Victoria (Wilson's Promontory, Waterloo Bay, 25m vertical face, coll. J.E. Watson 26.1.78, holotype QM GH 5104). Tasmania (Satellite I. off Bruny I., d'Entrecasteaux Channel, 6m vertical face, coll. J.E. Watson 18.2.72, paratype MV F59369).

FURTHER RECORDS: South Australia (Port MacDonnell, QM5104 GH2294). Tasmania (Satellite I. off Bruny I., MV F59366).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are rounded, cushion-shaped, sessile and fixed by a small part of the basal surface. The test is gelatinous and translucent. The zooids open onto the upper surface. The known colonies are squashed, often mutilated. Zooids are crowded. They may be arranged in circular systems but these are obscure. The colonies are up to 2cm high and up to 3cm in maximum dimension. Zooids are said to have been bright yellow in a yellow matrix when alive.

INTERNAL STRUCTURE: Contracted zooids are nearly 5mm long, the fleshy thorax and abdomen together being about half of the total length. The thorax is especially large, with 12 to 20 longitudinal muscle bands that extend the length of the zooids. Conspicuous sphincters are present around the base of the branchial siphon. The branchial lobes are relatively low and rounded. The atrial lip, continuous with the anterior rim of the aperture, is fleshy and usually bilabiate, with each lobe long and pointed.

Seven or 8 rows of about 20 stigmata are in the branchial sac. The stomach is large almost spherical and smooth walled. Long double rows of male follicles are in the relatively short posterior abdomen.

REMARKS

The species is distinguished by its fleshy, ses-

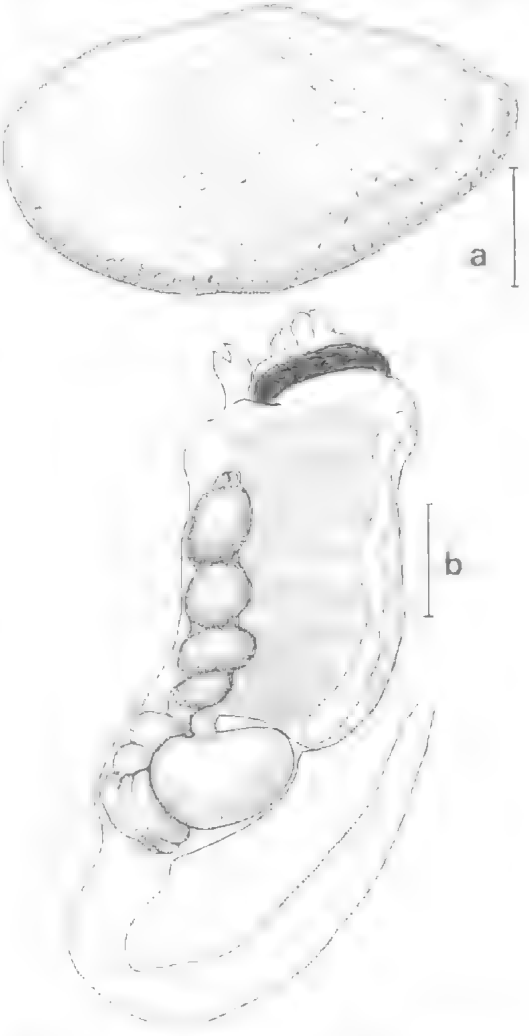


FIG. 46: *Synoicum citrum* n.sp. (holotype QM GH5014) — **a**, colony; **b**, zooid. Scales: **a**, 1cm; **b**, 0.5mm.

sile, cushion-shaped, translucent, greenish-yellow colony, which lacks sand either on the outside or embedded in the test. Zooids are relatively large for this genus, but they have fewer rows of stigmata than most other species. *Synoicum prunum*, which has a range on the mid- to north-eastern Australian coast, also has firm gelatinous colonies but the known ones are larger than the present species, and the zooids are smaller, with narrow thoraces.

Many species of this genus known *in situ* have red colonies, often with red zooids, rather than the yellowish colour of the present one.

Synoicum concavitum n.sp.
(Fig. 47. Plate 8g)

Distribution

Type Locality: Western Australia (Eclipse I. SW entrance to King George Sound, rocky granitic reef, large boulders, coll. AIMS Bioactivity Group 26.3.89, holotype QM GH5465).

Further Records: None.

Description

External Appearance: The colony is an irregular cushion about 6cm in maximum dimension and up to 3cm thick. The test is firm, gelatinous, and slightly translucent. It is orange in life, but brown in preservative. Sand is on the under surface and sides of the colony, but the upper surface is naked and even. Sand is absent from the upper (thoracic) layer of test but is sparsely but evenly scattered through the lower part of the colony. The upper surface of the colony is depressed over the circular cloacal cavities. Branchial apertures of the zooids (about 12) in each system open around the perimeter of each depression. The ventral lobes of each branchial aperture extend horizontally directing the openings toward the large, protuberant cloacal aperture that rises from the centre of each depression.

Internal Structure: Zooids are brown in preservative. They are large, the thorax and abdomen of about equal length, and together about 3mm long even when contracted. The branchial siphon is moderately long, with 6 pointed lobes, the ventral ones usually longer than the dorsal ones (see above). The atrial siphon, also protruding, has 3 small pointed lobes around its posterior rim, and a long strap-like tongue from the upper rim of the opening. This tongue has a straight tip with small denticulations on it.

A large number of fine longitudinal muscle bands are on the thorax, making an almost con-

FIG. 47: *Synoicum concavitum* n.sp. (holotype QM GH5465) — **a**, part of colony from above; **b**, zooid. Scales: **a**, 1cm; **b**, 0.5mm.

tinuous coat. These extend in a band along the ventrum of the abdomen and along both sides of the posterior abdomen. Transverse muscles are in the transverse vessels. The pharynx is wide, with 15 rows of stigmata with up to 18 per row. The gut loop is moderately long, with the large, voluminous stomach about halfway down the abdomen. The stomach wall is smooth, although in these specimens it often is collapsed into irregular or horizontal folds. The duodenum and proximal part of the mid-intestine are long, and almost continuous. There is an oval posterior stomach at the base descending limb of the gut loop. The posterior abdomen is relatively short and tapering in these zooids. Gonads are not developed.

REMARKS

The species resembles *Synoicum tropicum* in the form of its systems. It is distinguished principally by the larger branchial sac of the present species.

Synoicum durum n.sp.

(Fig. 48)

Synoicum kuranui: Kott, 1963, p.88.

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I., low tide, coll. R. Carson June 1961, holotype AM U3990).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: Small wedge-shaped to inverted conical lobes, reducing in diameter toward the base, to 1cm high and 0.8cm diameter across the flat upper surface. Sand is in a surface layer around the sides of the lobes, and on the upper surface and internal test between the systems. Two to 4 circular systems, each of up to 10 zooids, open on the flat top of each of the lobes, and sand is absent from the surface above these systems. Each system has a central sessile common cloaca. At first the test is yellowish in preservative and zooids are red, but subsequently all colour is lost.

INTERNAL STRUCTURE: The zooids are small, up to 2mm long, of which the thorax and abdomen is about half. Ten longitudinal muscles are on each side of the thorax, and these extend in a wide band along each side of the abdomen and posterior abdomen. The branchial siphon is short and

FIG. 48: *Synoicum durum* n.sp. (holotype QM U3990) — a, colony; b, zooid; c, larva. Scales: a, 2mm; b, 0.5mm; c, 0.1mm.

there are 6 distinct lobes. The rounded atrial lip is produced from the upper rim of the atrial siphon. A distinct median dorsal papilla is behind the atrial siphon. There are about 10 rows of 15 stigmata. The oesophagus curves ventrally to enter the large, smooth walled stomach. A gonad-free part of the posterior abdomen is behind the abdomen, but the posterior two-thirds of the abdomen is occupied by the irregular double row of large male follicles with the small ovary anterior to them.

Up to 2 embryos are in the posterior half of the atrial cavity. Tailed larvae are amongst the smaller viviparous larvae known, having a trunk only about 0.4mm long. They have median and lateral ampullae, and an otolith and ocellus. The tail is wound about three quarters of the way around the trunk.

REMARKS

These colonies do slightly resemble those of the New Zealand *S. kuranui* Brewin, 1950 which, however, has shallow circular swellings on the stomach wall, giving it a slightly mulberry-like appearance. The species also resembles *S. suarenum* n. sp., having an atrial lip from the upper border of the opening, a smooth stomach, a dorsal papilla, embryos being incubated in the posterior half of the atrial cavity, and circular systems opening on the flat upper surface of the colony lobes. There is, however, a difference in the relative size of the zooids and larvae in these two species, viz. 2mm and 0.4mm respectively in *S. durum*, and up to 1cm and 0.6mm in *S. suarenum* n. sp.

Synoicum erectum n. sp.
(Fig. 49)

DISTRIBUTION

TYPE LOCALITY: Victoria (south of Warnambool, 250 – 350m, from shark lines, coll. V. Johnstone 14.5.69, holotype MV F59367). South Australia (SSW Eucla 33°17'S 128°12'E, 18m, CSIRO RV *Soela* 13.1.89, paratype SAM E2554).

FURTHER RECORD: Victoria (27mls east of Gabo I., SAM E2555).

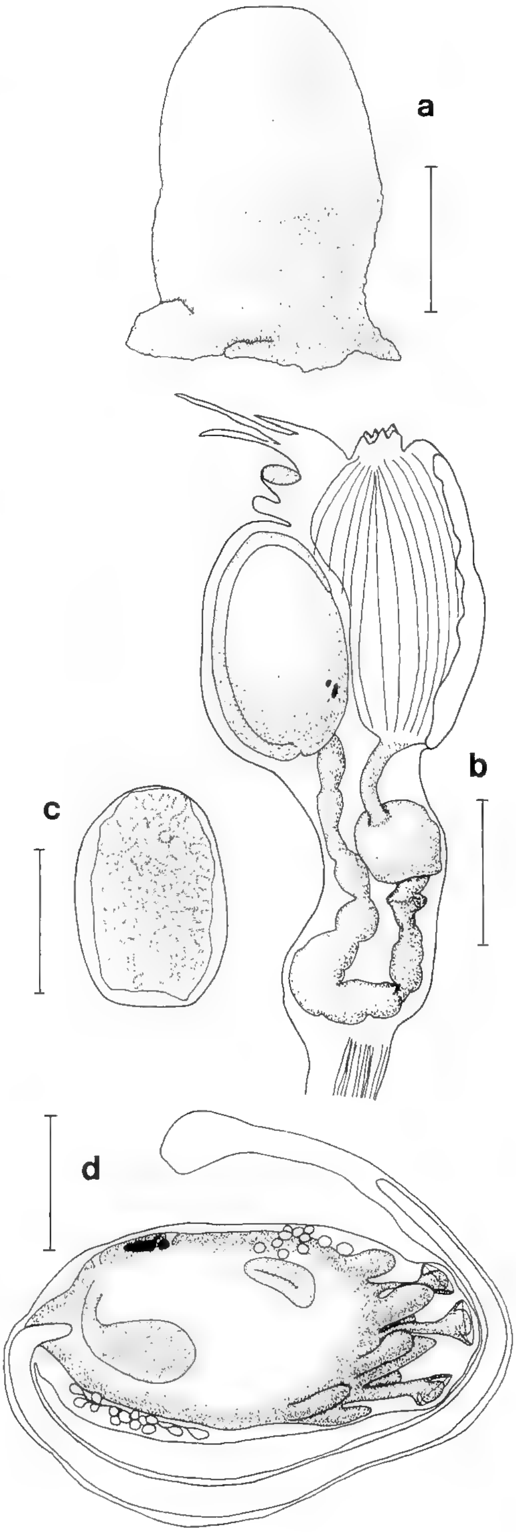


FIG. 49: *Synoicum erectum* n.sp. — **a**, colony outline (paratype SAM E2554); **b**, thorax and abdomen with embryo in atrial cavity (holotype MV F59367); **c**, internal wall of stomach (paratype SAM E2555); **d**, larva (holotype MV F59367). Scales: **a**, 1cm; **b**, **c**, 0.5mm; **d**, 0.2mm.

DESCRIPTION

EXTERNAL APPEARANCE: The holotype colony has been mutilated, but it appears to have been an upright cone, 3cm high and about 3cm in diameter across the flat base. The colony is covered with a thin layer of sand. Some root-like processes spread out around the base. Internally the test is very soft with only sparse embedded sand grains. Zooids, opening to the surface around the upper part of the cone, are crowded, possibly in circular systems. There is no trace of pigmentation in these zooids.

The Gabo I. and the paratype colonies are very similar to one another, smaller (to 2.5cm high) than the holotype, and retaining red colour in the zooids which are seen through the relatively light encrustation of sand on the upper half of the colony. The lower half of each of these colonies is slightly reduced in diameter and is more thickly encrusted with sand, forming a short, thick stalk. The base of the stalk is packed with embedded sand, but there is very little sand embedded in the rest of the soft internal test. Crowded circular systems of 8 to 9 zooids can be seen around the top half of each colony.

INTERNAL STRUCTURE: Zooids are robust, but when contracted the thorax and abdomen are less than 1mm long. The posterior abdomen is long. Branchial lobes are well defined, but relatively shallow. The atrial lip extends out from the anterior border of the aperture, long and fleshy, sometimes bifid at the tip, sometimes undivided and pointed, or with a fringe of up to 10 points on the straight edged tip. There is a small median dorsal papilla behind the atrial aperture. Longitudinal muscles (about 12) from the thorax extend back along each side of the zooid to its posterior extremity.

The pharynx has about 12 rows of about 8 stigmata, but these were difficult to count, as all the colonies have contracted zooids. The gut loop is almost the same length as the thorax in most of the examined zooids, but, as the thoraces are invariably more contracted than the abdomen, this ratio probably varies with the condition of the zooids.

The oesophagus is long, narrow and curves to enter the stomach. The stomach wall usually has glandular thickenings of the inner wall. However sometimes (SAM E2555) there are mulberry-like external swellings on some parts of the stomach. The distal part of the descending limb of the gut loop has the usual long duodenum, expanded mid-intestine, posterior stomach, and narrow intestine opening into the rectum at the proximal end of the ascending limb of the loop. The posterior abdomen is long and cylindrical. Only the ovary could be clearly identified, halfway down the posterior abdomen of the Gabo I. specimen (MV F2555).

Up to 2 embryos are incubated in the atrial cavity of specimens collected in May (MV F59637) and October (SAM E2555). They were not present in the paratype colony collected in January (SAM E5554). The larval trunk is about 0.7mm long, and the tail is wound about three quarters of the way around it. There are median and lateral ampullae, and patches of postero-ventral and antero-dorsal epidermal vesicles.

REMARKS

The zooids are small (though not as small as those of *S. prunum*), but the larval trunk is longer than usual for *Synoicum* spp. *Synoicum sacculum* n. sp. has a similar temperate range to the present species; and it also has the atrial lip from the upper rim of the aperture, a mulberry-like stomach, narrow thoraces, and red zooids and colonies. However, *S. sacculum* n. sp. has a short posterior abdomen with bunched male follicles, a brood pouch constricted off from the thorax, and larvae with a shorter trunk than those of the present species. Also, *S. sacculum* has a multilobed colony with a naked surface that is produced into rounded protrusions over each system of zooids (unlike the present species which has a fine encrustation of sand and a smooth external surface).

The sandy lobes of this species resemble those of *S. partitionis* Monniot, 1987, from New Caledonia. The latter species is distinguished by its wide pharynx with 18 rows of stigmata as well as by its tropical occurrence.

Synoicum galei n. sp.

Macroclinum hypurgon: Michaelsen, 1930, p.535 f. galei.

Not *Synoicum hypurgon*: Kott, 1963, p.86 (> *Aplidium* spp.); 1976, p.62 (< *Polyclinum fungosum*).

DISTRIBUTION

TYPE LOCALITY: Western Australia (Fremantle — Michaelsen 1930).

FUTHER RECORDS: None.

DESCRIPTION (after Michaelsen 1930)

EXTERNAL APPEARANCE: The colonies are irregular, flat topped cushions or sheets, with broad ridges and furrows on the surface, up to 5cm in maximum dimension and 1.8cm high. The test is soft, but with a tough, thin outer cuticle. Zooids (from 4 to 11) are arranged in circular to oval systems. The cloacal apertures are sessile, and depressed into a groove. Sparse sand is present on the margin, but the upper surface of the colony is naked.

INTERNAL STRUCTURE: The zooids are about 1cm long, of which about 8mm is posterior abdomen. The thorax is longer than the abdomen. The branchial lobes are inconspicuous. The atrial siphon has the tongue extending from the upper rim of the aperture. Two loose bands of muscle extend along each side of the zooid to its posterior end. The stomach is smooth-walled. A brood pouch is constricted off from the postero-dorsal corner of the thorax. It always contains 2 embryos.

REMARKS

Despite the difference in colonies and the absence of the faecal pellets that occur in the type specimen from New Zealand, Michaelsen (1930) assigned the Western Australian specimen to *S. hypurgon* on the basis of the similarities in the zooids. However there are differences between the New Zealand and Fremantle colonies, and they are not conspecific. A new species is erected to accommodate the Fremantle specimens referred to *S. hypurgon* f. galei: Michaelsen, 1930. The species is distinguished from others which have the atrial lip associated directly with the rim of the aperture by the smooth stomach wall, absence of a dorsal papilla, and the flat-topped irregular colony with surface ridges and furrows.

Kott (1963), interpreting the dark oval bodies embedded in the test as faecal pellets, assigned colonies — one each from Heron I. and Rottnest I. — to the present species. Re-examination of these specimens (AM Y1382 U3991) has shown them to be *Aplidium lobatum*.

Embryos are incubated in a brood pouch (as they do in the present species) in *S. sacculum* n. sp., which has lobed colonies, a dorsal papilla and a mulberry-like stomach wall distinguishing it.

The broad ridges and furrows on the surface are reminiscent of those in *Aplidium crateriferum* and *A. lobatum* n. sp. However the latter species has a distinctive zooids which more closely resemble those of *S. papilliferum* (see below) than of the present species.

Synoicum intercedens (Sluiter, 1909)
(Fig. 50)

Morchellium intercedens Sluiter, 1909, p.108.
Synoicum intercedens: Monniot and Monniot, 1987, p.81.
?*Synoicum suesanum* Michaelsen, 1919, p.27.

DISTRIBUTION

NEW RECORDS: Queensland (Capricorn Group, QM GH5084–5101 GH5105–7 GH5180 GH5182 GH5193 GH5253 GH5256 GH5282 GH5499 GH5566 GH5571–2 GH5591–2 GH5608 GH5672).

PREVIOUSLY RECORDED: Indonesia (Sluiter 1909), Moorea, Tahiti (Monniot and Monniot 1987).

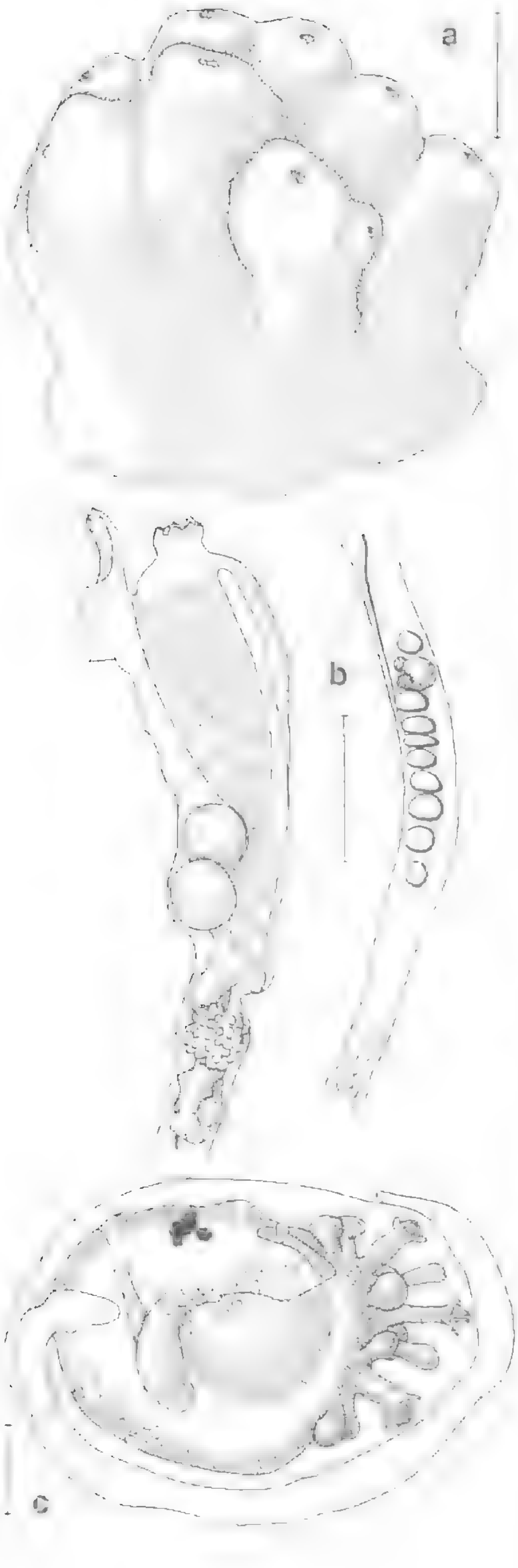
Although at present there are no records from Australian locations, other than those from the southern end of the Great Barrier Reef, it is probable that the species will be found generally around the northern part of the continent and in the western Pacific.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies form cushions up to 3cm long with the upper surface divided into low, rounded swellings to domes from 3 to 10mm in diameter, projecting up to 5mm from the solid sandy basal common test and outer margin of the colony. Each of these protuberances has a large central sessile common cloacal aperture. One specimen has a few randomly distributed test swellings each containing a single system of juvenile zooids on the surface of a mass of firm gelatinous basal test (QM GH5090) and probably is a regenerating colony. Sometimes only a shallow crease is in the surface test delineating the circular area that is homologous with a rounded projection in other specimens. Sand sometimes lies in the crease between the surface swellings, and is present in the basal test. Up to 10 zooids are in each system.

The test is particularly opaque and firm in consistency in larger colonies, but is transparent and soft but firm in small ones. The living colonies are a chestnut or claret colour, or 'claret brown', or 'chocolate brown', or 'aster purple' (Ridgeway 1886), with 'madder brown' cells throughout the test. Some small colonies, when living, are described as 'red cherries projecting from sandy base and margin'. Zooids are 'burnt carmine' or 'aster purple' (Ridgeway 1886), or brownish-black. Basally colonies are yellowish, probably owing to the embedded sand showing through the brown test. In preservative the colonies are light yellowish, cloudy and translucent and the zooids are reddish-brown.

INTERNAL STRUCTURE: Zooids are up to 1cm long. Six rounded lobes surround the branchial aperture. The atrial siphon is relatively large, its



upper border is produced into a long lip with 3 small lobes on its tip. Sometimes the atrial lip curves around to form a tube with its lumen continuous with that of the siphon itself. A small papilla projects from the dorso-median line near the base of the posterior border of the atrial siphon. Eight fine longitudinal and oblique muscles are on the thorax and these extend along each side of the abdomen and posterior abdomen in a narrow band. There are 14 to 17 rows of 12 to 14 stigmata. The oesophagus is curved, entering the relatively short dorsal border of the stomach. The stomach wall is covered with rounded prominences (mulberry-like). The duodenal area is wide, the mid-intestine inflated and an oval posterior stomach is in the bend of the gut loop. The anal opening is about one-third of the distance up the thorax.

Gonads are in the middle third of the posterior abdomen, the small ovary behind the most anterior of the testis follicles, which extend back in a single series, or are bunched together when muscles contact.

Two embryos (but not tailed larvae) are in the posterior part of the atrial cavity of specimens collected in November (QM GH5087). Specimens collected in April and May have 3 embryos including a tailed larvae lined up in the atrial cavity (QM GH5088 GH5091). The larval trunk is about 0.50mm long. It has median and lateral ampullae alternating with the adhesive organs. Epidermal vesicles branch off strands that extend along each side of the mid-dorsal line as in *Polyclinum*, but ventral vesicles appear to be median. The lateral ampullae sometimes appear to have lost their connection with the epidermis.

REMARKS

The species is distinguished from others by its surface swellings each containing a circular system, and its mulberry-like stomach. The surface swellings are very variable and they are not always conspicuous. Thus the fact that Sluiter (1909) did not observe them may not be significant. Other characters of the newly recorded material conform with the type specimen, and the Australian and Indonesian specimens appear to be conspecific. *Synoicum intercedens*: Monniot and Monniot, 1987, has fewer rows of stigmata than either the type or the present Australian specimens, and the number of stigmata per row

FIG. 50: *Synoicum intercedens* — **a**, colony (QM GH5087); **b**, zooid (QM GH5087); **c**, larva (QM GH5107). Scales: a, 5mm; b, 1mm; c, 0.1mm.

has not been reported. Otherwise these French Polynesian specimens appear to conform with the type material. *Synoicum suesanum* Michaelsen, 1919 has similar colonies with circular systems, and 13 to 15 rows of stigmata with 10 to 12 per row. Michaelsen (1919) distinguished the species by the depression separating the systems. However that depression sometimes occurs in *S. intercedens*. There is no known character separating *S. suesanum* from the present one.

The new Australian temperate species *Synoicum sacculum* n. sp. has a mulberry-like stomach, but its systems are not separated from one another by grooves or depressions, and a single embryo is incubated in a stalked brood pouch. The tropical *Synoicum suarenum* n. sp. which is sympatric with *S. intercedens* and is the same dark colour has, like *S. sacculum* n.sp., many circular systems in each of its wedge-shaped lobes, and lacks grooves or subdivisions which, in the present species, tend to isolate the systems from one another. *Synoicium suarenum* n.sp. is further distinguished by its smooth-walled stomach and larger larval trunk.

Synoicum macroglossum (Hartmeyer, 1919) and *S. tropicum* (Sluiter, 1909) are also distinguished from the present species by their smooth-walled stomachs.

Synoicum longistriatum n.sp.

(Fig. 51)

DISTRIBUTION

TYPE LOCALITY: Western Australia (off Cockburn Sound, 32°S 155°08'E CSIRO Cruise 144/DM4/63, 110m, coll. L. Thomas 28.8.63, holotype QM GH5583.
FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony is an upright, almost cylindrical lobe, slightly expanded terminally. It is 7cm high and about 3cm in diameter. Basally there are sandy root-like projections of the test. The lower third of the lobe, comprising the lower part of the stalk, is transversely wrinkled, and covered with a layer of sand. The middle third has a layer of finer sand and is not wrinkled. The naked upper third has openings of the crowded zooids. These, seen through the transparent test, appear to be arranged in crowded longitudinal rows converging to cloacal apertures on the terminal free end. The crowded zooids are perpendicular at the surface, but posteriorly they curve down into the stalk of the colony.

INTERNAL STRUCTURE: In this colony a large quantity of sand fills the pharynx of most of the zooids, obscuring its structure. The branchial apertures have 6 lobes, and atrial apertures are large openings with the upper rim extended out to form a tongue. About 12 fine longitudinal muscles are in the thoracic body wall. These extend along the length of the abdomen and posterior abdomen. Stigmata are in 16 rows of about 16. The stomach is large and voluminous, without longitudinal folds, but sometimes collapsing into irregular or horizontal ones. Double rows of male follicles are in part of the long posterior abdomen of some of the zooids, although the ovary was not detected.

FIG. 51: *Synoicum longistriatum* n.sp. (holotype QM GH5583) — colony. Scale: 1cm.

REMARKS

The colony is distinctive and unique in this genus, superficially resembling that of *Distaplia australiensis* (see Kott 1990). However, the zooids are characteristic of the Polyclinidae. The *Aplidium* species with longitudinal double-row systems converging to the top of the head, viz. *A. australiense*, *A. geminatum* n.sp., *A. inflorescens* n.sp. and *A. paralineatum* n.sp. are distinguished by their numerous stomach folds. The shape of the colony and its sandy surface resembles *S. atopogaster*, but the form of the systems differ.

It is unfortunate that this unique specimen is not well preserved. Nevertheless as it is a unique colony form and unlikely to be confused with other species in this genus, it is considered appropriate for it to be designated holotype. It is probable that damage was caused to the specimen by the way it was collected (beam trawl), rather than its treatment after collection.

Synoicum macroglossum (Hartmeyer, 1919)
(Fig. 52. Plate 9a)

Macroclinum macroglossum Hartmeyer, 1919, p.126.

DISTRIBUTION

NEW RECORDS: Queensland (Heron I., QM GH5055; Mackay, QM GH5421).

PREVIOUSLY RECORDED: Western Australia (Cape Jaubert — Hartmeyer 1919).

DESCRIPTION

EXTERNAL APPEARANCE: One colony (QM GH5055) is a large flat-topped cushion 6cm in diameter, 2cm high, with rounded margins and a vertical border. Sand is present on the base and around the border, but not on the upper surface. Sparse sand is present internally in the lower half of the colony, but it becomes even more sparse toward the centre, as if it was gradually moving in from the sandy outer border. The colony from

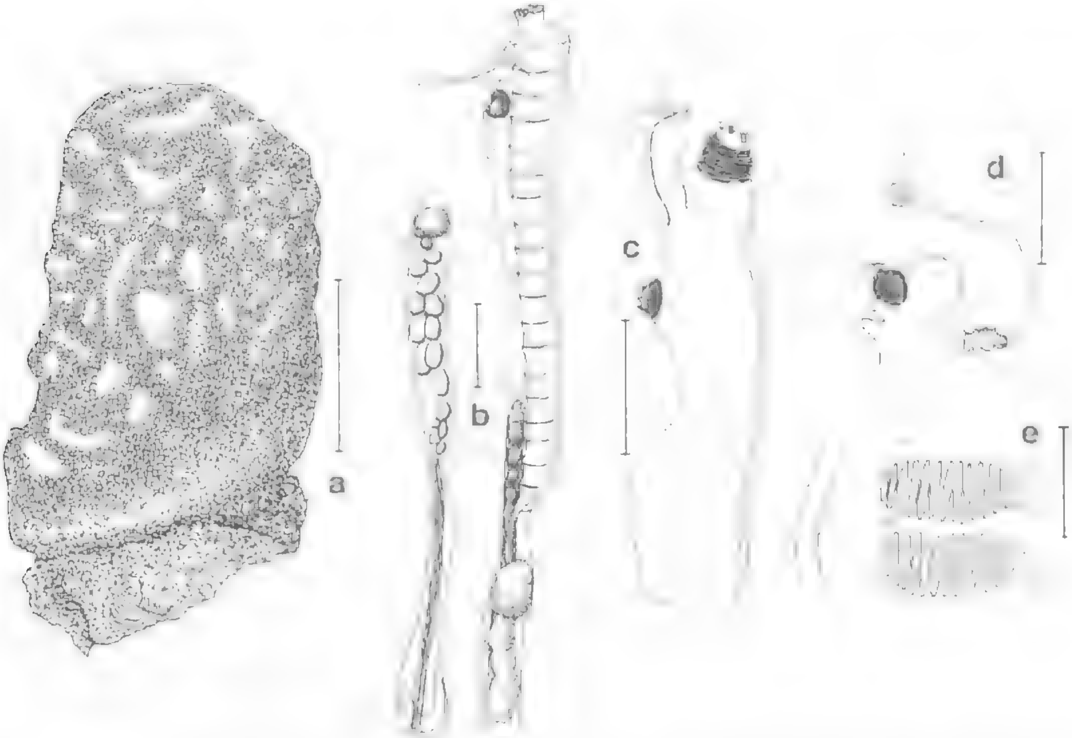


FIG. 52: *Synoicum macroglossum* — a, colony (QM GH5421); b, whole zooid severed between thorax and posterior abdomen (QM GH5055); c, d, thorax and atrial aperture, with atrial lip shown in different positions (QM GH5421 GH5055); e, portion of right branchial wall (QM GH5055). Scales: a, 2cm; b, c, 1mm; d, e, 0.5mm.

Mackay is an upright cone, 6cm high, with sand around the base and sparsely embedded through the test.

The test is translucent and gelatinous but firm and rigid in both specimens. Circular to long, low swellings, with shallow depressions between them are on the upper surface. The small and inconspicuous branchial openings can be seen around the periphery of the swellings, and in the depressions between them. Large cloacal apertures occur in the depressions, especially where 2 or more converge. These apertures either are sessile, or they protrude on surface swellings created by thickened test over the circular cloacal cavities that are formed at the junctions of the cloacal canals.

Internally the posterior ends of the zooids criss-cross one another. The test is pale yellowish-brown to greenish-yellow in preservative, and the preservative itself is stained yellow-orange. One living specimen (QM GH5055) was, 'mummy brown' internally and 'seal brown' (Ridgeway 1886) on the surface. The other (from Mackay) is said to have been black when living.

INTERNAL STRUCTURE: Zooids are long (to 1.5cm) and narrow. The thorax is about one-third of the length of the zooid, and the abdomen and about half of the gonad bearing part of the posterior abdomen together comprise another third. Eight longitudinal muscles extend the length of the thorax, and are reduced to 2 or 3 each side of the abdomen and posterior abdomen. The branchial aperture is on a trumpet-shaped siphon that appears to be fixed in the firm surface layer of test. A sphincter is around the base of the siphon. The long, muscular atrial lip has a dentate tip, and is difficult to remove from the test where it lies over the top of the cloacal cavity. It arises from the body wall opposite the first row of stigmata, anterior to the muscular atrial aperture which lies opposite the third row of stigmata. A sphincter is also present around the atrial aperture. When contracted, the atrial lip curves over the aperture. A papilla projects from the body wall just behind the atrial siphon opposite the fifth row of stigmata. Nineteen rows of 12 to 14 fairly long stigmata are in the branchial sac, although the number reduces posteriorly. A wide strip of unperforated test is each side of the endostyle. There is a minute papilla on each transverse vessel at about the level of the third ventral stigma on each side of the body. A row of robust dorsal languets are to the left of the dorsal mid-line.

The gut loop is vertical and narrow — the oesophagus curves ventrally to enter the bilaterally symmetrical, smooth-walled stomach. The duodenum is large, the mid-intestine inflated and a large oval posterior stomach is in the bend of the gut loop. The bilabiate anus opens at the level of the fourth row of stigmata from the posterior end of the thorax.

A very short gonad-free part of the posterior abdomen is behind the gut loop. A small ovary is anterior to the oval testis follicles which are in 2 longitudinal series, alternating with one another. Sometimes (but not always) an extent of the posterior end of the posterior abdomen is free of gonads. A V-shaped heart is in the posterior extremity of the posterior abdomen. The newly recorded specimens collected in November, have well-developed ovaries, but no embryos were found.

REMARKS

The species is distinguished by its protruding atrial siphon, separate atrial lip, narrow zooid and robust cushion-shaped colony. The type specimen differs from the present one in the presence of a layer of sand on the upper surfaces as well as around the margin; and in the presence of up to 14 rows of stigmata rather than the 18 of the present eastern Australian colonies. Hartmeyer (1919) did not observe the small branchial papilla toward the ventral end of each transverse vessel, but these are inconspicuous and obscured unless the thorax is completely relaxed.

The dorsal papilla and separate atrial lip are like *S. papilliferum* (Michaelsen, 1930) and the zooids also have similar numbers of stigmata. However, although Michaelsen believed the dorsal papilla was unique to his species (see below), it occurs in both *Polyclinum* and *Synoicum*. Although the conspicuous cloacal apertures and long curving double row systems of the present tropical species may be different from *S. papilliferum* (in which Michaelsen did not find any cloacal apertures and could not determine the form of the systems), at present the only character definitely known to separate the species is the presence of sand adhering to the external test of the temperate *S. papilliferum*. Species of *Aplidium* with similar zooids (e.g. *A. lobatum*, *A. cratiferum*) lack a median dorsal papilla, and have different systems from those of the present species. *Synoicum chrysanthemum* has similar systems, but the colonies are different.

Synoicum obscurum n.sp.
(Fig. 53)

DISTRIBUTION

TYPE LOCALITY: Victoria (Bass Strait, reef off Ninety-mile Beach, 90km SW of Lakes Entrance, coll. J. Watson R3E/36 1977, holotype QM G12726, paratype QM G12727).

FURTHER RECORD: NSW (Arrawarra, QM GH5589).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are thick mats with sand crowded throughout making them hard and brittle. The mats are made up of sandy cone-shaped, upright lobes which adhere closely to one another. The terminal free ends of these lobes project from the upper surface of the colony as rounded swellings, each of which accommodates a circular system of up to 12 zooids. Zooids are tightly enclosed in the sand and hard to remove from it although the thin channels that accommodate the zooids are rigid. The zooids surround a shallow common cloacal cavity (in the terminal end of each lobe) which opens through a common cloacal aperture in the centre. Branchial apertures are inside, and protected by, the rounded margin of the terminal end of each lobe. The cloacal cavities beneath the upper surface of colony confer a loose appearance to the surface layer of brittle sand-filled test.

INTERNAL STRUCTURE: The zooids are relatively muscular, with about 20 longitudinal bands on the thorax. These muscles extend posteriorly to form a band along each side of the mid-ventral line. Zooids are relatively long, even when contracted the thorax, abdomen and gonad-bearing anterior part of the posterior abdomen are about 6mm long, while the long posterior part of the posterior abdomen, without gonads in it, extends into the sandy base of the colony.

The 6 branchial lobes are rounded. An atrial siphon protrudes from the dorsal surface, and a flat atrial tongue with a tridentate tip is produced out from the upper rim of the opening. The lower rim of the atrial opening is divided into 3 small lobes. A pointed median dorsal papilla is at the base of the atrial siphon. About 20 rows of up to 20 stigmata appear to be present, although the pharynx is too contracted for accurate counts. Irregular internal glandular areolations of the stomach wall are present, especially on the mesial side of the stomach (against the intestine). A few

FIG. 53: *Synoicum obscurum* n.sp. (holotype QM G12726) — a, colony; b, zooid; c, larva, tail removed. Scales: a, 5mm; b, 1mm; c, 0.1mm.

of these shallow glandular areas sometimes form irregular longitudinal ridges which resemble the longitudinal folds of *Aplidium*. The duodenal, mid-intestinal and posterior stomach regions are characteristic for the genus.

In the type material, a large ovum is present behind the gut loop, anterior to a short double longitudinal series (about 8 per series) of testis follicles. The posterior abdomen continues posterior to the testis follicles, which protrude dorsally from it as a result of the contraction of the ventral muscles. Four or 5 embryos are crowded in the atrial cavity.

The larval trunk is 0.6mm long. The anterior end is obscured by numerous narrow ectodermal ampullae. There are 3 median adhesive organs, and an ocellus and otolith are in the cerebral vesicle.

REMARKS

A similar colony form is found in many species of *Aplidium* (e.g. *A. bacculum* n.sp., *A. filiforme* n.sp.). However, despite the presence of some longitudinal glandular ridges in the stomach wall, the present species is distinguished from the genus *Aplidium* by the shape of its zooids with a relatively primitive lobed atrial opening and the median dorsal papilla.

Synoicum durum has colonies consisting of sandy lobes, but the test above each system is naked, and each lobe has 2 or 3 systems.

Synoicum papilliferum (Michaelsen, 1930)

Macroclinum papilliferum Michaelsen, 1930, p.530.
Synoicum papilliferum: Millar, 1966, p.360. Not Kott, 1963, p.87 (< *Polyclinum tenuatum* n. sp.); 1972a, p.16; 1972b, p.177 (< *S. sacculum* n. sp.).

DISTRIBUTION

NEW RECORDS: None.

PREVIOUSLY RECORDED: Western Australia (Bunbury — Michaelsen 1930). Victoria (Nepean Peninsula — Millar 1966).

DESCRIPTION (after Michaelsen 1930)

EXTERNAL APPEARANCE: Colonies are cushion shaped or irregular sheets, up to 3cm diameter and 2.4cm high. Sometimes they are fixed by a narrowed base. The preserved colonies are transparent and yellowish, with an external layer of sand. Some sand is present internally but it is not as crowded as it is externally. The outer layer of test is tough. Cloacal cavities are present at the level of the atrial apertures, but cloacal apertures were not seen.

INTERNAL STRUCTURE: The zooids are vertically arranged in the test, with their posterior abdomina criss-crossing. The body wall is delicate with about 10 longitudinal muscle bands. The branchial siphon is conspicuous with a well developed sphincter at its base. The short atrial siphon, surrounded by a sphincter muscle, projects laterally from the body wall a short distance behind the atrial lip, which is narrow, but not long, and its tip is produced into 2 or 3 small papillae. A conspicuous median papilla projects from the body wall just behind the atrial siphon. Sixteen or 17 rows of 9 or 10 stigmata are in the long, narrow thorax. The oesophagus curves to enter the smooth stomach which is about halfway down the abdomen. A short gonad-free area is behind the abdomen, in front of the single row of male follicles that occupies the rest of the narrow posterior abdomen. When the posterior abdomen contracts, the male follicles are drawn up into a double row. Two short vascular stolons project from the end of the zooid.

REMARKS

Although Michaelsen thought the papilla was unique, it does occur in species of *Polyclinum* as well as in other *Synoicum* species. Nevertheless Kott (1963; 1972a,b) followed Michaelsen and assigned specimens of *S. sacculum* n. sp. and *Polyclinum tenuatum* to this species because, like *S. intercedens* and *S. suarenum* n.sp., they had a dorsal papilla. However, all these species are readily distinguished from the present one by having the atrial lip extending from the anterior rim of the aperture. *Synoicum macroglossum* has both a separate atrial lip and a dorsal papilla, but is distinguished from the present species by its conspicuous cloacal systems with raised cloacal apertures and the absence of an external layer of sand.

Although they differ in having a dorsal papilla, zooids of the present species, with their long, narrow thorax, long muscular branchial siphon, and atrial siphon separate from the atrial lip, resemble those of certain *Aplidium* spp. (e.g. *A. cratiferum*, *A. lobatum*, see below). The stomach folds of some of these *Aplidium* spp. are few and indistinct, but they all have distinct cloacal systems that distinguish them from the present species.

Millar (1966) records that his specimens of *S. papilliferum* had all the features of the type specimens, except the dorsal papilla. However, as there is no other known temperate species of *Synoicum* with similar characters, it is possible that the papilla was obscured in the material he examined.

Synoicum prunum (Herdman, 1899)
(Fig. 54. Plate 9b)

Psammaplidium prunum Herdman, 1899, p.84.
Synoicum prunum: Kott, 1963, p.87.

DISTRIBUTION

NEW RECORDS: New South Wales (Arrawarra, QM GH5394). Queensland (Bribie I., QM G2102; off Cape Tribulation, QM GH799).

PREVIOUSLY RECORDED: New South Wales (Port Jackson — AM G2101 Herdman 1899).

DESCRIPTION

EXTERNAL APPEARANCE: Like the holotype, the colony from Cape Tribulation is upright, oval, converging to a narrow sandy base produced into sandy roots. It is about 7cm high and 4cm in diameter. The specimen from Bribie I. is massive (14cm long and 9cm maximum diameter), lumpy, oval and football-shaped overall, but with deep creases dividing it into lobes. It has no obvious point of fixation.

The internal test always is firm and gelatinous with long tough fibres in it. It is almost opaque in preservative, while the outside layer is tough and hard with occasional patches of sand embedded. The long thread-like zooids are found withdrawn from the surface and criss-cross one another through the internal test. Their arrangement is obscure and the form of the systems was not determined.

INTERNAL STRUCTURE: Both newly recorded colonies are in a vegetative stage, many developing buds being present. Adult zooids are thin and thread-like. The very long, thin posterior abdomen is up to 2cm, being many times the length of the rest of the zooid (only about 2mm long when contracted). The contracted thoraces (QM GH799) are slightly longer than the abdomen, and when extended (QM G2102) they are at least twice the length of the abdomen. About 12 fine longitudinal muscles are on the thorax and these extend the length of the zooid in a band on each side. A single fleshy atrial lip continuous with the anterior rim of the atrial aperture has a straight tip with a single, small, pointed, median tooth. The branchial lobes are only shallow. A small dorsal papilla arising from the body wall behind the atrial aperture can be seen in the contracted zooids, but was not detected in the extended ones.

Fourteen dorsal languets were counted in the specimen from Cape Tribulation, indicating that there are 15 rows of stigmata, the same number as in the Bribie I. zooids. The thoraces are characteristically narrow and up to 8 stigmata per row were counted. The abdomen is small. The narrow and characteristically long oesophagus curves to enter the smooth-walled, small stomach which is halfway down the abdomen. The relatively long duodenum, inflated mid-intestine and posterior

FIG. 54: *Synoicum prunum* — a, colony outline (QM GH799); b, thorax and abdomen (QM GH799); c, larva (holotype AM G2101). Scales: a, 2cm; b, 0.2mm; c, 0.1mm.

stomach are distal to the stomach in the descending limb of the gut loop. Gonads are not developed in the newly recorded specimens. They are present in the long posterior abdomen of the type specimen, which also has 2 embryos in the atrial cavity.

The larval trunk is 0.55 to 0.65mm long. It has median and lateral ectodermal ampullae alternating with the 3 median adhesive organs, and patches of ectodermal vesicles antero-dorsally and postero-ventrally.

REMARKS

The large, almost naked colonies of this species are unique in the Australian fauna. There are some dark, greenish-black colonies of *Polyclinum vasculosum* recorded from Moreton Bay that reach the same size as the present species and superficially can be confused with it. *Synoicum citrum* has naked but sessile colonies, smaller than those of *S. prunum*, with larger zooids, fewer rows of stigmata and more stigmata per row.

Synoicum sacculum n. sp.

(Fig. 55, Plate 9c–e)

Synoicum papilliferum: Kott 1972a, p.16; 1972b, p.177; 1976, p.62.

DISTRIBUTION

TYPE LOCALITY: South Australia (Waldegrave I. in caves, 2m strong waves, coll. S. Shepherd 25.11.73, holotype SAM E2556, paratypes QM GH5044). Victoria (Flinders, jetty piles, 5m, coll. N. Coleman 18.6.77 AMPI 201, paratype QM G10163).

FURTHER RECORDS: South Australia (St. Vincent Gulf, West I. — Kott 1972a; Thorny Passage, SAM E2491). Tasmania (W. Granville Harbour, SAM E2552).

The Tasmanian specimen was taken from a depth of 425m.

DESCRIPTION

EXTERNAL APPEARANCE: The colony consists of crowded sessile, flat-topped to rounded lobes about 1cm in diameter rising from a sandy basal membrane or test mass. Sometimes the lower half of the lobe is constricted to form a thick stalk with some sand embedded. Sand is sparse internally in the upper part of each lobe. Sand is sometimes present on the upper surface, although the test above the zooid systems is usually left naked. The test is very soft internally. Zooids form circular systems of 2 to 3mm diameter with up to 10 zooids around a central cloacal aperture. The cloacal apertures are about 2cm apart, and are evenly spaced on the top of each lobe. In one small (1.7cm high) flat-topped colony (SAM E2491) the branchial openings are around the outer margins of surface depressions, and sessile cloacal apertures are in the centre. The test is raised in firm rounded ridges between the depressions.

In life the lobes are bright red, with bright red zooids. In preservative the test is yellowish and translucent, and the preservative is stained a yellowish-red.

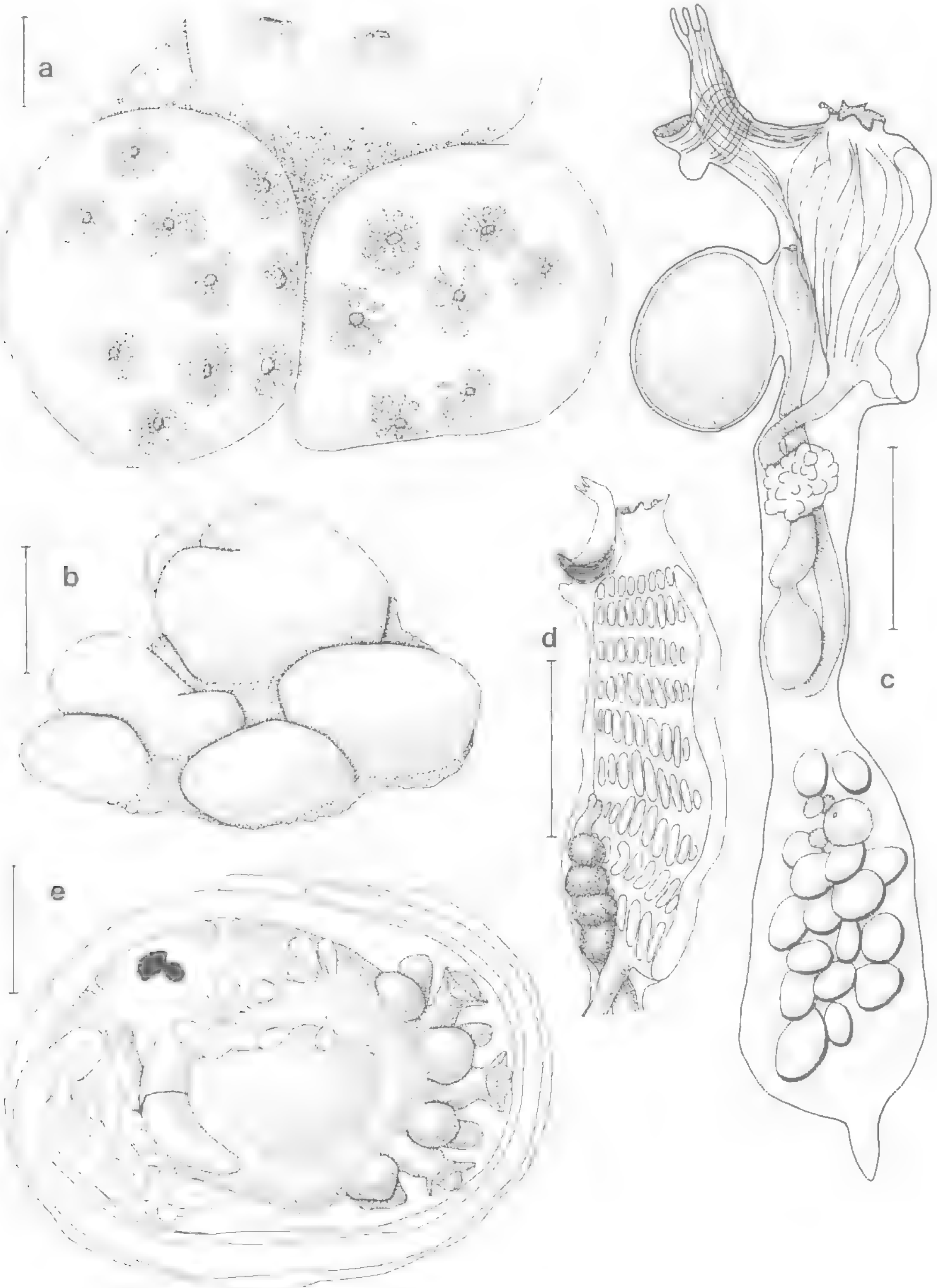
INTERNAL STRUCTURE: The zooids are 2 to 3mm long, with a short posterior abdomen. The thorax, abdomen and posterior abdomen are each about one third of the total length. There is a fine, short posterior vascular stolon. About 6 fine longitudinal and oblique muscles are on the thorax and these continue along the length of the zooid. Strong muscles extend from the branchial siphon along the atrial siphon (which often is long) onto the atrial lip which continues out from the anterior rim of the opening. The straight tip of the atrial lip has 3 narrow finger-like papillae evenly spaced along it. A papilla is in the mid-dorsal line behind the atrial aperture, sometimes carried out along the siphon when that is produced dorsally.

About 8 short stigmata are in 9 or 10 rows. The oesophagus is long and curved, and the stomach, about halfway down the abdomen has mulberry-like swellings in its wall. The duodenal area is long, the mid-intestine inflated, and an oval stomach is in the bend of the gut loop. The anal opening is opposite the third last row of stigmata. Colonies with large mature male follicles in the short posterior abdomen have about 20 bunched around the ovary (SAM E2491, QM GH5044). These colonies also have one to 3 embryos, up to the tailed larval stage, present in a brood pouch constricted off from the postero-dorsal corner of the thorax.

The larval trunk is almost spherical, 0.4mm in diameter, with otolith and ocellus, postero-ventral vesicles, and median and lateral ampullae anteriorly. The tail is wound about three quarters of the way around it.

REMARKS

The form and colour of the colonies is distinctive, as are the atrial lip from the anterior rim of the opening with finger-like papillae on its tip, the mulberry-like stomach, and the short posterior abdomen with bunched male follicles. The spherical larval trunk also is unusual. The brood pouch constricted off from the body wall is reminiscent of the one described for *Macroclinum*


a
b
c
d
e

hypurgon f. galei: Michaelsen, 1930 although the latter contains 2 embryos, its stomach is smooth, and its colonies are not lobed.

A dorsal papilla similar to the one in the present species, a short posterior abdomen and a similar atrial aperture occurs in the tropical species *S. suarenum* n. sp. However in the latter species the stomach is smooth, the larvae are not spherical and a brood pouch is not constricted off from the body wall.

Synoicum erectum, a species that overlaps the South Australian range of the present one, has sandy colonies consisting of single lobes rather than the many lobes of the present species. The zooids can be distinguished by their longer posterior abdomen, longer larval trunk and absence of a brood pouch.

Synoicum suarenum n. sp.
(Fig. 56, Plate 9f,g)

Synoicum kuranui: Kott, 1981, p.159.
Synoicum ?clavatum: Millar, 1975, p.255.

DISTRIBUTION

TYPE LOCALITY: Queensland (Capricorn Group, Wilson Reef, rubble zone, low tide, coll. P. Kott Jan 1977, holotype QM GH5080; Heron I., rubble zone, low tide, coll. P. Kott 4.11.86, paratype QM GH5070).

FURTHER RECORDS: Queensland (Capricorn Group, QM GH5066–9 GH5071–9 GH5081–3 GH5176 GH5178; Hardy Reef, QM GH5377; Lizard I., QM GH5277 GH5586); Fiji (Kott 1981). Indonesia (Millar 1975).

DESCRIPTION

EXTERNAL APPEARANCE: Flat-topped wedge- to top-shaped lobes, crowded together and narrowing to the base where they are joined by common basal test or by connecting strands to adjacent lobes. Sometimes the basal stalk portion of the lobe is branched and there are 2 heads from a basal common stalk. Colonies from Hardy Reef have long stalks (longer than those from Heron I.); narrowing toward the base. When alive and inflated the separate lobes that make up the colony appear confluent. The separate lobes are more apparent when it is removed from the substrate. The flat-topped lobes are up to 2.5cm high and up to 3.0cm in diameter at the top. In life colonies have a characteristic appearance resembling a pig's kidney both in colour and form. They are always opaque, shiny cherry coloured, crimson, and a dark maroon, plum colour, or 'pansy-' 'pomegranate-', 'Indian-' to 'aster-purple' (Ridgeway 1886). In preservative colonies become brownish-black, but the colour eventually is lost altogether. At first the preservative is stained orange-yellow, and clouds of brownish-black pigment cells are in the test. Circular cloacal systems of 4 to 8 zooids are evenly spaced over the surface. The central common cloacal apertures are in slight surface depressions about 2.5mm apart, and each system is about 2.5mm in diameter. The rim of each common cloacal aperture has small denticulations, into which the denticulations on the tip of the atrial lips of each zooid fit. The cloacal chambers are shallow and circular, being almost completely open to the exterior through the large cloacal aperture. The test is firm and gelatinous. Sand is absent from the surface, and from the internal test. Up to 15 systems occur in one lobe of the colony.

INTERNAL STRUCTURE: The zooids are less than 1cm in length, even when distended, and the thorax is half the total length of the zooid. The posterior abdomen is generally relatively short for a species of this genus. One or 2 short vascular appendages are at the posterior end of the posterior abdomen. The 6 branchial lobes are small and pointed. The atrial siphon is short but wide, with its upper border produced into a short, broad tongue with 3 to 5 short pointed teeth on its broad, straight outer edge. There is a median pointed papilla projecting out from the dorsal line behind the atrial aperture. About 12 fine longitudinal and oblique thoracic muscles in bands of moderate width extend along each side of the thorax and abdomen and are inserted into a projecting horn on each side of the posterior abdomen. Sixteen rows of 10 short, oval stigmata are in the branchial sac, each row reducing in length dorsally and ventrally. The oesophagus is curved and the dorsal border of the stomach between the oesophageal and duodenal openings is relatively short. The stomach wall is smooth externally, but internally it has some glandular areolations. The duodenal area is long, the mid-intestine inflated and an oval posterior stomach is in the bend of the gut loop. The bilabiate anus is about one-third of the distance up the thorax. The posterior abdomen is continuous with the abdomen and the gonads are in its posterior half, there being a narrow gonad-free neck of variable length behind the gut

FIG. 55: *Synoicum succulum* n.sp. — a, b, colonies (paratype QM G10163, a, showing circular systems; b, colony outline); c, zooid with embryo in brood pouch (SAM E2491); d, thorax (paratype QM G10163); e, larva (paratype SAM E5044). Scales: a, 2mm; b, 1cm; c, d, 0.5mm; e, 0.1mm.

loop. The ovary is mixed in with the anterior testis follicles, which are either in one or 2 irregular longitudinal series or, when muscles are contracted, bunched in the posterior end of the posterior abdomen, giving it a sac-like appearance. There are about 20 testis follicles.

Embryos (up to 3) are in the posterior end of the atrial cavity of zooids collected in January, April and May Tailed larvae have a trunk about 0.6mm long. Median and lateral ampullae are present. A postero-ventral cluster of epidermal vesicles is in the larval test each side of the mid-line, near the

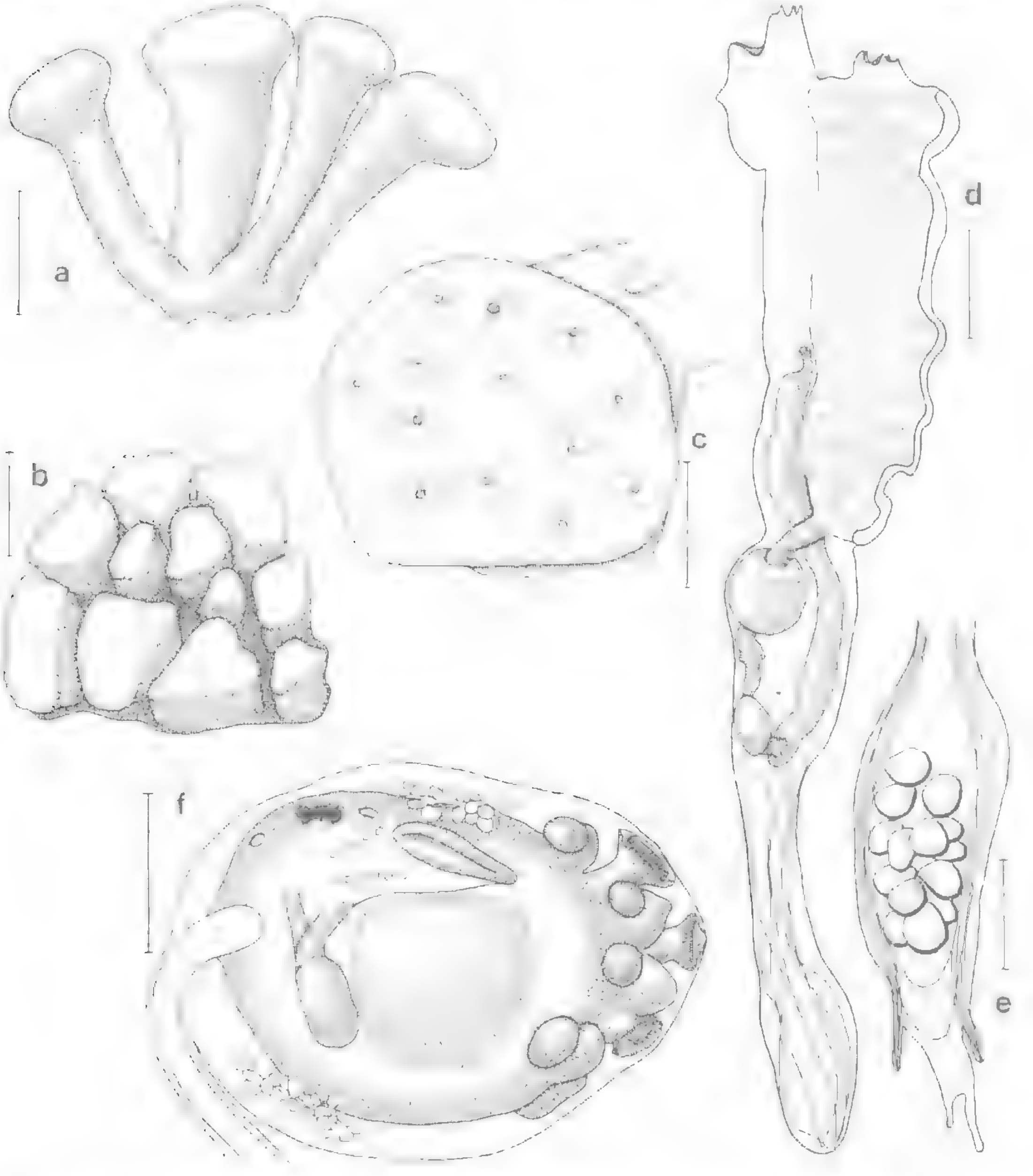


FIG. 56: *Synoicum suarenum* n.sp. — **a**, colony with longer lobes (QM GH5377); **b**, colony with short lobes (holotype QM GH5080); **c**, colony from above showing systems (QM GH5067); **d**, zooid (QM GH5067); **e**, posterior abdomen showing gonads bunched in posterior end (paratype QM GH5070); **f**, larva (QM GH5073). Scales: **a**, 1cm; **b**, 2cm; **c**, 5mm; **d**, **e**, 0.5mm; **f**, 0.2mm.

base of the tail. These separate from an epidermal strand that trails posteriorly through the test, from each side of the mid-line ventral to the adhesive organs. A similar strand of epidermis from which epidermal vesicles separate off into the dorsal test above the endostyle is on each side of the mid-dorsal line behind the adhesive organs. The tail winds about two-thirds of the distance around the trunk. The lateral ampullae separate from the rest of the larval ectoderm and become large and spherical.

REMARKS

In those colonies with male follicles clumped in the posterior end of the zooid, the anterior part of the posterior abdomen is relatively narrow, resembling the neck of a polyclinid posterior abdomen. However, the species has characters of *Synoicum* rather than *Polyclinum*, viz. the mid-intestine is large and inflated, the gut loop straight and relatively long, and the cloacal systems small.

Synoicum clavatum (Oka, 1927) from Japan resembles the present species in some characters, but it differs in having larger round-topped rather than flat-topped lobes with longer, narrow stalks. There is some confusion regarding the characters of the Japanese species, however, for Nishikawa (1990) records 20 to 24 longitudinal muscles and 10 to 12 stigmata, but Tokioka (1954b) reported only 12 muscles and 20 stigmata (see Tokioka 1954b, Pl. IVF). The colours of living colonies of the Japanese populations, which could provide more evidence of their relationships with one another and with the present species, have not been recorded.

Synoicum clavatum: Millar, 1975 from the Philippines has flat-topped lobes containing circular cloacal systems similar to those of the newly recorded Australian material; and the zooids have 8 to 9 longitudinal muscles similar to those from Heron I. However, although they are in 15 rows like the Australian material, Millar reports about 20 stigmata per row in his specimens. The flat-topped Philippine colonies, therefore, are only questionably conspecific with the Australian colonies. The dorsal papilla has not been recorded for Philippine or Japanese specimens. *Synoicum kuranui* Brewin, 1950b from Great Barrier I. (New Zealand) are sandy capitate lobes with crimson zooids and areolated stomach walls and are readily distinguished from the present species. *Synoicum kuranui*: Kott, 1963 from Heron I. is not conspecific with either the present one or with the New Zealand species (see *S. durum*, above). The sympatric *S. intercedens* has sessile cushion-like colonies with sandy margins. Their upper surface with swellings corresponding to the systems, larger systems, longer atrial tongues, a mulberry-like stomach and a smaller larva.

Synoicum suarenum is a tropical species and it differs from the temperate *S. sacculum* by the shape of the colony lobes (sessile in *S. sacculum*), the smooth stomach wall (mulberry-like in *S. sacculum*), and the small, almost rudimentary cloacal systems with the wide cloacal aperture exposing the cloacal cavity to the exterior, as in some *Eudistoma* spp. (*angolanum* group: Kott 1990).

Synoicum tropicum (Sluiter, 1909)
(Fig. 57)

Atopogaster tropicum Sluiter, 1909, p.107.

DISTRIBUTION

NEW RECORD: Western Australia (NW Shelf, QM GH5056).

PREVIOUSLY RECORDED: Indonesia (Sluiter 1909).

The species is known only from the type and from the newly recorded portion of a colony.

DESCRIPTION

EXTERNAL APPEARANCE: The specimen is a wedge-shaped slice of what appears to have been a large, upright lobe, about 12cm high. The test is firm and the surface naked.

Zooids are arranged in circular systems of 8 to 20. The branchial apertures are around the margin of a circular depression about 5mm diameter in the surface test. A conspicuous common cloacal aperture protrudes on a conical prominence in the centre of each circle of zooids. The test is white and opaque, with a patch of dark pigment where each zooid opens to the surface. Common cloacal apertures are about 7mm apart, an area of test without zooid openings separating the circles of branchial apertures from one another.

INTERNAL STRUCTURE: The zooids in the present piece of a colony have not been adequately fixed and cannot be dissected or manipulated without disintegrating. They are, as in the type specimen, perpendicular to the surface. The zooids of the type colony (Sluiter 1909) have 12 rows of 8 to 10 stigmata. The gut forms a simple loop, the stomach wall is smooth, and there is a long posterior abdomen.

REMARKS

The present specimen agrees with the type in having circular depressions on the surface with branchial apertures around the margin of each depression, protruding cloacal apertures, and no sand either embedded or adhering to the surface. The circular surface depression is characteristic. Although circular systems with a large circular cloacal cavities surrounded by zooids occur in other species of *Synoicum*, the well-spaced and depressed circles of the present species are unusual.

The horizontal stomach folds that characterised the genus *Atopogaster* (to which Sluiter assigned this species), are artefacts that occur in species with large, smooth stomachs and *Atopogaster* is here proposed as a junior synonym of *Synoicum*.

Genus **Morchellium** Giard, 1872

Type species: *Amaroucium argus* Milne Edwards, 1842.

The known species have a relatively long oesophagus. A vertical, barrel-shaped stomach halfway down the abdomen is smooth or has mulberry-like swellings in the stomach wall. Gonads are in the posterior abdomen with the ovary anterior to the serially arranged testis follicles. Rows of stigmata are numerous. The atrial aperture is wide and open, often forming a protuberant siphon with an enlarged uppper rim. Neither the atrial lip nor the sphincter muscle are as well developed as they are in *Aplidium* and *Polyclinum*. The posterior abdomen is narrow and continuous with the abdomen, there being no constriction between them.

The number of rows of stigmata are in the range known for other genera of the Polyclinidae. However the number per row (20 to 30) generally exceeds that of all other genera of this family, being almost as numerous as in Polycitoridae and *Sigillina* spp. The number of stigmata per row in Protopolyclinidae, and in some *Ritterella* spp., are of this order. In Euherdmaniidae and Placentelidae they are more, and in Pseudodistomidae less numerous.

Although they are not present in the type species, the Australian species of this genus have parastigmatic vessels in the branchial sac. A few species of *Aplidium* — e.g. *A. caeruleum* (Sluiter, 1906) — and *Synoicum atopogaster* also have parastigmatic vessels (see Kott 1969) and so do certain Protopolyclinidae (*Monniotus* spp., *Condominium*) and certain *Ritterella* spp. (see above)

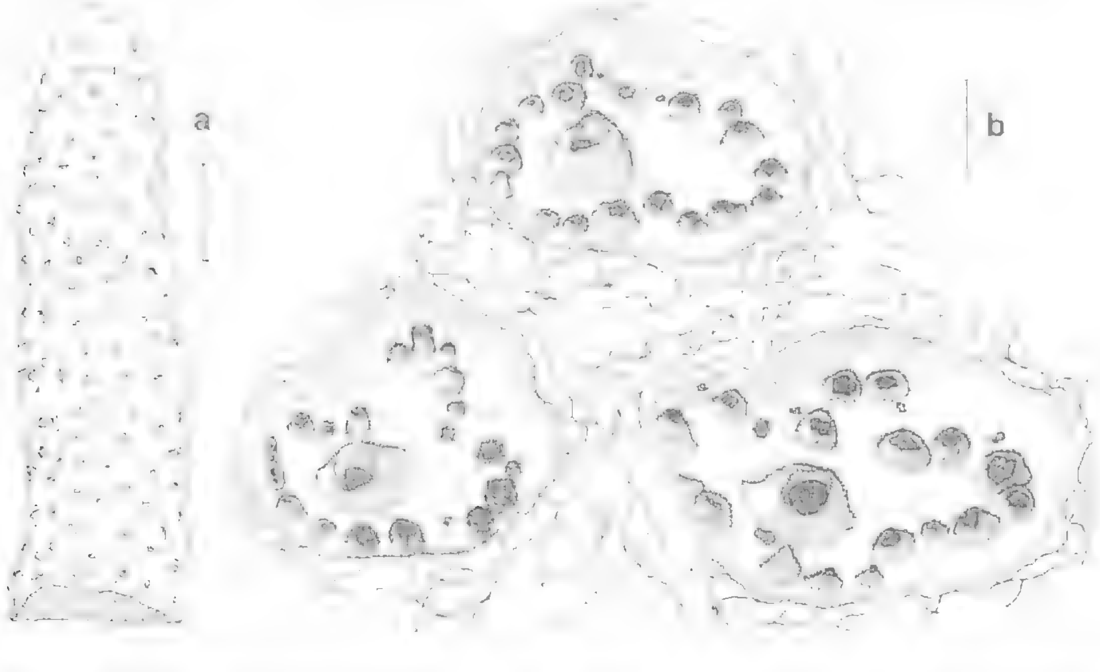


FIG. 57: *Synoicum tropicum* (QM GH5056) — a, part of colony; b, circular systems with protuberant branchial apertures surrounding a larger, central common cloacal aperture, each depressed into the surface. Scales: a, 2cm; b, 2mm.

as well as holozoid genera *Distaplia*, *Sycozoa* and *Hypsistozoa*. Thus no profound phylogenetic significance can be attached to the presence of these vessels in *Morchellium* species. Parastigmatic vessels hold in place the long, parallel interstigmatic bars that occur in most species with particularly long, narrow stigmata. These generally occur when there are few rows of stigmata relative to the size of the branchial sac. Probably the presence of parastigmatic vessels, preventing distortion of the stigmata, maintaining the dimensions of their apertures and the effective operation of the cilia lining them, is a convergent character in the taxa referred to above.

FIG. 58: *Morchellium albidum* n.sp. (holotype QM GH5582) — a, part of upper surface showing zooid systems; b, zooid, with detached posterior abdomen showing ventral muscle band. Scales: a, 4mm; b, 0.5mm.

The transverse thoracic muscles of the Australian species *M. pannosum* n.sp. are unique in the Polyclinidae, although they are known in *Sigillina* (Holozoidae), Polycitoridae (see Kott 1990) and some Ritterellidae (see above). The pigment spots in each of the branchial lobes (as in the Diazonidae and *Euherdmania* spp.) are also unsual. Neither of these characters occurs in *M. albidum* n.sp. Thus, they do not seem to be generic characters as the genus is currently defined. Nor do they occur in *Synoicum*.

Morchellium argus (type species) has 4 symmetrically arranged unusual pigment spots around the apertures (Berrill 1950), but these are not homologous with the diazonid-like pigment spots of *M. pannosum* n.sp.

The large atrial aperture, and barrel-shaped stomach without longitudinal folds found in both Australian species are similar in certain *Synoicum* spp. from which *Morchellium* is distinguished only by its 8 branchial lobes.

The type species is from the English Channel and the west coast of Britain, Ireland and France.

The species discussed below are the only 2 of this genus described from Australia. They differ from one another principally in their colonies, *M. pannosum* n.sp. having sandy lobes, each with a single system, and *M. albidum* n.sp. having numerous circular systems in each cushion-like colony.

Morchellium partitionis (Monniot, 1987) from New Caledonia, the only species of thus genus previously recorded from the tropical western Pacific, is divided into sandy claviform lobes and is 2cm high. The external test is thickly encrusted with sand. Its colony form is similar to that of *M. pannosum* n.sp., and it has a similar number of rows of stigmata (13 to 14) and a similar number of stigmata per row (18). However its lack of parastigmatic vessels and its mulberry-like stomach distinguish it.

Morchellium albidum n.sp.
(Fig. 58)

DISTRIBUTION

TYPE LOCALITY: South Australia (West Bay, Wedge I., southern Spencer Gulf, Earthwatch site 2, coll. A. Butler 16.2.88 QM GH5582).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a large, oval bolster 4cm long and 3cm wide. Zooids are arranged in crowded, circular systems of up to 12, with large sessile common cloacal apertures in the centre of each. The test is firm and transparent and the zooids, seen clearly from the surface, are translucent-white in preservative. An opaque white deposit is in the surface test between the systems.

INTERNAL STRUCTURE: Zooids are large and robust. However, the thorax and abdomen together are as little as 1.4mm long when contracted. The posterior abdomen is longer. The rim of the branchial aperture has 8 conspicuous rounded lobes. The atrial aperture protrudes from the dorsal surface, and its anterior rim is sometimes produced into a strap-like tongue, with 3 pointed terminal lobes. In other specimens the atrial lip is shorter and broader, the 3 terminal lobes being more conspicuous than the tongue itself. A median dorsal papilla is present behind the aperture. The thorax has about 12 longitudinal muscles which form a wide band along the ventral border of the abdomen and posterior abdomen. When contracted this ventral band draws the posterior abdomen up alongside the abdomen.

Stigmata are in about 12 rows of probably up to 12, but the thorax is too contracted to allow accurate counts to be made. Each row of stigmata is crossed by a parastigmatic vessel.

The stomach is voluminous, and collapsed into irregular, more or less horizontal folds. The posterior abdomen is about the same length as the rest of the zooid. It contains a double series of male follicles and an ovary anterior to these.

REMARKS

The zooids of this species resemble those of *Morchellium pannosum* n.sp., as well as *Synoicum atopogaster* and *S. concavitum*. The naked bolster-like colonies differ from all these except the last, which, however, has firmer test, less crowded systems, and lacks parastigmatic vessels. The present species also has fewer rows of stigmata, and fewer per row than *Synoicum atopogaster* or *Morchellium pannosum* n.sp.

Morchellium pannosum n.sp.
(Fig. 59)

DISTRIBUTION

TYPE LOCALITY: Victoria (Port Phillip Heads, 18m, fast current, coll. J. Watson 10.9.77, holotype QM G12722).

The species is said to be common off Port Phillip Heads.

DESCRIPTION

EXTERNAL APPEARANCE: The newly recorded specimen is an irregular mass of sandy test, up to 3cm high, with the upper half of the colony divided into flattened to cylindrical lobes about 1cm in diameter.

FIG. 59. *Morchellium pannosum* n.sp. (holotype QM G12722) — a, part of colony; b, whole zooid; c, anterior part of zooid showing atrial lip, atrial aperture, branchial aperture and tentacles, and position of neural complex. Scales: a, 5mm; b, 1mm; c, 0.5mm.

A bare area with a large usually long, narrow opening in the centre is on the upper surface of each of the lobes, which contain single, or occasionally 2 cloacal systems. The cloacal cavities are relatively shallow.

The test is very soft, jelly-like, flaccid and translucent. Internally, sand is present in the base of the colony, but not elsewhere. The living zooids are reported to have been mauve.

INTERNAL STRUCTURE: The zooids are robust. About 20 strong longitudinal muscle bands on the thorax extend along on each side of the ventral line of the abdomen and posterior abdomen in 2 wide bands. On the thorax there also appears to be a layer of transverse muscle fibres over the longitudinal thoracic bands. In these contracted zooids (about 6mm long), the abdomen is shorter than the thorax, which is about the same length as the posterior abdomen. The latter curves ventrally as a result of the strong ventral longitudinal bands.

The rim of the branchial aperture appears to have 8 very shallow lobes in which there are faded pigment spots, although in some contracted specimens the rim looks puckered and gathered rather than lobed. A fleshy tridentate lip extends out from the upper rim of the atrial aperture. There are about 16 branchial tentacles of about 3 size groups, each group in a circle at slightly different levels in the base of the branchial siphon. About 15 rows each of about 20 long stigmata are folded along a parastigmatic vessel. The stomach is large, smooth-walled, and has irregular transverse folds that probably result from its collapse. The duodenum is moderately long, and a posterior stomach is in the bend of the gut loop. The voluminous rectum extends halfway up the thorax. A double row of male follicles are in the middle of the posterior abdomen.

REMARKS

In addition to the number of branchial lobes, the species distinctive characters are its fleshy body wall, strong (including transverse) muscles, roomy, transversely folded stomach, parastigmatic vessels, and distinctive lobed colony with flaccid test and large naked cloacal apertures.

The transversely folded stomach is similar to that of *Synoicum atopogaster* and *S. tropicum* (Sluiter, 1909). It was previously thought to be characteristic of the genus *Atopogaster* (< *Synoicum*).

Zooids resemble those of *Synoicum atopogaster* Kott, 1963 which has a similar number of stigmata, parastigmatic vessels and longitudinal muscles that draw the posterior abdomen up alongside the abdomen. The present species is distinguished by its 8 branchial lobes and their associated pigment spots, transverse thoracic muscles and single cloacal system per lobe.

Genus **Aplidium** Savigny, 1816

Type species: *Aplidium lobatum* Savigny, 1816.

Zooids usually are small and thread-like with a relatively, narrow thorax and gonads in a posterior abdomen that is continuous with (rather than constricted off from) the abdomen. There are 6 or sometimes 8 branchial lobes. The atrial tongue is relatively small and rises from the anterior rim of the opening or from the body wall anterior to it. The atrial cavity also is relatively small. Longitudinal muscles extend the length of the thorax and continue onto the abdomen and posterior abdomen. Transverse muscles are in the transverse branchial vessels, joining with the longitudinal muscles in the parietal body wall through atrial connectives. The gut loop is vertical with a vertical rather than curved oesophagus and a vertical barrel-shaped stomach with parallel longitudinal folds in its wall. In *Aplidium*, like *Synoicum*, but unlike *Polyclinum*, *Aplidiopsis*, and other families of Aplousobranchia with a short abdomen, the post-duodenal or proximal part of the mid-intestine — between the duodenum and posterior stomach — has more or less the same diameter as the duodenum rather than being narrower. A short distal section of mid-intestine lies between the oval posterior stomach (which usually is in the bend of the gut-loop) and the rectum. Often there are small pockets (caeca) each side of the proximal end of the rectum, and these form a rectal valve. The anus opens one third to halfway up the atrial cavity.

Larvae are small, the trunk usually less than 1mm and most often less than 0.8mm. Three small, shallow adhesive organs on long slender stalks are present in the anterior mid-line. Median and lateral ectodermal ampullae sometimes are present anteriorly, and usually there are ectodermal vesicles at the anterior end of the trunk. These are 2, 3 or more deep in a wide band, or in a single series, forming an arc along each side of the median adhesive organs. Sometimes they also occur in the median line between the adhesive organs (Fig. 60). The vesicles separate from, or sometimes remain directly attached to the ectoderm by, fine, sometimes branched, stalks. This

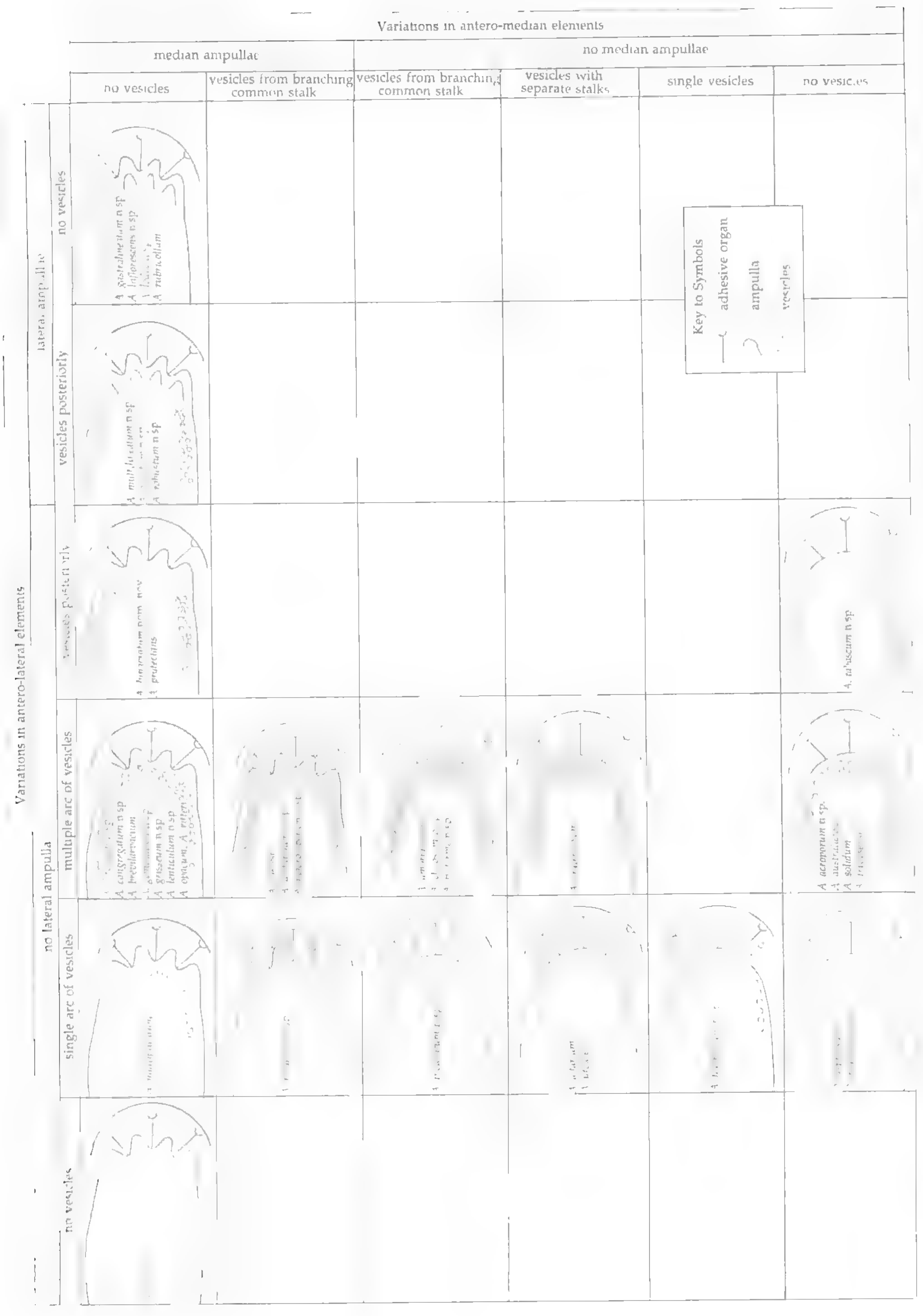


FIG. 60. Epidermal elements of the anterior end of the larval trunk in *Aplidium* spp. (showing their relative position, but not their precise number for any one species; diagrammatic).

constitutes a distinction from *Polyclinum* in which the only vesicles are those that branch off long strands of ectoderm which trail back through the larval test, one on each side of the mid-dorsal and mid-ventral lines and form postero-ventral and antero-dorsal patches of vesicles. These patches of vesicles occasionally also occur in *Aplidium*, but are seldom the only ones present. As in *Polyclinum*, the larval ocellus and otolith in *Aplidium* are well developed.

Colonies often are large, but appear to be well integrated, with zooids organised into cloacal systems and with an external morphology of the colony that enhances its interactions with the external environment. Thus, branchial openings may be protected in depressed parts of the surface test, at the base of ridges or swellings of the surface test (e.g. *A. caelestis*, *A. crateriferum*). Cloacal apertures usually are elevated above the colony on conical prominences (Kott 1989). The test of *Aplidium* is gelatinous, but often is relatively firm, and sometimes is further strengthened by dense inclusions of embedded sand. Many species appear to sort the sand embedded in the test, large sand particles being found in the base and margins of the colony while smaller particles are around the branchial and cloacal apertures, where the test could be expected to be more flexible.

The cloacal cavities generally are shallow, with only a thin layer of surface test over them. Atrial apertures always are at the anterior end of the dorsal surface, and variations in their position usually are a result of contraction of body musculature. Deeper cloacal cavities sometimes develop, and the atrial opening into the base of the cloacal cavity with the atrial lip inserted above it is accommodated by the separation of the atrial lip from the aperture. Thicker surface test is accommodated by a long branchial siphon (e.g. *A. crateriferum*).

The genus *Sidnyum* Savigny, 1816 (type species *Sidnyum turbinatum* Savigny, 1816) is distinguished from *Aplidium* only by the 8-lobed (rather than 6-lobed) branchial apertures. The zooids form circular systems which open on the upper surface of soft, cushion-shaped or lobed colonies with translucent test, and with or without encrusting sand. The best known species of this genus are the type and the related *S. elegans* (see Berrill 1950), which both are common in some European locations. In addition to the 2 related European species, the known species with usually (but not always) 8 branchial lobes are:

Synoicum appendiculatum Michaelsen, 1923 from the Azores. Although assigned to *Sidnyum* by Monniot (1974), the species with its deeply curved oesophagus bilaterally symmetrical stomach with furrows (rather than folds), seems appropriately placed in the genus *Synoicum*.

Sidnyum pentatrema Monniot, 1972 from Bermuda and Guadaloupe (see Monniot 1983) appears to be an *Aplidium* species in which the number of branchial lobes varies from 6 to 9, although 8 is the number which occurs most often (Monniot 1972, 1983). These lobes are not equal in size, and probably several have subdivided to produce the higher number, which accordingly cannot be said to represent a reliable plesiomorphic character indicating generic status for the taxon.

Sidnyum pentatrema: Monniot and Monniot, 1987, known only from 2 small sand covered lobes from French Polynesia probably is convergent rather than conspecific with the Azores species.

Aplidium mernooensis (Brewin, 1956) from Chatham I., New Zealand has characters in common with both *S. pentatrema* and *S. appendiculatum*. Monniot (1972) concluded that *S. appendiculatum* from the Azores is distinct from *A. mernooensis*, but the relationships between the latter and the Tahitian *S. pentatrema*. Monniot and Monniot, 1987 and *A. mernooensis*: Monniot, 1987 from New Caledonia are not clear (see *A. filiforme* n.sp., below).

Aplidium amorphatum Kott, 1963 and *A. protectans* (Herdman, 1899) have (see below) 8 branchial lobes. Their other characters (including the stomach folds) conform with the genus *Aplidium*.

Sidnyum indicum Renganathan and Monniot, 1984, a massive gelatinous colony from the Indian Ocean, has thread-like zooids that have the usual characteristics of *Aplidium* including a folded stomach (see *A. protectans*, below).

Thus, of the 8 species that are possible candidates for the genus *Sidnyum*, 3 — *S. pentatrema* Monniot, 1972; *S. pentatrema*: Monniot and Monniot, 1987; and *A. mernooensis* (Brewin, 1956) — with 5 rows of stigmata and 5 stomach folds, probably are the result of convergent evolution. The number of branchial lobes in at least one of these species is unstable. The species appear at least as closely related to species of *Aplidium* as to one another. Of the other 5 known species, the 2 closely related and sympatric European ones do not seem to have closer relationships with the Australian *A. amorphatum* and *A. protectans*, and the Indian Ocean *A. indicum* than with other *Aplidium* species.

Further, in the diverse genus *Aplidium*, both adult and larval morphological differences between species and groups of species appear to transcend (in evolutionary terms) the few differences between *Sidnyum* and *Aplidium*. Accordingly, in this work the genus *Sidnyum* is considered a synomym of *Aplidium*.

Aplidium has a close relationship with *Synoicum*. The difference between them disappears when, in some *Aplidium* species, the stomach wall is distended and the 5 folds flatten out. Further the larvae are similar, and it is probable that these two polyclinid genera are closely related phylogenetically.

Resolution of the taxonomy, and identification of species of the genus *Aplidium* has been, and continues to be, a problem. Owing to post-mortem changes and other artefacts of fixation and preservation, the reported appearance of living specimens is often difficult to reconcile with their changed appearance in preservative. In the preserved specimens, systems often are obscured by sand, and colours oxidise or are lost altogether. Zooids, already small and convergent, contract and withdraw from the surface, thus obscuring both their morphology and their arrangement in opaque and often distorted colonies. This confusion is compounded by a degree of plasticity in the shape of colonies which grow to accommodate a variety of substrates and conditions. Further the number of specimens available for examination does not always include a range of age groups or material from a variety of populations so that intraspecific variation is often not known, or has not been recognised. Difficulties also exist in finding reliable taxonomic characters in these small, simplified zooids, and in their crowded colonies.

The number of rows of stigmata, stomach folds, stigmata per row, and the configuration of the atrial aperture and lip, are important characters for species identification. Also of significance are characters of the colonies such as the distribution of pigment, consistency of the test, distribution and nature of test inclusions, form of the systems, shape of the colony and the presence or absence of a stalk. Usually of only limited significance at the species level are the relative lengths of different parts of the zooid (especially the posterior abdomen), the number of longitudinal muscle bands and the number and arrangement of testis follicles, which either are affected by the flexibility and contractability of the zooids, or by variations in form that occur with growth and sexual maturity.

In identifying species of this genus, particular care needs to be paid to the counting of stomach folds. The whole thickness of the stomach wall is pleated, and accordingly folds are internal as well as external. Internal pleats seen through the wall and counted with the external ones may explain the high intraspecific variation in the number of folds sometimes recorded. A transverse section of the stomach enables accurate counts to be made. The number of rows of stigmata is obscured when a part or the whole of the branchial sac is contracted. Inaccurate counts of the number of rows and the number per row occur when, in contracted sacs, stigmata are folded, and the interstigmatic bars and the perforations are crowded together. Fully relaxed branchial sacs are desirable for accurate determination of their structure, and dissection to expose the stigmata is essential, as shadows seen through the contracted body wall are not a reliable way to count the rows.

Nishikawa (1990) points out that the genus *Aplidium* is one of the largest in the Ascidiacea. *Aplidium* species abound in temperate as well as tropical seas. Because of the difficulties in resolving the taxonomy of species in this genus some of the approximately 200 recorded may be invalid. Others have been lumped together, more critical examination showing that many previously considered conspecific taxa are actually distinct from one another.

Most of the previous works on the *Aplidium* fauna of Australia are based on relatively small collections from limited areas, viz. from New South Wales (Herdman 1899), northwestern Australia (Hartmeyer 1919, Millar 1963), south-western Australia (Michaelsen 1930), Port Phillip Bay (Millar 1966), eastern and north-eastern Australia (Herdman 1886, Herdman and Riddell 1913, Kott 1966, 1972c), South Australia (Kott 1972a,b, 1975 and 1976). Kott (1963) dealt with Australia-wide collections. Sluiter (1909) in his report on the Siboga collection encountered only 5 species of *Aplidium* of which 4 occur in Australia. Only 25 species of *Aplidium* spp. have previously been reported from Australia.

The number of specimens available for examination in the present study has made it possible to more accurately determine species parameters and resolve synonymy. The identity of most of the 16 previously known indigenous Australian species and the 4 recorded also from the Western Pacific has been confirmed, however the 2 species said to be conspecific with species recorded from New Zealand, 3 from South Africa, and a pantropical species (*A. lobatum*), were wrongly assigned. No *Aplidium* species has been found to have a range from Australia to either South Africa or New Zealand, and the number of apparently indigenous Australian species has been significantly increased as a result of the present review.

Aplidium, with 46 known species, including a relatively high indigenous component, now recorded from Australia, is one of the most diverse genera of the Ascidiacea in these waters (Tables 7–9).

Key to species of *Aplidium* recorded from Australia

1. Stomach folds more than 8 2
   Stomach folds not more than 8 25

2. Cloacal apertures few and terminal or central; parallel longitudinal or radial cloacal canals 3
   Cloacal apertures numerous and scattered over the colony surface; no long, parallel longitudinal or radial cloacal canals 9

3. Colonies flat-topped sandy lobes adhering to one another .... *A. congregatum* n.sp.
   Colonies not flat-topped sandy lobes adhering to one another 4

4. Colony with thin, leathery stalk. *A. australiense*
   Colony without thin leathery stalk 5

5. Stomach folds less than 20 6
   Stomach folds more than 20 7

6. Stomach folds 10 .... *A. brevilarvacium*
   Stomach folds more than 10 .... *A. parvum*

7. Colony sessile or top-shaped, without a stalk.... *A. altarium*
   Colony not sessile or top-shaped, with a stalk..8

8. Head of colony with sand externally; larval trunk with epidermal vesicles .... *A. geminatum* n.sp.
   Head of colony without sand externally; larval trunk without epidermal vesicles .... *A. inflorescens* n.sp.

9. Stigmata in 5 rows 10
   Stigmata in more than 5 rows 11

10. Atrial aperture with a lip .. *A. minisculum* n.sp.
    Atrial aperture without a lip .... *A. depressum*

11. Zooids in long conspicuously branching double-row systems 12
    Zooids not in long conspicuously branching double-row systems 14

12. Sand embedded throughout .... *A. elatum*
    Sand not embedded throughout 13

13. Branchial siphon surrounded by wide band of white, opaque cells; larvae with single series of epidermal vesicles each side of anterior mid-line .... *A. multiplicatum*
    Branchial siphon not surrounded by wide band of white, opaque cells; larvae with multiple series of epidermal vesicles each side of anterior mid-line .... *A. opacum*

14. Stomach folds not more than 15 15
    Stomach folds more than 15 17

15. Sand embedded in the test 16
    Sand not embedded in the test .... *A. fluorescum* n.sp.

16. Sand embedded in surface layer of test; zooids in conspicuous circular systems .... *A. jacksoni*
    Sand embedded in basal layer of test; zooids not in conspicuous circular systems .... *A. triggsense*

17. Stigmata more than 20 per row; brood pouch present .... *A. uteute*
    Stigmata less than 20 per row; brood pouch not present 18

18. Stigmata in more than 12 rows 19
    Stigmata in 12 rows or fewer 21

19. Stomach folds 18; stigmata not more than 8 per row .... *A. gelasinum* n.sp.
    Stomach folds 20 or more; stigmata more than 8 per row 20

20. Stomach folds oblique .... *A. gastrolineatum* n.sp.
    Stomach folds not oblique .... *A. robustum* n.sp.

21. Stomach folds 30, oblique .... *A. multilineatum* n.sp.
    Stomach folds less than 30, not oblique 22

22. Systems circular 23
    Systems not circular .... *A. rosarium* n.sp.

23. Sand on upper surface of colony .... *A. incubatum* n.sp.
    Sand not on upper surface of colony 24

24. Stigmata more than 10 per row ... *A. lodix* n.sp.
    Stigmata not more than 10 per row .... *A. ornatum* n.sp.

25. Atrial lip separate from rim of aperture 26
    Atrial lip not separate from rim of aperture .35

26. Colonies undivided, upright and regular 27
    Colonies not undivided, upright and regular 26

27. Colony sandy externally .... *A. magnilarvum* n.sp.
Colony not sandy externally ...... *A. coniferum*

28. Systems circular 29
Systems not circular 31

29. A single system per colony lobe ... *A. directum*
More than a single system per colony lobe . 30

30. Branchial siphon with bulging branchial sphincter .... *A. crateriferum*
Branchial siphon without bulging branchial sphincter .... *A. lunacratum* nom. nov.

31. Cloacal systems irregular; cloacal apertures at junction of 2 or 3 canals 32
Cloacal systems regular; cloacal apertures in centre of radially converging canals 33

32. Common cloacal canals surround circular to polygonal zooid-free areas .... *A. lenticulum* n.sp.
Common cloacal canals do not surround circular to polygonal zooid-free areas .... *A. caelestis*

33. Stomach folds 5 34
Stomach folds 8 .... *A. griseum* n.sp.

34. Stigmata in 18 rows .... *A. clivosum* n.sp.
Stigmata in 12 rows .... *A. rubricollum*

35. Stigmata in 4 or 5 rows 36
Stigmata in more than 5 rows 39

36. Colony a 3 dimensional reticulum; 8 stomach folds .... *A. acroporum* n.sp.
Colony not a 3 dimensional reticulum; 5 stomach folds 37

37. Stigmata in 4 rows .... *A. distaplium* n.sp.
Stigmata in 5 rows 38

38. Stalks long; one system per terminal branch .... *A. bacculum* n.sp.
Stalks not long; more than one system per terminal lobe .... *A. filiforme* n.sp.

39. Sand sparse or absent from internal test 40
Sand moderate or crowded in internal test .. 42

40. Branchial lobes 8 41
Branchial lobes 6 .... *A. parastigmaticum* n.sp.

41. Parastigmatic vessels present .... *A amorphatum*
Parastigmatic vessles not present .... *A. protectans*

42. Colony a single system . *A. paralineatum* n.sp
Colony not a single system 43

43. Stigmata more than 10 per row .... *A. macrolobatum* n.sp.
Stigmata less than 10 per row 44

44. Cloacal canals surround extensive irregular patches of zooid-free test; systems not crowded; embedded sand not crowded .... *A. tabascum* n.sp.
Cloacal canals do not surround extensive irregular patches of zooid-free test; systems crowded; embedded sand crowded 45

45. Cloacal canals surround small circular zooid-free areas 46
Cloacal canals surround narrow zooid-free ridges .... *A ritteri*

46. Larva with median ampullae; southern Australian .... *A. petrosum* n.sp.
Larvae without median ampullae; not southern Australian .... *A. solidum*

Species recorded from waters adjacent to Australia

Aplidium cellis Monniot, 1987 has double rows of zooids around raised zooid-free areas of test as in *A. tabascum* n.sp., from which the species is distinguished by its smaller larva (less than 0.6mm trunk) and the sand which is said to completely encrust the surface, albeit it is less crowded over the cloacal canals. Although the colony resembles *A. lenticulum* n.sp. the zooids differ, having the atrial lip from the upper rim of the opening, similar to the zooids of *A. ritteri* (> *A. lobatum*: Monniot, 1987). The species may be conspecific with *A. lobatum* Savigny (see below).

Aplidium flavolineatum: Monniot 1987, from the Coral Sea, has zooids (with brood pouch, large thorax and short posterior abdomen), and possibly also the larvae (with epidermal vesicles around each adhesive organ attached to the epidermis by narrow stalks) like those of *A. altarium*. *Aplidium altarium* has only a limited number of systems in each colony, each consisting of double rows of zooids converging to central or terminal cloacal apertures. The Coral Sea specimen has circular systems and a brood pouch like *A. uteute*. However, the latter species has more numerous lateral vesicles in the larval trunk.

Aplidium lobatum Savigny, 1816 from the Gulf of Suez, later (as *A. africanum* Sluiter, 1905) reported from the Gulf of Aden, is said to be irregularly lobed but small (5 to 6mm thick), with yellowish white zooids in lines amongst the sand embedded in the transparent test. The upper surface is divided into flat-topped oval cushions which have deep furrows surrounding them. The cloacal canals into which the zooids open are in these furrows. Sand does not adhere externally, stigmata are in 9 or 10 rows of about 12, the trifid atrial lip is part of the anterior rim of the aperture. The posterior abdomen is short, the male and female gonads are not present in the same zooid at the same time and the larval trunk is 0.5mm long (Michaelsen 1920). In his review of the species, Michaelsen added records from the Mediterranean (through the synonymy of *A. tremulum* Savigny, 1816), and suggested a range extending to Malaysia and Indonesia through synonymy with *Aplidium tremulum*: Sluiter, 1909. However, this requires confirmation as most assignations from the western Pacific by Tokioka (1967), Nishikawa (1984a), Monniot (1987) and Monniot and Monniot (1987) appear to be synonyms of *A. ritteri* (see below). *Aplidium lobatum*: Kott, 1963 is conspecific with *A. macrolobatum* n.sp. *Aplidium tabascum* n.sp. and *A. cellis* Monniot, 1987, with smaller lobes on the apertures, and elevated cushions surrounded by depressions into which the zooids open, have both colony and zooids like *A. lobatum* from Suez. Particularly *A. cellis*, with its embedded sand and small larva, is indistinguishable.

The small specimens from the Marianas (*A.* aff. *lobatum*: Tokioka, 1967), with the atrial lip separate from the aperture, is not this species. It is similar to *A. caelestis* or *A. nadaense* Nishikawa from Japan. Atlantic specimens assigned to *A. lobatum* (see Van Name, 1945) have fewer rows of stigmata than the types, the colonies are different, and they probably are not conspecific with the Red Sea specimens. Their similarity could well be the result of convergence.

Aplidium maru Monniot and Monniot, 1987, from French Polynesia, has a larva with median ampullae and, on each side, a band of lateral epidermal vesicles at the anterior end of the trunk (see Fig. 60). There is no other species in the group with similar larvae which also has circular to oval systems of zooids arranged around a protuberant cloacal aperture, 5 stomach folds and an atrial lip separate from the opening.

Aplidium mernooensis (Brewin 1956) from the subantarctic Chatham I., New Zealand (see also Millar 1982) is reported from the tropical New Caledonian waters by a single colony (Monniot 1987). The colony has sand externally but not internally. Its upper surface is lobed, each lobe containing a single circular system. Zooids have red thoraces, with 8 branchial lobes, 5 stomach folds and 5 rows of stigmata. The occurrence of this species in a tropical location is surprising and the identity of the New Caledonian specimen requires confirmation, especially in view of the possibility of convergence in species with zooids as small as these. The New Zealand specimens have almost twice as many stigmata as *A. filiforme* n.sp. (see below). The larvae of both the Chatham I. and New Caledonian specimens are larger than *A. filiforme* n.sp., but they are otherwise all similar to one another.

Aplidium multipapillatum Millar, 1975 from Hong Kong and New Caledonia (Monniot 1987) is characterised primarily by its larvae with 5 adhesive organs.

Aplidium nadaense (Nishikawa, 1980), a species probably indigenous to Japan has the atrial lip separate from the aperture, 13 to 15 rows of up to 8 stigmata, and 5 stomach folds. The colony is smooth-surfaced and the systems are not as conspicuous as they are in *A. caelestis*. Monniot and Monniot (1987) and Monniot (1987) assigned specimens, from French Polynesia and New Caledonia respectively, to this species. *Aplidium nadaense*: Monniot, 1987 from New Caledonia has 14 to 16 rows of stigmata, but branchial apertures are in furrows in the surface, between small polygonal areas, resembling *A. solidum*, which, however, does not have the atrial lip separated from the aperture. *Aplidium nadaense*: Monniot and Monniot, 1987 has a longer, narrower zooid but fewer rows of stigmata than the type. Neither the number of stigmata per row nor the form of the systems is reported. The small larva and other features of the zooid are similar to *A. lobatum*, but the long narrow posterior abdomen is not. Probably neither *A. nadaense*: Monniot 1987 nor *A. nadaense*: Monniot and Monniot 1987 are conspecific either with the Japanese species or any known Australian ones.

Aplidium uouo Monniot and Monniot, 1987 from French Polynesia resembles *Aplidium ritteri* in its long, winding systems, atrial lip from the upper border of the apertures, 10 rows of about 6 stigmata, 5 stomach folds, short posterior abdomen containing gonads of only one sex at a time, and a larva without median vesicles or ampullae and a band of lateral vesicles. It is distinguished only by the absence of embedded sand usually associated with *A. ritteri*, the band of lateral vesicles is not as wide, and the larval trunk (0.7mm long) is longer than that of *A. ritteri*.

Aplidium acroporum n.sp.

(Fig. 61. Plate 10a,b)

DISTRIBUTION

TYPE LOCALITY: South Australia (The Gap, near Thistle I. Spencer Gulf, coll. S. Shepherd 8.4.87, holotype SAM E2554 *QM GH4169*; Horseshoe Reef near Kingston, 36°35.0'E. flat rock platform, small overhang, sand patches 20m, coll. R. McCauley 17.2.89, paratype QM GH5443; Kangaroo I, Cape D'Estaing, Emu Bay north of reef, 35°34.3'S 137°30.2'E brown algae covered rocks merging to sand and sea grass 12m, coll. AIMS Bioactivity Group 30.1.89, paratype QM GH5431.

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony forms a 3-dimensional reticulum of hard, rigid, sandy,

TABLE 7. Summary of characters of species of *Aplidium* recorded from Australia

Group A: species with the atrial lip not separated from the opening; and with more than 5 stomach folds

Species	Biogeographic Description[1]	Range anticlockwise around Australia	Stomach folds	Systems: form; number	Stigmata: no. rows;no./row	Posterior abdomen	Colony	Embedded sand	Larvae: no. incubated; median trunk length (mm)	Other
A. altarium	WP,tr	Mackay to Cockburn Sd	25–30	radial;one	9–10;25	short	upright cushions	none	3;1.0	
A. australiense	A,te	Recherche Arch. to Shoreham	16	parallel rows; numerous	15;15	long	stalked	none	1;1.5	
A. geminatum n.sp.	A,te	Gt Australian Bight to Western Port	20–23	parallel rows; 1 to 3	15;10–12	"	"	external only	3;0.95	
A. brevilarvacum	A,te	Cockburn Sd to Gt Australian Bight	10	"	14;10	"	"	throughout	1;0.6	
A. inflorescens n.sp.	A,te	Spencer Gulf to Western Port	20	"	15;14–15	"	"	stalk only	4;0.9	
A. parvum	A,te	Albany to Bass Strait	18	"	12;8	"	"	"	3;0.8	
A. congregatum n.sp.	A,tr	Moreton Bay	12	radial; numerous	11;12	"	upright flat-topped	throughout	6;0.5	
A. rosarium n.sp.	A,tr	Capricorn Gp	20	"	12;12	short	cushion	basally	3;0.6	
A. elatum	A,te	Gt Australian Bight	15	branching; numerous	8;8	"	upright lamellae	throughout	?;?	
A. multiplicatum	WP,tr,te	Cockburn Sd to far northern Gt Barrier Reef	22	"	9–11;14–20	"	sheet-like to irregular fleshy mass	none	2–7;0.9	surface even
A. opacum	A,te	Cockburn Sd to Western Port	20	"	12;12	long	"	"	1;0.7	"

[1] A, indigenous; WP, Western Pacific; tr, tropical; te, temperate.

TABLE 7. Summary of characters of species of *Aplidium* recorded from Australia (Group A, Cont.)

Species	Biogeographic Description[1]	Range anticlockwise around Australia	Stomach folds	Systems: form; number	Stigmata: no. rows;no./row	Posterior abdomen	Colony	Embedded sand	Larvae: no. incubated; median trunk length (mm)	Other
A. lodix n.sp.	A,te	Spencer Gulf to Western Port	25	circular; numerous	10;numerous	long	sheetlike	none	6;0.7	surface even
A. robustum n.sp.	A,te	Albany to Tasmania	20	"	14–16;12	"	spherical to conical cushions	"	3;1.06	"
A. multilineatum n.sp.	A,te	Cockburn Sd to Tasmania	30	"	10;16	"	circular cushion	basally	?;0.9	"
A. gastrolineatum n.sp.	A,te	Gt Australian Bight to Pearson I.	24	"	16;14	"	"	external only	?;0.8	ridges surround systems
A. gelasinum n.sp.	A,tr	Northern Great Barrier Reef	16–18	"		16;8	"	"	none	?;? "
A. jacksoni	A,te	Port Jackson	12	"	12;16	"	"	throughout	?;?	surface even
A. ornatum n.sp.	A,tr	SE Qld	25	"	12;10	"	upright flat-topped	none	2;0.7	
A. incubatum n.sp.	A,te	Moreton Bay	25	"	10;15	"	plate to upright flat-topped	throughout	6;0.55	brood pouch
A. uteute	WP,tr	Heron I. to Sarina	25–35	"	11;25	short	sheets	"	2–5;0.7	"
A. fluorescum n.sp.	A,tr	Heron I. to Lizard I.	12–14	"	10;16	"	cushion to sheet-like	"	3;0.5	
A. triggsense	WP,te,tr	Cockburn Sd to Heron I.	15	?	8;10	long	sheets to upright lobes	basally	2;0.6	
A. depressum	WP,tr	Heron I. to Bundaberg	11	?; numerous	5;10	short	sheets	"	3;0.35	no atrial lip
A. minisculum n.sp.	A,te	Vic.	10	circular; numerous	5;10–12	"	cushion to sheets		1;0.4	
A. acroporum n.sp.	A,te	SA	8	"	5;6-7	"	3 dimensional reticulum	throughout	2;0.4	

[1] A, indigenous; WP, Western Pacific; tr, tropical; te, temperate.

TABLE 8. Summary of characters of species of *Aplidium* recorded from Australia

Group B: species with the atrial lip separated from the opening; and usually with 5 stomach folds [1]

Species	Biogeographic Description[2]	Range anticlockwise around Australia	Systems: form; number	Stigmata: no. rows;no./row	Posterior abdomen	Colony	Embedded sand	Larvae: no. incubated; median trunk length(mm)	Other
A. lenticulum n.sp.	A,te	Cockburn Sd to Heron I.	long curved; numerous	16–20;8	long	thick sheets	throughout	1;0.85	systems surround elevated mounds
A. caelestis	WP,tr,te	Shark Bay to Lizard I.	long straight; numerous	10–18;6–14	"	"	"	1;0.65	ridges separate systems
A. rubricollum	A,te	Gt Australian Bight to Western Port	radial; numerous	11–12;14	"	"		1;0.7	ridges surround systems
A. clivosum n.sp.	A,tr,te	Port Hedland to Heron I.	radial; few to numerous	16–18;12	"	massive wedge or thick cushions	"	1;1.75	"
A. crateriferum	WP,tr	Heron I. to Exmouth Gulf	circular; numerous	18–21;14	"	"	"	1;2.0	"
A. lunacratum nom. nov.	A,te	Cervantes to Manning River NSW	circular; numerous	10–15;12–15	"	"	"	1;2.2	"
A. directum	A,te	Cronulla to Moreton Bay	circular; one per lobe	10–13;14	"	upright lobed	"	2;0.55	
A. coniferum	A,te	Elliston Bay to Twofold Bay numerous	circular to radial;	22;8	"	upright stalked	"	1;0.65	surface even
A. magnilarvum n.sp.	A,te	Gt Australian Bight	?; numerous	21;20	"	"	"	1;2.2	"
A. griseum n.sp.	A,tr	Capricorn Group	circular to radial; 2 or 3 per lobe	13;6	"	upright	"	1;0.85	ridges surround systems

[1] the exception is *A. griseum* n.sp. with 8 or 9 stomach folds. [2] A, indigenous; WP, western Pacific; Te, temperate; tr, tropical.

TABLE 9. Summary of characters of species of *Aplidium* recorded from Australia

Group C: species with the atrial lip not separated from the aperture; and usually with 5 stomach folds[1]

Species	Biogeographic Range[2]	Range anticlockwise around Australia	Systems: form; number	Stigmata: no. rows;no.\row	Posterior abdomen	Colony	Embedded sand	Larvae: no. incubated; median trunk length (mm)	Other
A. distaplium n.sp.	A,te	Spencer Gulf to Bass Strait	?; numerous	4;12	short	irregular	throughout	4;0.52	rows of stigmata paired
A. filiforme n.sp.	A,tr	Capricorn Group	circular; 4 or 5 per lobe	5;6	"	upright flat-topped	"	3;0.3–0.47	
A. bacculum n.sp.	A,te	SA	circular; one per lobe	5;6	long	stalked	"	?;?	
A. petrosum n.sp.	A,te	SA	curved; numerous	9;6	"	3-dimensional reticulum	"	3;0.8	
A. solidum n.sp.	A,tr,te	Jervis Bay to Bundaberg and Dampier Arch.	"	9–12;6	short	upright lamellae	"	2–5;0.45	
A. tabascum n.sp.	A,tr	Capricorn Gp, Cockburn Sd	"	15;8	"	sheets or cushions	patchy	2;0.7	
A. ritteri	WP,tr	Heron I.	long; numerous	11–12;7	"	"	"	3;0.55	
A. macrolobatum n.sp.	A,tr	Heron I. to Lizard I.	circular to long; numerous	9–10;15	"	"	"	7;0.65	large lips on aperture
A. paralineatum. n.sp	A,te	Tasmania	long, parallel; 2 or 3	18;12	long	irregular	throughout	?;?	
A. protectans	WP,tr	NSW to far northern Gt Barrier Reef	circular; numerous	18–24;20	"	spheres or domes	none	3;0.85	8 branchial lobes
A. amorphatum	A,te	Elliston Bay to Jervis Bay	"	15;16	"	"	"	1;1.2	8 branchial lobes; parastigmatic vessels
A. parastigmaticum n.sp	A,tr	Heron I.	"	18;12	"	"	"	?;?	parastigmatic vessels

[1] The exception is *A. amorphatum* with 4 stomach folds. [2] A, indigenous; WP, western Pacific; te, temperate; tr, tropical.

branching, anastomosing stalks, usually with horizontal terminal branches that lie in the one horizontal plane. The whole upper surface and the sides of each terminal branch are covered with naked, saucer-shaped circular concavities of 2 to 3 mm diameter, separated from one another by raised sandy ridges. The base of each of these concavities consists of a thin layer of test overlying a shallow thoracic cloacal cavity with a central, sessile cloacal aperture. In the paratype colony (QM GH5431) some of the branches of the stalks, including the terminal ones, are often flattened vertical lamellae.

Zooids are in circular systems of about 10 around each cloacal cavity. Owing to the depressed, transparent, clear, naked test over each cloacal cavity the surface depressions appear deeper than actually they are. Sand is crowded throughout the remainder of the colony. The zooids, smaller than the sand grains, are embedded in the test between the crowded sand grains. Rigid open compartments in the test, which occur in

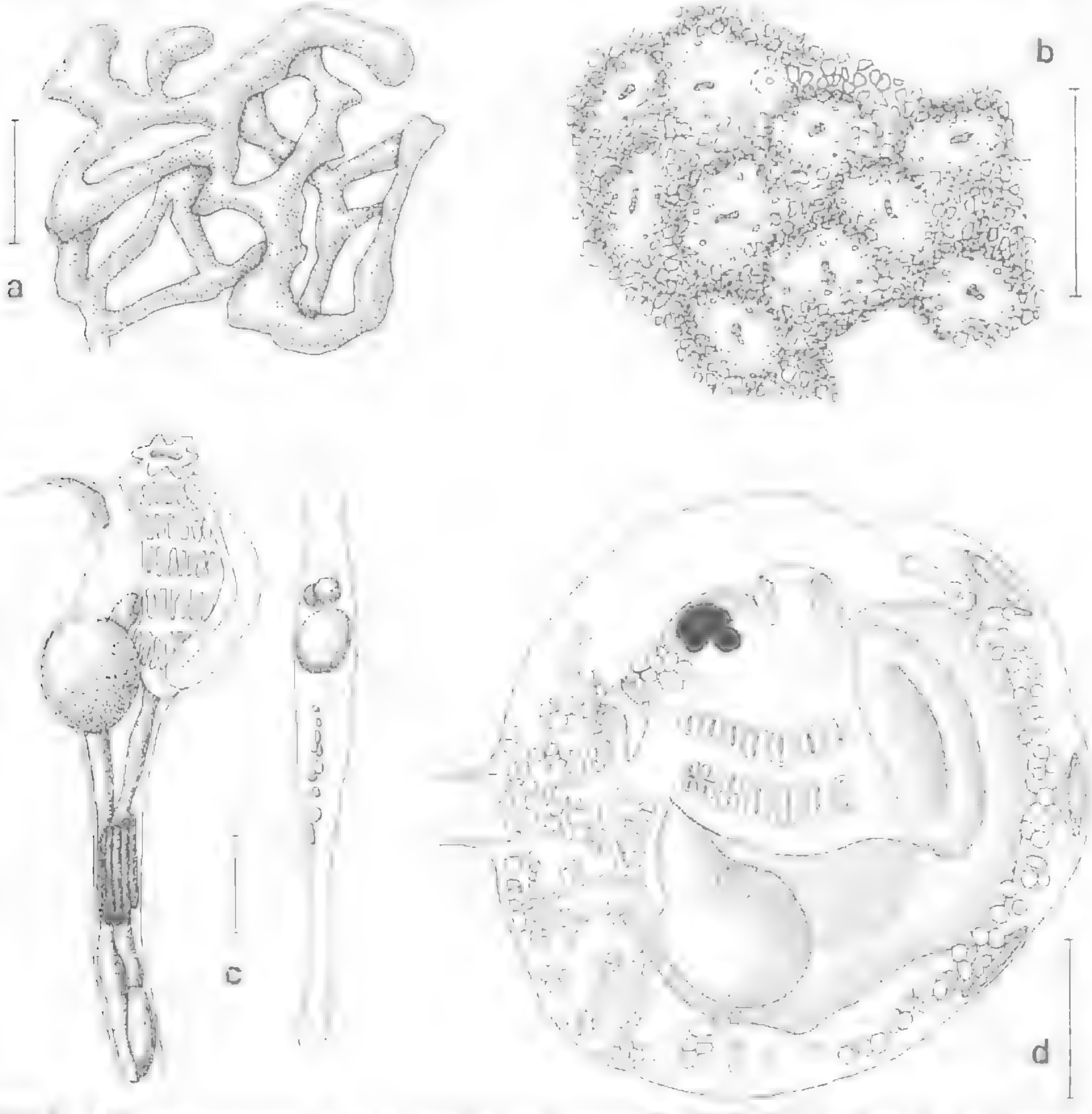


FIG. 61. *Aplidium acroporum* n.sp. — a, part of colony (paratype QM GH5443); b, surface of colony showing naked areas over cloacal cavities with branchial apertures around the margins (holotype QM GH4169); c, zooid, with embryo in atrial cavity and posterior abdomen separately (paratype QM GH5443); d, larval trunk, with large test cells (?) posteriorly (QM GH5341). Scales: a, 1cm; b, 5mm; c, 0.2mm; d, 0.1mm.

some aplousobranch species to accommodate the zooids, do not occur in the present species.

The maximum dimension of the available specimens is about 10cm and they are 5cm high. However, in no case was the entire colony taken, and it is probable that they are particularly extensive *in situ*. The branches toward the top of the colony have a diameter of 5mm, but the lower branches are narrower, and the basal vertical stalks taper like roots.

INTERNAL STRUCTURE: The zooids are particularly small, up to 2mm long, and thread like. The thorax, abdomen and posterior abdomen are of about equal length, except in those species in which the latter is contracted. The branchial and atrial siphons are short, the former with 6 (sometimes bifid) lobes, and the latter with a single pointed lip from the upper rim of the opening. There are 5 rows of stigmata with 6 or 7 in a row. The small stomach has 8 folds. A short posterior abdomen has 4 or 5 male follicles bunched in it in specimens collected in May. One colony (QM GH5431) collected in February has mature ova in the short posterior abdomen, and 2 embryos are incubated, one at the top of the abdomen and another completely obliterating the atrial cavity.

The larval trunk is spherical, 0.4 mm in diameter, and the tail is wound three-quarters of the way around it. There is a large cerebral vesicle with otolith and ocellus. Epidermal vesicles are in a band about 3 vesicles deep to form a conspicuous arc on each side around the anterior half of the trunk. These develop from a circle of epidermis around the adhesive organs, subsequently becoming detached and scattered in the test. Large morula corpuscles are scattered in the test over each side of the posterior half of the trunk. The 3 adhesive organs are wide but shallow, with short stalks.

REMARKS

Characteristics of the present species are the small zooids and the form of the colony, with its rigid, narrow, sandy branching stalks, and surface depressions separated by raised ridges which give the colony the appearance of the corallites of an acroporid coral.

The anastomosing horizontal terminal branches of this species, with zooid systems opening on the sides and upper surface, probably form a mat above the sandy substrate, with the rest of the reticulum (which lacks zooid openings), buried in the substrate. Such a growth form ensures that the colony is firmly anchored, and must add considerably to the consolidation and stability of the substrate.

The cloacal systems are smaller than similarly shaped ones of *A. lunacratum* nom. nov., from which the species is further distinguished by its 8 (rather than 5) stomach folds, 5 (rather than 9 or more) rows of stigmata and the atrial lip which is separate from the aperture in *A. lunacratum*.

Aplidium altarium (Sluiter, 1909)

(Fig. 62. Plate 10c,d)

Amaroucium altarium Sluiter, 1909, p.105.

Aplidium altarium: ?Millar, 1963, p.695. Kott 1966, p.282. Not Michaelsen 1919, p.90. Not Millar, 1956, p.914.

DISTRIBUTION

NEW RECORDS: Western Australia (Broome, WAM 873.83 *QM GH2118*; Ningaloo Barrier Reef, WAM 1029.83; Houtman's Abrolhos, WAM 79.75 189.75 388.75 763.82 754.83 837.83 1030.83 *QM GH2146* QM GH5557; Shark Bay, WAM 871–2.83 QM *GH2148 GH2147* 1026–8.83 209.88; Cockburn Sound, WAM 75.75 143.75). Queensland (Moreton Bay, QM GH5478–9; Capricorn Group, QM GH5307 GH5521–2 GH5558–9; Broadhurst Reef QM GH5131; Sarina, QM G4990; Lizard I., QM GH330–1 GH5480).

PREVIOUSLY RECORDED: Western Australia (?Cape Boileau — Millar 1963). Northern Territory (Darwin — AM Y1396 Kott 1966). Indonesia (Sluiter, 1909).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are circular to oval cushions up to 3cm in greatest dimension, lightly attached to hard substrates such as coral skeletons as well as weed. In life the colonies are less flattened, sometimes almost spherical or top-shaped, narrowing basally. They are found either in large populations, their margins probably in contact, to form a mosaic-like covering over the substrate; or they are bunched together. In preservative most of the colonies from Western Australia collected in 1974 to 1979 are a purple colour. Apparently the colour is progressively lost when in preservative for longer, as some from the Abrolhos collected in 1963 (WAM 754-82) are beige transparent cushions. The colour of living colonies is recorded for only one of the Western Australian specimen lots (AMP1 60 QM GH5307), which is said to have been purple and white, although photographs of it are white. It is possible that the colour notes were taken after the specimen was collected, when some oxidation had taken place. Living colonies from the Capricorn Group were described as 'brick' coloured with white in longitudinal lines down the sides of the colony, or 'pansy purple' (Ridgeway 1886) with beige or yellowish zooids, or 'brown ball ascidians'. The white lines referred to appear to have been calcareous faecal pellets in the cloacal canals. The specimens from Lizard I. and Myora are reported to have been 'maize yellow' (Ridgeway 1886) with a red dot each side of the apertures.

When present, the purple or brick pigment particles are crowded in the surface layer of the soft but turgid gelatinous test of the preserved colonies, becoming more sparse below the surface, and absent altogether from the basal test. Between the pigment particles, and after the pigment has faded, the test is clear and transparent. Sand is neither attached to, nor embedded in, the colony.

Usually a single, central, large, sessile and irregular common cloacal aperture is on the upper surface, and branching cloacal canals converge to it from the outer margin or the base of the upright colonies. Some colonies have up to 3 systems. Zooids, cream in preservative, are arranged in rows along each side of the cloacal canals. They are tightly enclosed in the firm test and are difficult to remove. Their large, white, atrial lips can be seen stretched out along the roof of the cloacal canals, and inserted around the rim of the cloacal apertures. White opaque vesicles in the surface test around the sides and upper surface are terminal ampullae of test vessels.

INTERNAL STRUCTURE: The zooids are about 6mm long when contracted, the thorax, abdomen and posterior abdomen each being about one-third of the total length. About 20 fine longitudinal muscles extend from the thorax along the

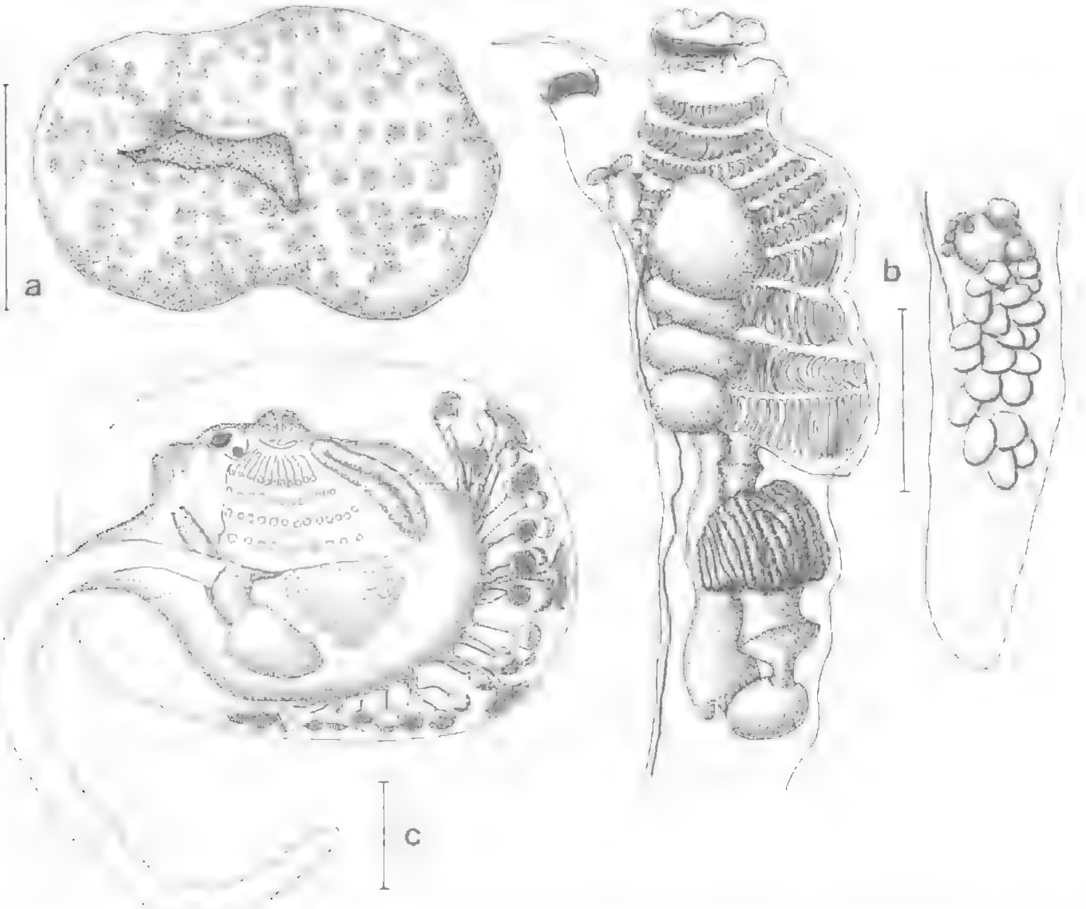


FIG. 62. *Aplidium altarium* — a, colony (QM GH5307); b, zooid, with posterior abdomen separately (AM Y1396); c, larva (WAM 79.75). Scales: a, 1cm; b, 1mm; c, 0.2mm.

length of the zooid, and even though all of the examined zooids are contracted, the muscles are inconspicuous. The branchial siphon is short. Only a short imperforate area is posterior to the prepharyngeal groove. The atrial tongue is of variable length, and is undivided or sometimes divided into 2 or 3 points. It arises from the anterior rim of the atrial aperture. The atrial aperture is a vertical slit, bounded on each side by a projecting convex lip which has muscles in its outer, convex, vertical margin. The homology of these muscles appears to be with the sphincter muscle usually found around the atrial aperture. The unusual configuration of the atrial sphincter in this species results from its component muscle bundle being drawn together by fine longitudinal muscles, one each in the middle of the anterior and posterior rims of the aperture, to form, respectively, the anterior and posterior extremities of a vertical aperture.

As well as being long, the branchial sac is wide, with up to 25 stigmata per row. However, despite its length, there are only 9 or 10 rows of stigmata. The stigmata are long. In the contracted, preserved zooids they usually are found folded horizontally along the centre of each row. The stigmata are fusiform, pointed at each end. They are only slightly reduced in length toward the dorsal and ventral mid-lines.

The oesophagus increases in diameter anterior to the stomach to form a prestomach. The stomach is wide, reduced in diameter at the cardiac end, with some oblique folds terminating against the suture line. It has 25 to 30 fine folds, sometimes interrupted along their length. The duodenum is wide, and the short mid-intestine narrows abruptly to enter the oval posterior stomach in the bend of the gut loop. Short rectal caeca are present at the proximal end of the ascending loop. The rectum extends half way up the branchial sac (opposite the fifth row of stigmata), but the contraction of the anterior part of the thorax can draw the anus up behind the atrial aperture. The anal opening is bounded by two large semicircular lips. The ovary is in the relatively short, stumpy posterior abdomen a short distance behind the gut loop, and 12 to 20 male follicles are clustered behind it. There is no constriction between the abdomen and the posterior abdomen

Up to 2 embryos are in a brood pouch projecting from the postero-dorsal corner of the thorax in colonies collected in April and May from Western Australia (WAM 754.82 763.82 837.83 1030.83 871–2.83), and from the Capricorn Group in November (QM GH5307) and December (QM GH5559). Mature gonads are not present in colonies collected in August (WAM 1029.83). In the Darwin colonies, collected in October, up to 4 embryos are lined up in the atrial cavity, the largest a tailed larva. Specimens collected in October (QM GH5131) and November (Heron I.), May (Myora) and June (Lizard I.) have up to 3 embryos at various stages crowded into the atrial cavity, projecting dorsally from it when the thorax is contracted. These embryos distend the whole atrial cavity and are not in a postero-dorsal brood pouch as they are when only one embryo is present. Larvae are short and deep, with a trunk to 1mm long. As they mature they become almost spherical, the trunk about 1.0mm long with the tail wound about three-quarters of the way around it. Circles of 6 to 8 epidermal vesicles are around each of the adhesive organs and these remain attached by narrow stalks to the epidermis. About 5 epidermal vesicles are also attached to the trunk ectoderm in the median line ventrally, behind the adhesive organs. The 3 median adhesive organs at the anterior end of the trunk are small and shallow. A mass of blue pigment is in the haemocoelic cavity, especially dense in the posterior horns, although these are largely obliterated as the oozooid develops. Mature larvae with a spherical trunk have 4 rows of stigmata, and a relatively short yolk mass beneath the large, upright pharynx, with its vertical endostyle.

REMARKS

The branching cloacal canals of these colonies resemble some species of *Polyclinum*. The mosaics formed by the closely spaced colonies resemble those of *Ritterella dispar*, and some species of *Diplosoma* (see Kott 1980). Nevertheless, the zooids are characteristic of *Aplidium*. It is possible that these lightly attached small colonies subdivide, and move to space themselves evenly over the substrate.

The zooid, sometimes with a brood pouch, and with bunched male follicles in a short posterior abdomen and numerous stomach folds, resembles *Aplidium uteute*. However, the latter species has zooids with longer, more barrel-shaped stomachs, arranged in circular systems, and the colonies are larger and more irregular than those of the present species. Further, although larvae of *A. uteute* have arcs of lateral vesicles, they also have median vesicles which do not occur in the present species. *Aplidium multiplicatum* has branching systems and similar larvae to the present species. However, *A. multiplicatum* colonies are larger, softer, the pigmentation is different, thoraces are narrower and systems longer and more crowded. *Aplidium opacum* has more crowded systems, spreading colonies, narrower thoraces, more rows of stigmata and fewer stomach folds.

A. flavolineatum: Monniot (1987) from Chesterfield Reef has 12 rows of stigmata and about 30 stomach folds. Although Monniot does not record the number of stigmata per row the zooids are similar to the present species. However the colonies are sheet-like rather than being cushions or wedge-shaped lobes, the zooids are arranged in circles rather than radiating double rows, embryos are incubated in a brood pouch and larvae have median ampullae (like *A. uteute*, see below). Although the larvae have some similarities, the present species is not conspecific with the South African *A. flavolineatum* (see Millar 1962) which is sandy (rather than naked) and red (rather than a cream, yellow, purple or brown colour).

The most conspicuous feature of the present colonies, viz. the double-rows of zooids converging to the central or terminal cloacal apertures, were not observed either by Sluiter (1909) or Millar (1963) in specimens they assigned to *Aplidium altarium*. However, the shape of the colonies, the form of the stomach, and the short posterior abdomen without a constriction between it and the abdomen are similar in all descriptions. The large semicircular lips of the anal opening, and its unusual, relatively anterior, position are recorded by Sluiter for the type specimens, which also have an expansion in the oesophagus as in the present specimens. The 4 to 6 embryos reported to be in the atrial cavity (Sluiter 1909, Taf. V9a) are very much smaller than those in the newly recorded specimen — indeed they are smaller than is known for any species of *Aplidium* and possibly Sluiter misinterpreted these bodies. A further discrepancy between Sluiter's account of the type and the newly recorded specimens is that he recorded only 10 stigmata per row — however there often are discrepancies of this order in Sluiter's counts of stigmata.

Reexamination of specimens from Darwin (Kott 1966) shows that the number of stigmata per row and the shape of the colonies were recorded incorrectly. The colonies are cushions, rather than sheet-like and the branchial sacs have the same number of stigmata as the present newly recorded ones. These Darwin colonies appear to be conspecific with the newly recorded specimens and with the Indonesian type material (Sluiter 1909).

Specimens assigned to *A. altarium* from Zanzibar and Mozambique (Michaelsen 1919; Millar 1956) appear different from the present species, with more numerous stomach folds (about 40), and small larvae with only 4 large epidermal vesicles and no ampullae (see Millar 1956).

Aplidium amorphatum Kott, 1963
(Fig. 63)

Aplidium amorphatum Kott, 1963, p.101; 1975, p.6.
Aplidium pseudobesum Kott, 1963, p.101.

DISTRIBUTION

NEW RECORDS: Victoria (Deal I., QM GH ; South Gabo I., QM GH5155–6). New South Wales (Jervis Bay, QM GH5617–9).

PREVIOUSLY RECORDED: South Australia (Elliston Bay — SAM E2581 Kott 1975). Victoria (Bass Strait — AM U3918 Kott 1963). New South Wales (Eden — AM U3922 U3924 Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are soft, gelatinous cushions, about 8cm in diameter, almost spherical or dome-shaped. The test is translucent and the zooids can be seen through it arranged in circular systems of 9 or 10 in each circle, although in these preserved colonies they are generally withdrawn from the surface and the systems are obscured. Specimens from South Gabo I. (QM GH5155–6) are described by the collector as 'red rose' ascidians.

INTERNAL STRUCTURE: The zooids are large, the thorax and abdomen together being about 5mm long. In relaxed condition the thorax would be longer than the abdomen. The posterior abdomen is long, but when contracted is drawn up to the left side of the gut loop. The zooids are muscular with about 20 longitudinal bands on the thorax that extend along the ventral border of the abdomen and posterior abdomen. The branchial aperture has 8 pointed to shallow rounded lobes around the rim of the short siphon. The long, robust, tongue-like atrial lip, from the upper border of the opening, has a tridentate tip with each division of equal size. The pharynx has 15 rows of up to 16 long stigmata. Each of the rows is crossed by a parastigmatic vessel. An intermediate dorsal languet associated with each of these parastigmatic vessels alternates with, and is the same size as, the languets on the primary transverse vessels.

The oesophagus is about one third of the length of the abdomen. The large voluminous stomach occupies the middle third. It has 4 shallow glandular ridges in its internal wall. The usual duodenal and mid-intestinal regions and a pear-shaped posterior stomach are in the posterior third of the descending limb of the gut loop. A double series of testis follicles is in the posterior end of the posterior abdomen and the ovary is anterior to them.

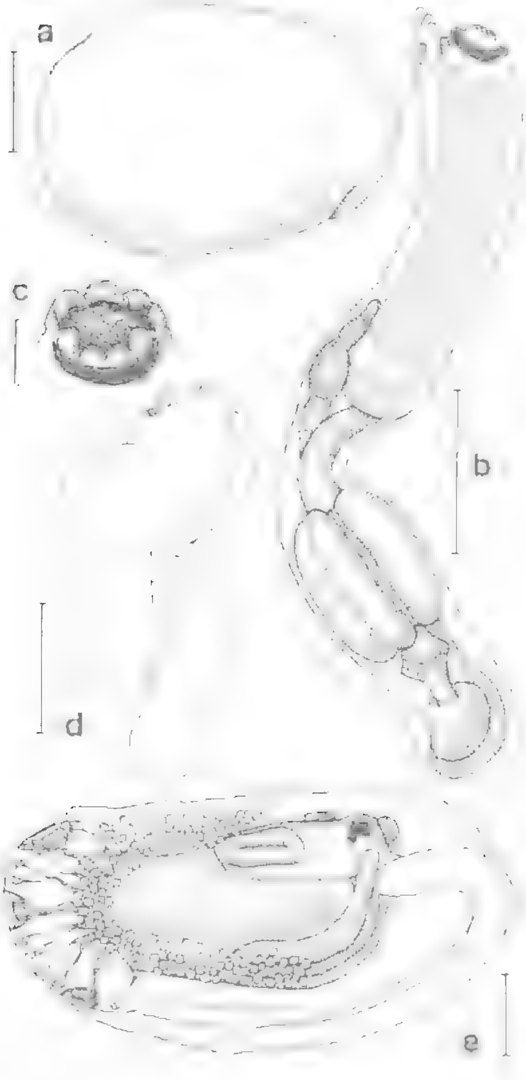


FIG. 63. *Aplidium amorphatum* — **a**, colony outline (SAM E2581); **b**, thorax and abdomen (holotype AM U3918); c, branchial aperture (holotype AM U3918); d, outline of contracted zooid, showing posterior abdomen pulled up alongside the abdomen (QM GH5617); e, larva (SAM E2581). Scales: **a**, 2cm; **b**, 1mm; c, e, 0.2mm; d, 2mm.

The colony from Elliston Bay collected in February has a single, large, embryo being incubated in the atrial cavity, almost completely occluding the pharynx. The larval trunk is 1.2mm long, and the tail is wound only halfway around it. Ectodermal vesicles are crowded in the test around the anterior part of the trunk, obscuring the 3 adhesive organs in the anterior mid-line. They consist of wide lateral bands of vesicles, and some in the median line attached by 2 or 3 long branching stalks in each interspace between the adhesive organs. The developing adult organs are at the posterior end of the long trunk.

REMARKS

The distinctive aspects of this species are its soft, rounded colonies, large zooids in circular systems, 8 branchial lobes, parastigmatic vessels, large stomach with shallow glandular ridges, and the large larva filling the atrial cavity in which it is brooded. The species has a superficial resemblance to *Aplidium protectans* which also completely lacks sand, and has a similar rounded shape, circular systems, 8 branchial lobes, large zooids, and shallow stomach folds. However, in *A. protectans* the test is firmer, the systems are depressed into the surface test, rows of stigmata are more numerous, parastigmatic vessels are absent, and the range is tropical.

The wide ventral muscle which draws the posterior abdomen up alongside the posterior end of the abdomen is reminiscent of the muscle band in *Aplidium circumvolutum* which distorts the zooid in a similar way (see Miller 1982).

Aplidium australiense Kott, 1963
(Fig. 64)

Aplidium australiensis Kott, 1963, p.111 (part, type specimen from Shoreham).
Aplidium colelloides: Kott 1972a, p.15; 1972b, p.176; 1975, p.7.

DISTRIBUTION

NEW RECORDS: Western Australia (Recherche Archipelago, WAM 147.75). South Australia (Eyre Peninsula, SAM E2557; Great Australian Bight, SAM E2478; Nuyts Archipelago, SAM E2472 E2476 E2558; Hotspot, QM GH1325).

PREVIOUSLY RECORDED: South Australia (Great Australian Bight — Kott 1972b, 1975; St. Vincent Gulf — Kott 1972a; Investigator Strait — Kott 1972b). Victoria (Shoreham — AM Y1398 holotype Kott 1963).

The records suggest that the species occurs only off the southern Australian coast.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are long (up to 8cm), more or less elliptical heads to 6cm diameter on long (to 20cm) narrow, tough, sandy stalks narrowing to a basal holdfast of short, thick root-like branches. The test on the head is soft, gelatinous, translucent. The terminal end of the head sometimes is pointed.

In the larger preserved colonies there are 4 to 6 deep, longitudinal furrows or creases formed between deep folds of the surface of the colony. Common cloacal canals are at mid-thoracic level and extend into large cloacal spaces in the edge of the folds referred to above. Three or 4 large cloacal apertures are either sessile or on protuberant cones along the edge of the folds. Sometimes they seem to alternate from side to side of the edge of the fold. Branchial openings of zooids are on both sides of these folds, i.e. on their outer and inner surfaces, as well as in the base of the depressions between and under the folds. Branchial apertures are absent only from the edges of the folds over the large cloacal canals.

Zooids are seen to be in longitudinal rows near the top of the stalk. However, in preserved colonies the arrangement of zooids towards the middle and top of the head is obscure.

Relatively small heads (2cm long) on long (10cm) stalks (SAM E2558) suggest that heads may regenerate on persisting stalks. These smaller heads lack the deep creases of the larger ones, and the zooids are arranged in more or less conspicuous double rows, converging to large cloacal apertures — 3 or 4 randomly distributed around the sides of the head, and 2 or 3 on the top of the head.

INTERNAL STRUCTURE: Zooids are particularly long and thread-like, their posterior ends curving down into the stalk. The rim of the branchial apertures is divided into 6 large, rounded lobes. The atrial aperture is a small sessile opening in the middle of the dorsal border of the thorax with a small pointed languet from the upper rim of the opening. About 10 longitudinal muscle bands on the thorax extend the length of the zooid, joining into a single wide ventral band along the long posterior abdomen.

Stigmata are in 15 rows with about 15 per row, although both the number of rows and the number per row are difficult to count owing to contraction of the small zooids. Twelve to 16 deep, longitudinal folds are in the stomach wall. The number varies with the size of the zooids. Testis follicles are in a double series in the posterior end of the posterior abdomen.

One large embryo or tailed larva and sometimes also what appears to be an infertile ovum are in the posterior part of the atrial cavity in colonies collected in September (SAM E2557) and in October (Kott 1972b). Specimens collected in March (SAM E2476) have mature male gonads.

The larval trunk is 1.5mm long. Its anterior end is obscured by a cloud of minute epidermal vesicles along each side of the base of the adhesive organs. The tail is wound three-quarters of the way around the trunk.

REMARKS

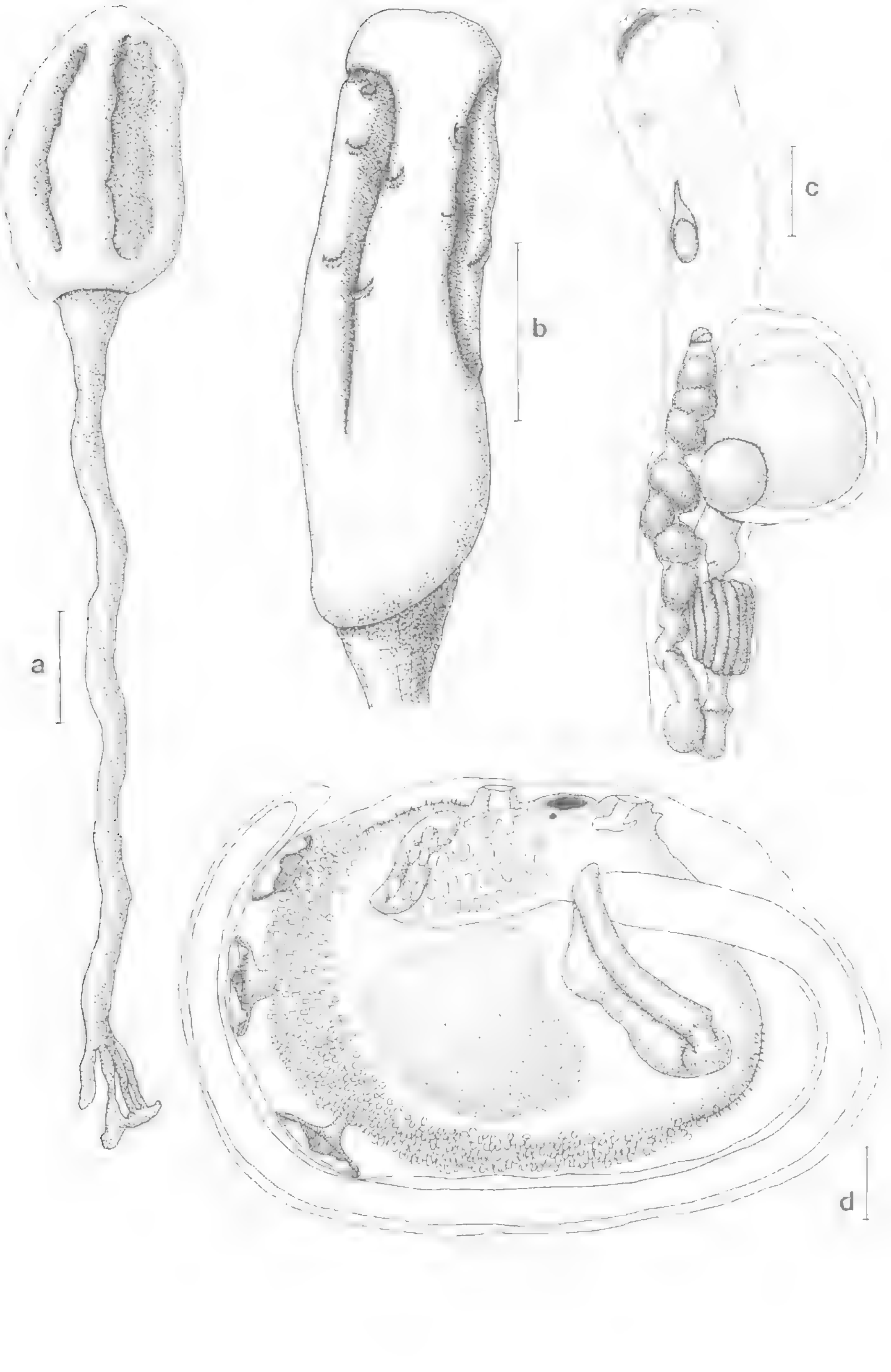
The colonies of this species, with their long, narrow, hard, sandy stalks and long gelatinous heads with small, crowded zooids and deep longitudinal creases, are distinctive.

Despite Herdman's (1886) speculation that *Aplidium colelloides* (Herdman, 1886) from South Africa had a short stalk, Millar (1962) established that it has a long (up to 6cm), narrow, hard stalk like that of the present species and reminiscent also of the long-stalks of species of *Sycozoa* and *Pseudodistoma*. Kott (1972a,b; 1975) in assigning South Australian specimens to the South African species, ignored the fact that the former have larger colonies with external creases on the head, more numerous stomach folds, and a larval trunk twice the size of the South African specimens. The large colonies that characterise the Australian species also have more crowded zooids less conspicuously arranged in long, oval systems (Millar 1962).

The larger colonies, deep creases, complex crowded systems as well as the long, narrow, hard stalks help to distinguish the species from *A. geminatum* n.sp. which has double rows of zooids, but short and thick stalks, less crowded zooids, more numerous stomach folds, longer, more conspicuous and often 3-lobed atrial tongues, and different larvae.

The type specimen of the present species from Shoreham (AM Y1398) is a head which has lost its stalk. The other specimens assigned to this species by Kott (1963) are colonies of

FIG. 64. *Aplidium* [illegible] — a, whole colony (QM GH1325); b, head of large colony (SAM [illegible]); c, thorax and abdomen with embryos being brooded in posterior end of atrial cavity (SAM E2557); d, larva (SAM E2557). Scales: **a**, **b**, 2cm; **c**, 0.5mm; **d**, 0.2mm.


a
b
c
d

A. geminatum n.sp., to which the larva figured by Kott (1963, Fig. 25) also belongs.

Aplidium bacculum n.sp.
(Fig. 65. Plate 10e)

DISTRIBUTION

TYPE LOCALITY: South Australia (Yorke Peninsula, Edithburgh, 35°9.7S 137°47.4E, 12m, coll. AIMS Bioactivity Group 6.2.89, holotype QM GH 5434).

FURTHER RECORD: South Australia (Thorny Passage, SAM E2568).

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a compact mass of parallel, long (3cm), narrow (to 5mm) sandy stalks, that branch once or twice along their length and adhere to one another. Their terminal free ends are flattened, horizontal, and level with one another to form a more or less even platform. They have a cloacal aperture in the centre of each terminal flat tip. This opens from a shallow, circular, cloacal cavity which is surrounded by about 10 zooids. Branchial apertures open around the upper margin of the terminal flat surface, and atrial apertures open into the cloacal cavity. A single cloacal system is in each terminal branch. The specimens from Thorny Passage have the terminal test inflated over each zooid, and the central common cloacal apertures protrude slightly.

Sand is crowded over the surface of each stalk, and also is embedded throughout the internal test, but is absent from the surface over the terminal end of each lobe. The small thread-like zooids are difficult to remove from their narrow longitudinal spaces in the hard, sandy colony.

INTERNAL STRUCTURE: Zooids extend the whole length of the sandy stalk, but the thorax and abdomen are together only about 3mm of which the abdomen is about two-thirds. The branchial aperture has 6 rounded lobes. A fleshy atrial lip, divided into 3 pointed lobes, extends from the upper border of the atrial aperture. Longitudinal muscles on the thorax are moderately strong, but they become finer as they extend back along the ventral surface of abdomen and posterior abdomen in a wide band of delicate muscles.

Stigmata are in 5 rows of about 6 stigmata per row, but these were difficult to count owing to contraction. The oesophagus is relatively long,

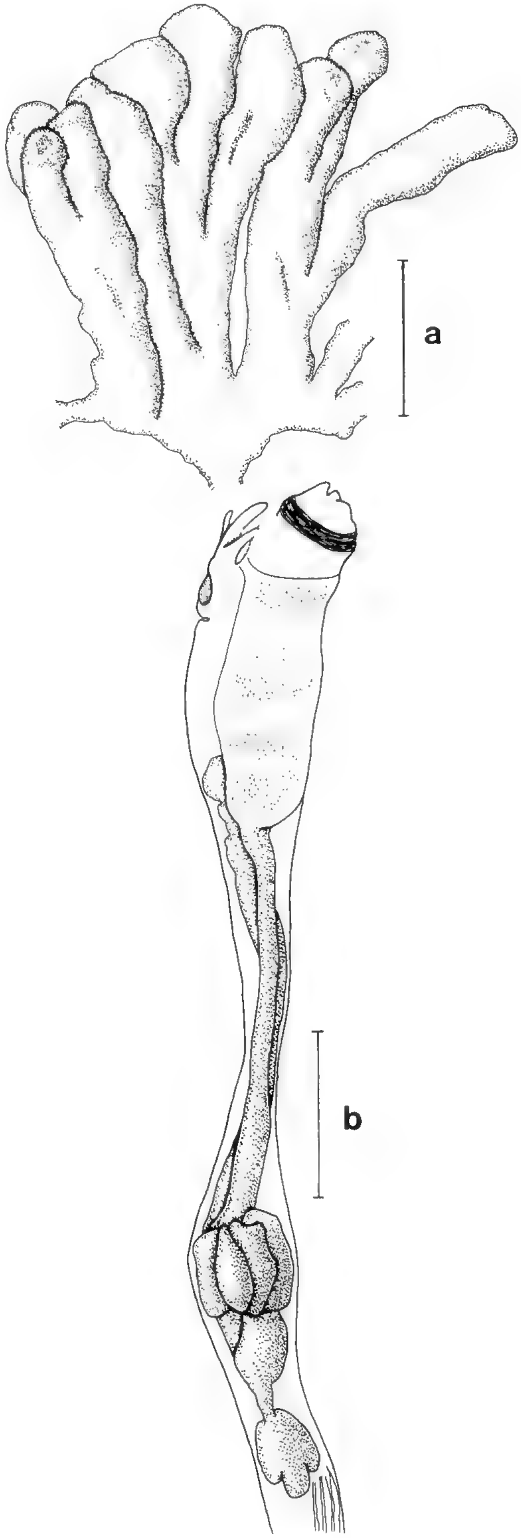


FIG. 65. *Aplidium bacculum* n.sp. (holotype QM GH5434) — **a**, colony; **b**, thorax and abdomen. Scales: **a**, 1cm; **b**, 0.5mm.

the small stomach being two-thirds of the way down the abdomen. The stomach wall has 5 deep folds. The duodenal area reduces in diameter to a short mid-intestine which opens into an oval posterior stomach in the descending limb of the gut loop. There is a small rectal valve at the proximal end of the rectum. Gonads are not developed in the available material.

REMARKS

Superficially, the sandy stalks of this species differ from those of *Ritterella* spp. and *Monniotus* spp. (which have no sand internally) principally in having embedded sand crowded in the internal test. Despite the long oesophagus, however, zooids are characteristic of *Aplidium* and open into a well developed cloacal cavity rather than directly to the exterior as in *Ritterella*. The form of the colony, and the long oesophagus (which probably is associated with the length of the colony lobes), together with the small zooids with only 5 rows of stigmata, characterise the species. Externally, the sandy lobes of the colony, especially the one from Thorny Passage with the test inflated over the anterior end of each zooid, and the protruding central cloacal aperture, resemble *Synoicum stewartense* Michaelsen, 1924 (see Millar 1982).

Other *Aplidium* species with 5 rows of stigmata viz. *A. filiforme* n.sp. and *A. depressum* lack the long stalks and long oesophagus of the present species.

Aplidium brevilarvacium Kott, 1963
(Fig. 66. Plate 10f,g)

Aplidium brevilarvacium Kott, 1963, p.113.
Aplidium digitatum Kott, 1975, p.7.

DISTRIBUTION

NEW RECORDS: South Australia (Ward I., QM GH2412; Top Gallant I., QM GH953; Investigator Group, QM GH1311 GH2413). Queensland (Heron I., QM GH961).

PREVIOUSLY RECORDED: Western Australia (Pt. Peron; Cape Naturaliste — AM U3926 syntypes *A. brevilarvacium* Kott, 1963). South Australia (Northern Great Australian Bight – QM G7508 AM Y1982 paratypes *A. digitatum* Kott, 1975).

The record from Heron I. is anomalous (see Remarks, below).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are rounded heads (0.5 to 1.5cm in diameter) on thick stalks, 0.5 to 6.0cm long, branching 2 or 3 times along their length, and up to about 0.5cm in diameter at the base. These sometimes arise from a basal test mass. Zooids are arranged in longitudinal rows along each side of cloacal canals that extend the length of the head, converging to 2 or 3 large, terminal cloacal apertures. The outer surface of both head and stalk is even, without wrinkles or protuberances.

There is a layer of sand in the outer surface that may obscure the zooids and their branchial openings. Sand is present also in the internal test. The anterior ends of the zooids are perpendicular to the outer surface and posteriorly they curve down into the stalk of the colony, criss-crossing one another as they go. In life the colonies are white to a sandy pink colour.

INTERNAL STRUCTURE: Zooids are robust. When contracted the thorax and abdomen are of equal length and together about 2mm long. About 12 very fine longitudinal muscles from the thorax run the length of the zooid. The branchial lobes are rounded. The atrial opening is sessile, with a fleshy, pointed lip from the anterior rim of the opening which sometimes is divided into 2 at the tip. The pointed dorsal languets are to the left of the mid-dorsal line, opposite the third row of stigmata. Stigmata are relatively short and oval, about 10 per row, and in 14 rows. The stomach, halfway down the abdomen has 10 deep longitudinal folds. The duodenum is long, and the oval posterior stomach is separated from the duodenum and rectum respectively by short lengths of proximal and distal mid-intestine. The posterior abdomen is narrow, up to 1cm long.

In the type specimens from Cape Naturaliste (collected in January) and the newly recorded South Australian specimens (collected in April) there is a large tailed embryo in the atrial cavity and sometimes a large (possibly non-fertile) ovum as well. The larval trunk is about 0.9mm deep, but only about 0.6mm long. It has an ocellus and an otolith, 3 medium stalked adhesive organs, and the tail is wound one and a half times around it. Epidermal vesicles are present along each side of the adhesive organs.

REMARKS

The colonies from Heron I. appear to have only one or 2 terminal cloacal apertures, instead of the more numerous openings in the South Australian colonies. However the zooids have the same number of rows of stigmata and stomach folds, and are not distinguishable from the southern or western Australian ones. These Heron I. colonies may represent a population at the northern extremity of the range of this otherwise temperate indigenous species.

Externally, the colonies of this species, and particularly the specimens from Heron I. with one or 2 systems per lobe resemble *Distaplia australiensis* (see Kott 1990). Colonies also resemble *Aplidium geminatum* n.sp. which, however, has more numerous (20), fine stomach folds, appreciably larger colonies, and less branched and more wrinkled stalks.

Aplidium caelestis Monniot, 1987
(Fig. 67, Plate 11a–f)

Aplidium caelestis Monniot, 1987, p.517.
Synoicum hypurgon: Kott, 1963, p.86.
?*Aplidium* aff. *lobatum*: Tokioka, 1967, p.22.

DISTRIBUTION

NEW RECORDS: Western Australia (Shark Bay, WAM 883.83; Mullaloo Beach, QM GH5450; Hillary's Boat Harbour, QM GH5452). South Australia (Edithburgh, QM GH5437; Beachport, SAM E2566 E2569; Kangaroo I., QM GH5428 GH5430). Victoria (Bass Strait QM GH5648). NSW (Norfolk I., QM GH5783). Queensland (Capricorn Group, QM G9474 GH5594 GH5633–40 GH5647–8 GH5650–9 GH5661–2 GH5665; Lizard I., QM GH5631–2).

PREVIOUSLY RECORDED: Western Australia (Rottnest — AM Y1382 Kott 1963). Queensland (Heron I. — AM U3991 Kott 1963). New Caledonia (Monniot, 1987). ? Marianas (Tokioka 1967).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies form robust, always sandy, investing sheets up to 20cm

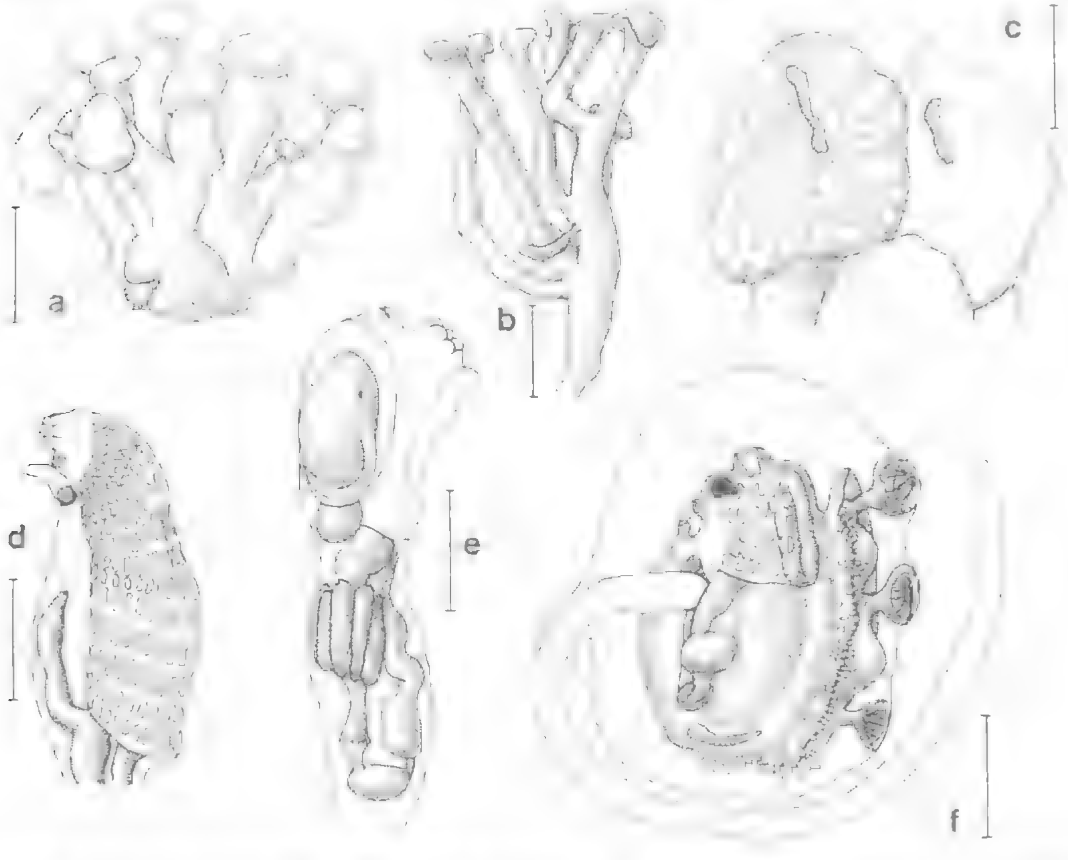


FIG. 66. *Aplidium brevilarvacium* — **a**, **b**, parts of colonies (QM GH953, G7508); **c**, details of a zooid system, with double rows of zooids converging to a terminal cloacal cavity (QM GH961); **d**, thorax (QM GH2112); **e**, thorax and abdomen (QM GH953); **f**, larva, showing arcs of lateral vesicles and median ampullae (syntypes AM U3926). Scales: **a**, **b**, 2cm; **c**, 5mm; **d**, **e**, 0.5mm; **f**, 0.2mm.

in maximum extent and up to 1cm thick. A row of zooids is along each side of the cloacal canals that extend between or around long, narrow areas of zooid-free test. Large sessile common cloacal apertures are at the junction of several canals and they often are elevated by the large cavity beneath them. The surface of the colony is depressed where relatively thin, usually transparent, naked test overlies the cloacal canals. Oval granular bodies about 0.1mm long, and some shade of brown to almost black are in the test and line the sides, base and walls of the cloacal canals, and often are in the surface as well. The grey to brown colour of the colonies results from these bodies and the included sand, sometimes in small clumps. Both the oval bodies and the clumps of sand appear to have been interpreted as faecal pellets. Sand is embedded throughout the test except in the thin transparent surface layer over the cloacal canals. Colonies have been described as 'sandy grey' or 'drab, with fawn zooids', 'sandy grey with yellow zooids', 'grey encrusting ascidian'. Living zooids are yellow, or orange. The test over the cloacal canals is irridescent in

FIG. 67. *Aplidium caelestis* — **a**, colony (QM GH5437); **b**, thorax with embryo being incubated (QM GH5150), **c**, thorax and abdomen (QM GH5647); **d**, whole zooid (QM GH5633); **e**, larva (QM GH5647). Scales: **a**, 5mm; **b**, **c**, 0.5mm; **d**, 1mm; **e**, 0.1mm.

living specimens. A colony from Heron I. (QM GH5661) had blue cells in the surface test between the rows of zooids of the living colony — as in the type from New Caledonia. *Prochloron* is often present on the surface (see Kott *et al.*, 1984; *Aplidium* sp. 1). Two colonies have red and green symbiotic cells embedded amongst the sand in the floor of the common cloacal canals. These are pink in preservative. Sand always is present in the basal half of the colony, and in the ridges between the double rows of zooids.

INTERNAL STRUCTURE: The zooids are long and thin (thorax and abdomen together to 5mm), but robust, with strong longitudinal muscles that extend their full length, along the ventrum of abdomen and posterior abdomen. The thorax and abdomen, of about equal length, are together about 3mm. The branchial siphon has 6 rounded lobes and a single conspicuous bulging sphincter muscle at their base. A long prebranchial area is posterior to the tentacles. The atrial aperture, a short distance down the dorsal surface, also has a conspicuous sphincter muscle. A robust, but not very long, pointed atrial lip, usually not divided, arises from the body wall anterior to the aperture. The atrial aperture at the level of the second or third row of stigmata opens into the sides or base of the cloacal canal.

Stigmata are in 10 to 18 rows, with 6 to 14 the maximum number per row. Expanses of unperforated pharynx are along each side of the mid-dorsal and mid-ventral lines. The oesophagus and post-pyloric part of the gut loop are relatively long for this genus, the gut loop being about the same length as the thorax when both are extended. The small stomach, halfway down the abdomen, has 5 distinct folds, although these sometimes flatten and occasionally it is difficult to see traces of any folds in the stomach wall. The duodenum, mid-intestine and posterior stomach are characteristic of the genus. Gonads are in the centre of the abdomen and consist of an irregular row of testis follicles with an anterior ovary a little distance behind the gut loop.

A single embryo with a trunk 0.65mm long and median ampullae alternating with the adhesive organs is in the atrial cavity of specimens taken in March and August from Heron I.

REMARKS

The zooids of this species, with their well-formed branchial siphons, sphincter muscles, atrial lips separate from the apertures, and long and narrow thoraces, resemble *A. crateriferum*, *A. griseum* n.sp., *A. lenticulum* n.sp., *A. lunacratum* nom. nov. and *A. clivosum* n.sp. The long, rather straight double row systems with long canals surrounding ridges of solid sandy test, sometimes can be seen in *A. ritteri*, but its atrial lip is not separate from the aperture. The oval granular bodies are present also in *A. lenticulum* n.sp., which has cloacal canals around raised polygonal areas rather than between the long ridges of the present species. The larvae also appear to be similar to those of *A. lenticulum* n.sp. The type specimen of *A. caelestis* Monniot, 1987 from New Caledonia has the same almost smooth stomach, narrow thorax, separate atrial lip, long double rows of zooids. The test is entirely encrusted with sand as it usually is in the newly recorded specimens. Although the transparent test over the cloacal canals is not always sky-blue in living specimens as it is in the type, it sometimes is. Colour and the number of rows of stigmata appear to be variable characters in this widespread species.

Kott (1963), interpreting the oval bodies as faecal pellets, assigned specimens of this species to *A. hypurgon* (Michaelsen, 1924), a New Zealand temperate species.

Aplidium clivosum n.sp.

(Fig. 68, Plate 12a–f)

Aplidium pantherinum: Kott, 1963, p. 98; 1972b, p. 176.

DISTRIBUTION

TYPE LOCALITY: South Australia (S.E. Beachport, 6–7m, on jetty piles, coll. W. Zeidler 20.2.89, holotype SAM E2561; Kangaroo I., on jetty piles, coll. N. Coleman 12.3.78 AMPI 220, paratype QM G1197).

FURTHER RECORDS: Western Australia (Port Hedland, WAM 1020-2.83; Montebello Is, QM GH5406; Cockburn Sound WAM 869–70.83, QM GH2149; Busselton, QM GH5469; Green Pools, QM GH5629). South Australia (Topgallant I., QM GH1287 QM GH2419; Hotspot, QM GH2417; Nuyts Archipelago, SAM E2562; Eyre Peninsular, SAM E2566 E2569; Flinders I., QM GH2305; Kangaroo I, QM G11997 GH5432 GH5433, SAM E2564; Ward I., Beachport, QM GH5447; West I., QM GH2415). New South Wales (Jervis Bay AMPI 78 QM GH5628). Queensland (Heron I. QM GH5569 GH5593 GH5597 GH5669–70 GH5675); Western Australia (Rottnest to Hamelin Bay — Kott 1963). South Australia (Elliston Bay — SAM E2585 Kott 1972b).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are large, to 4cm thick and to 15cm or more in maximum dimension. Some are of even thickness attached by the whole of the basal surface. Others converge toward the basal attachment area, or have irregular processes that may project into the substrate or around rocks and rubble. One colony (WAM 1021.83) is upright, rather flattened and divided into 2 lobes, about 15cm high, with systems evenly distributed over the both sides of the upright lobes.

The base and sides of the colonies have sand adhering to the surface. Sand usually is present on the zooid-free raised areas of the surface surrounding single systems, or groups of systems. The test over the systems usually is naked. Embedded sand is absent at thoracic level where zooids curve around the shallow cloacal cavities, but is present throughout the remainder of the test. In some colonies it can be seen projecting in from the periphery of each system as narrow wedges between the double rows of zooids.

The cloacal canals converge from the periphery of each system, to the large central cloacal cavity. A cloacal aperture raised on a conical protuberance (up to 5mm diameter across the base) is in the centre of each system. Zooids are arranged in double rows, one row along each side of the canals. In preserved colonies the surface is depressed over the systems, although it is not unusual for 3 or 4 systems to be present in one large depression, each system with its protruding common cloacal aperture. Systems are not always circular, often being irregularly shaped, the cloacal aperture being excentric with longer canals on one side than on the other. The diameter of the systems in this species is variable, ranging from 0.5 to 1cm, often in one colony.

In some colonies the whole upper surface is horizontal, and depressed within a rounded marginal rim. In others there is no sharp division between the margin and a convex upper surface.

In photographs, living colonies are pink, 'light wine' or bluish red. In preservative they are a translucent bluish-red. The colour is conspicuous on the upper surface over the systems and around the cloacal apertures.

INTERNAL STRUCTURE: In contracted zooids the thorax and abdomen together are from 3 to 6mm long. Long, thread-like posterior abdomina extend down through the crowded sand in the lower half of the colony.

About 12 fine longitudinal thoracic muscles extend posteriorly along the whole length of the zooids. The branchial siphon is long, with a narrow, bulging sphincter muscle behind the branchial lobes. Some fine circular muscles are on the remainder of the siphon, but they do not form a sphincter. The branchial tentacles are about halfway up the branchial siphon, with a long prepharyngeal area between them and the prepharyngeal groove. The diameter of the siphon bulges out in the vicinity of the branchial tentacles between the anterior sphincter and the prepharyngeal groove. A single, pointed atrial lip, sometimes bifid or trifid at the tip, arises from the body wall just anterior to the atrial siphon, which, depending on the state of contraction of its sphincter muscle, is either a sessile, circular opening, or is on a short, cylindrical siphon. The atrial siphon is well anterior, opposite the second row of stigmata.

In the branchial sac are 16 to 18 rows of up to 12 stigmata. A wide unperforated band of pharyngeal wall is present each side of the endostyle.

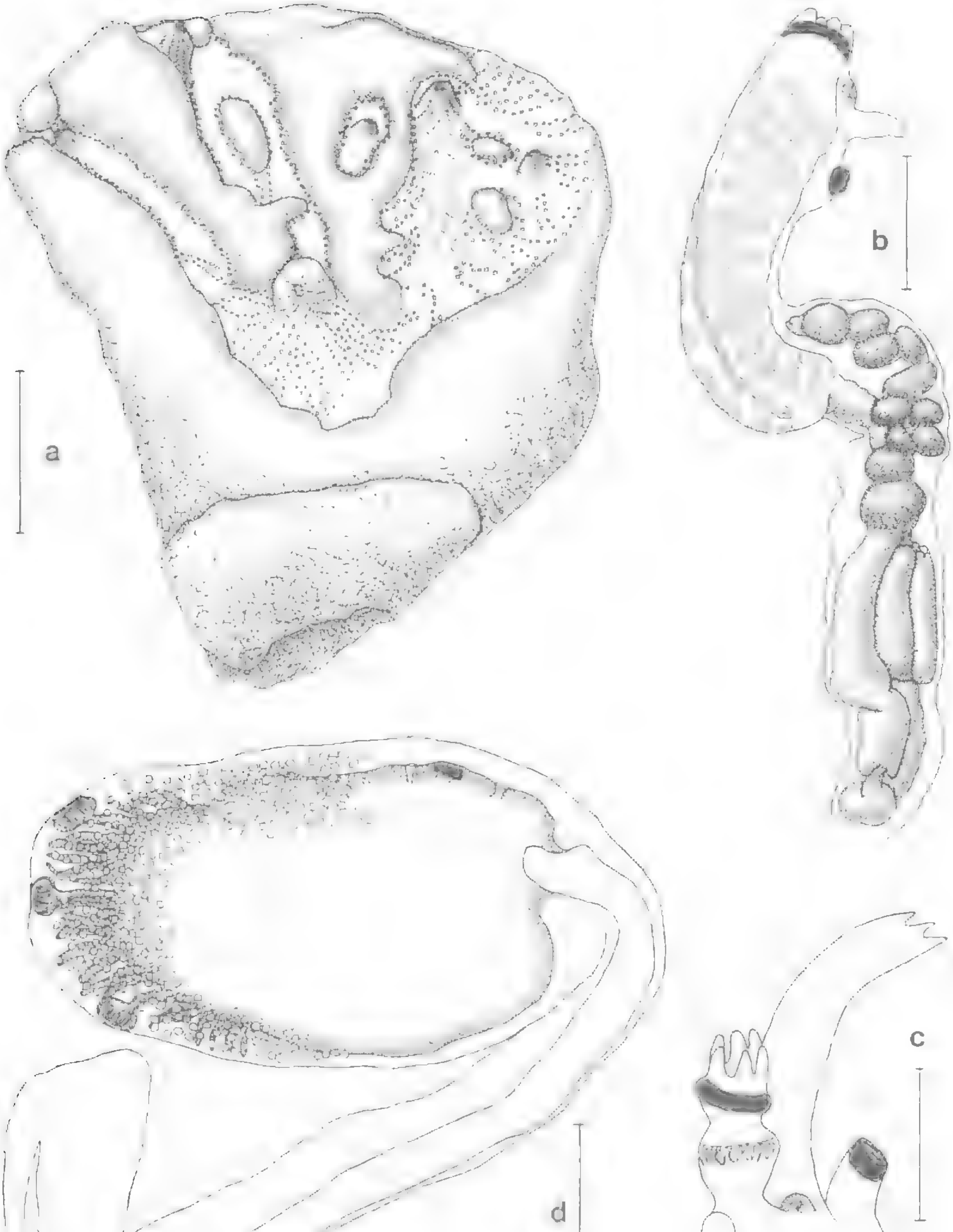
The abdomen is almost as long as the thorax. The oesophagus is long and narrow. The small stomach has 5 deep folds in its wall. A long duodenum is continuous with a narrow proximal part of the mid-intestine. A small oval posterior stomach is in the distal part of the descending limb of the gut loop. A short, narrow distal section of the mid-intestine is between the posterior stomach and rectum in the bend of the gut loop. A distinct rectal valve is present. The anal opening is opposite the fourth most posterior row of stigmata.

A single or double series of male follicles is in the posterior part of the posterior abdomen.

A large embryo (trunk 1.5 to 2.5mm long) is in the posterior half of the atrial cavity of specimens collected in March at Busselton (QM GH5469), and January at Kangaroo I. (QM GH5432). The tail extends only to the anterior end of the trunk which has crowded hair-like ampullae obscuring the anterior end. Embryos and larvae are heavily pigmented (red and opaque).

REMARKS

The species is distinguished by 2 characters which although they occur separately in other species, seldom are found together as they are in the present one — the atrial lip is close to, but separated from the aperture, and the double rows of zooids converge to the cloacal aperture. It also has a group of characters which it shares with *A. crateriferum* and the temperate and partly sympatric *A. lunacratum* nom. nov., viz. the bulky sandy colonies, protuberant cloacal apertures, narrow


a
b
c
d

zooids with 5 well-formed stomach folds, and the atrial lip separate from the aperture.

The zooid systems are not always so deeply depressed into the surface as they are in *A. crateriferum*, and *A. lunacratum* nom. nov. has sand in the test over the cloacal cavity and in the protuberant cone of the cloacal aperture. Both the latter species have their zooids arranged in a single circle around each common cloaca. In *A. crateriferum* the atrial lip is not close to the aperture as it is in the present species and *A. lunacratum* does not have the same bulging branchial sphincter and long siphon. In *A. lunacratum* the thoracic muscle bands, and in *A. crateriferum* the number of rows of stigmata are more numerous. The larvae of *A. clivosum* are in the same size range as those of *A. lunacratum* but larger than those of *A. crateriferum*. Larvae of the present species differ from *A. lunacratum* in having fewer epidermal vesicles and more ampullae.

Aplidium pantherinum (Sluiter, 1898) and its synonyms from South Africa (see Millar 1962) have a smaller larval trunk, and although they have narrow thoraces and about 17 rows of stigmata like the present species, the atrial tongue is not separate from the aperture.

Aplidium clivosum has possibly more variation in its external appearance than most other species of *Aplidium*. The size of the systems varies, as does the number per colony, the amount of embedded sand, the colour and the depth of surface depressions. These variations are not geographically based however and the whole range of morphological variations occurs in tropical as well as temperate waters.

In view of its wide range in Australian waters, it is probable that it will be found to occur in the Western Pacific. It is possible that some of the specimens assigned to *A. crateriferum* by Van Name (1918) from the Philippines are of this species.

Aplidium congregatum n.sp.
(Fig. 69)

DISTRIBUTION

TYPE LOCALITY: Queensland (North Stradbroke I., Point Lookout, coll. A. Rozefelds 17.11.78, holotype QM GH5584).

FURTHER RECORDS: None.

Specimens are found tucked into narrow rocky crevices at the type locality.

DESCRIPTION

EXTERNAL APPEARANCE: Sandy flat-topped lobes 1.5 to 2cm diameter around the upper surface, narrow toward the base where they are joined through common test. The edges of the flat upper surface fuse with adjacent lobes. A layer of sand adheres to the outside of the stalks and sides of the lobes, but is absent from the upper surface. Internally sand grains are scattered sparsely amongst the zooids. Zooids are crowded and parallel in the test. They may be in rows along each side of long canals that converge to the sessile cloacal apertures on the flat upper surface.

INTERNAL STRUCTURE: Zooids are long and narrow, up to 5mm long, of which the thorax and abdomen together comprise about half, and the thorax is about twice the length of the small abdomen. About 16 fine longitudinal muscles extend separately along the length of the zooid and are not gathered into bands on either side of the abdomen or the posterior abdomen. A distinct sphincter muscle is at the base of the 6 narrow, pointed lobes fringing the branchial aperture. The atrial aperture is at the anterior end of the dorsal surface with the forked atrial tongue extending from the anterior rim of the opening. Fine muscle fibres extend along the length of the atrial lip. The stigmata are in 11 rows of up to 12. The oesophagus is moderately long and narrow. The stomach is small and narrow with 12 longitudinal folds in its wall. There is the usual narrow mid-intestine, interrupted at the end of the descending limb of the gut loop by an oval posterior stomach. Small rectal caecaare at the proximal end of the rectum.

A large (4 or 5 oocytes) ovary is at the proximal end of the posterior abdomen and the testis follicles in a single or paired series are behind it in the long, narrow posterior abdomen. The holotype has up to 6 embryos being incubated in a developmental series lined up in the atrial cavity, tending to stretch the thorax longitudinally. Tailed larvae have a trunk 0.5mm long with the tail wound three quarters of the way around it. Conical median ampullae (4) alternate with the median adhesive organs. An arc of scattered epidermal vesicles (about 3 or 4 deep) is around the lateral line on each side of the adhesive organs and extending posterior to them along the dorsal and ventral border of the larval trunk. An ocellus and an otolith are present.

FIG. 68. *Aplidium clivosum* n.sp. — a, colony (QM GH5669); b, thorax and abdomen (QM GH5670); c, branchial aperture, atrial aperture and atrial lip showing sphincter muscles (SAM E2564); d, larva (QM GH5469). Scales: **a**, 1cm; **b**, 0.5mm; **c**, 1.0mm; **d**, 0.4mm.

REMARKS

The species is found in similar habitats and in the same geographic location as other flat-topped sandy, lobed species, all superficially resembling one another, viz. *Aplidium incubatum* n.sp., *A. directum* and *Botryllus stewartense* (see Kott 1990). The flat topped lobes of *A. congregatum* have more complex systems of crowded zooids than the others; *Aplidium directum* is distinguished by its tougher colonies with distinct circular systems, only 5 stomach folds and an atrial lip separate from the opening; *Aplidium incubatum* n.sp. tends to divide into separate lobes each with a single system, its zooids have 25 stomach folds, and the larvae have numerous vesicles but no ampullae.

The larvae of the present species resemble those of *A. opacum* which has investing, naked colonies; and *A. geminatum* n.sp. which has stalked heads with long cloacal canals converging to terminal cloacal apertures.

Zooids of the present species share some characters with those of *Aplidium fluorescum* n.sp., but both larvae and colonies are different.

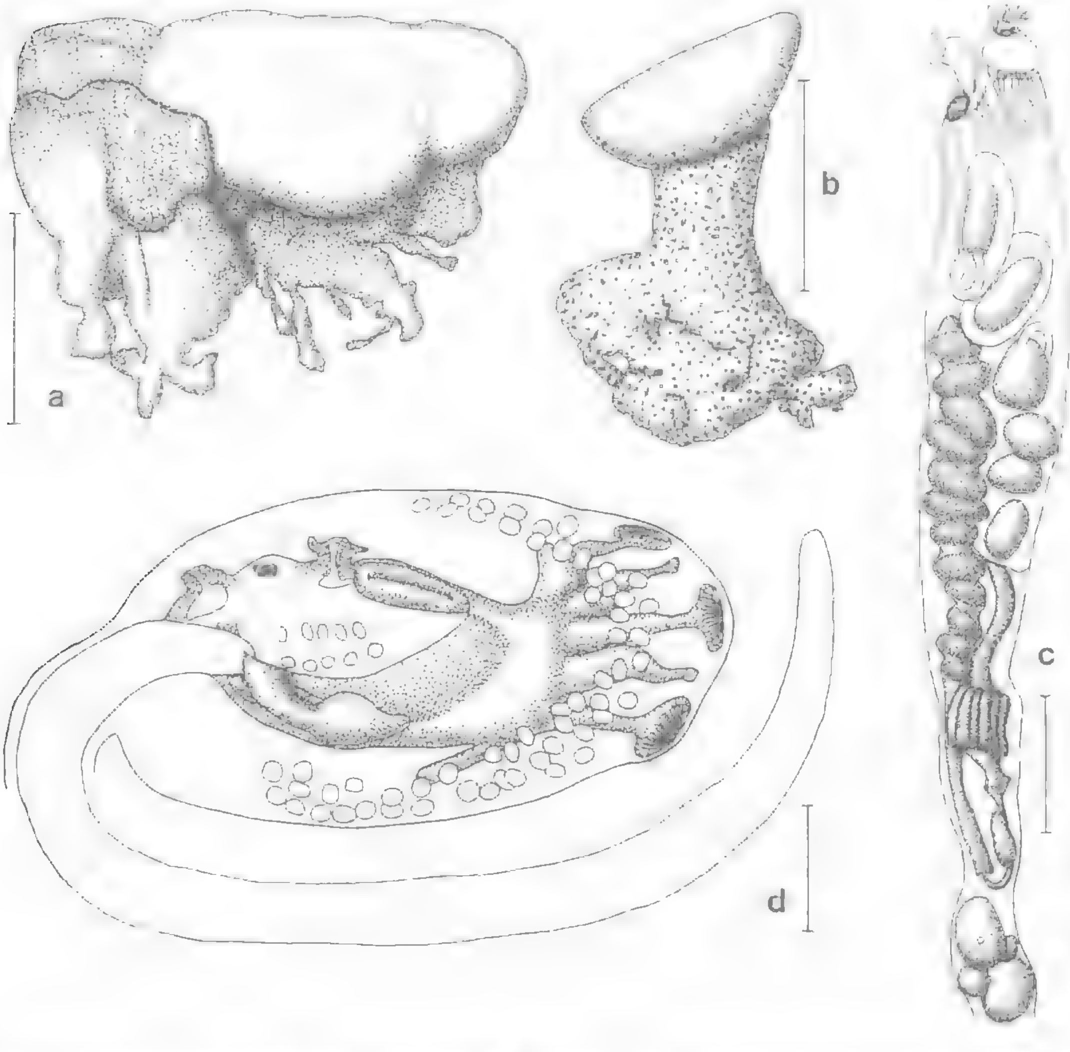


FIG. 69. *Aplidium congregatum* n.sp. (holotype QM GH5584) — **a**, **b**, colonies with positions of zooids shown in part of a colony lobe. **c**, thorax, abdomen, part of posterior abdomen and embryos in atrial cavity; **d**, larva. Scales; **a**, **b**, 1cm; **c**, 0.5mm; **d**, 0.1mm.

Aplidium coniferum Kott, 1963
(Fig. 70)

Aplidium coniferum Kott, 1963, p.102.

DISTRIBUTION

NEW RECORDS: South Australia (Elliston, SA E2580). Tasmania (off Devonport, AM E309; Huon Channel, TM D2074). Victoria (Bass Strait, QM G11861 GH5605, MV H462; Cape Everard, AM E6231–2; Gabo I., SAM E2592).

PREVIOUSLY RECORDED: New South Wales (Montague North, Twofold Bay, AM U3921 Kott 1963).

The species is known from depths to 400m (AM E6231–2).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are upright spherical to egg-shaped lobes, largely naked and without sand in the thin layer of smooth surface test. A basal hard sandy holdfast is probably rooted in sand. Sand is present in moderate concentrations internally. Zooids appear crowded in circular, oval to elongate systems, as well as some in double rows. However, the test is hard, whitish and almost opaque in preservative and it is difficult to determine the exact arrangement of the zooids. The shallow common cloacal cavities are relatively limited. They are surrounded by the fine, thread-like zooids, which are perpendicular at the surface, but cross one another posteriorly in the centre of the colony.

INTERNAL STRUCTURE: Zooids are narrow, and long. The branchial siphon is short, with 6 rounded lobes, but the prebranchial area is relatively long. The thorax and abdomen are each about 2mm even when contracted, and the posterior abdomen is many times that length. The atrial lip is small, pointed and arises from the body wall opposite the first row of stigmata. The atrial aperture is a small round opening, well removed from the lip, opposite the fifth or sixth row of stigmata. There is a pointed papilla posterior to the atrial aperture. About 2 longitudinal muscle bands are on the thorax and continue in wide bands along each side of abdomen and posterior abdomen. Stigmata are in 22 rows of 8 per row. The oesophagus also is long, and wrinkled when contracted. The stomach wall has 5 deep folds. There is a long duodenum and mid-intestine, and a small oval posterior stomach in the descending limb of the gut loop. Rectal caeca are not well developed.

A series of male follicles is in the posterior half of the posterior abdomen, and the small cluster of oocytes is just anterior to the male follicles. A large embryo sometimes is found being incubated in the atrial cavity (QM G11861). The larval trunk is 0.65mm long. It has lateral ampullae on each side near the base of the 4 median ampullae, the

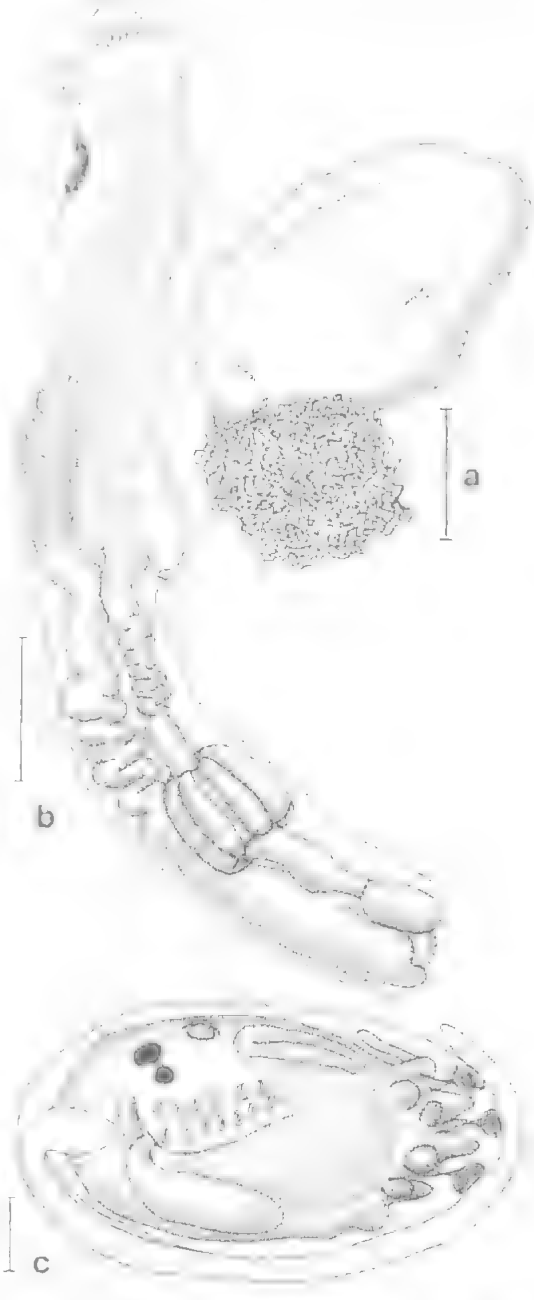


FIG. 70. *Aplidium coniferum* — a, colony (QM GH797); b, thorax and abdomen (MV H462); c, larva (QM G11861). Scales: a, 2cm; b, 0.5mm; c, 0.1mm.

latter alternating with the adhesive organs. The tail is wound about two-thirds of the distance around the trunk.

REMARKS

The large colony with embedded rather than surface sand and basal sandy holdfast, the long and narrow oesophagus, small and isolated atrial lip, and long thorax, are distinctive. The stomach folds are well formed, confirming that it is a species of *Aplidium* rather than *Synoicum*, which it resembles in having a dorsal papilla. The crowded systems distinguish the species from others such as *A. crateriferum* which, also has a long, narrow thorax, and separate atrial lip.

A colony from Bass Strait (AM E309) characteristic of this species, with sandy basal stalk, naked, upright, ovoid colony, and long narrow posterior abdomina criss-crossing internally, originally was assigned to *A. jacksoni* by Kott 1963. Despite her interpretation that the zooids were similar to those of *A. jacksoni*, this was not confirmed on reexamination of the specimen. The zooids are juvenile vegetative ones and neither stomach nor branchial sacs are developed.

Aplidium crateriferum (Sluiter, 1909)

(Fig. 71. Plate 13a–c)

Amaroucium crateriferum Sluiter, 1909, p.103.
Not Van Name 1918, p.163. **Not** Tokioka, 1967, p.40.
Aplidium crateriferum: Millar, 1975, p.242.

DISTRIBUTION

NEW RECORDS: Western Australia (Flinders Shoal near Onslow, QM GH5403; Exmouth, QM GH5398). Queensland (Capricorn Group, QM GH5158–9 GH5567; central section Great Barrier Reef, QM GH5422).

PREVIOUSLY RECORDED: Philippines (Sluiter 1909, Van Name 1918, Millar 1975).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are bulky, gelatinous and translucent but firm. The surface is smooth, and raised in high rounded ridges around irregular surface depressions. One to 3 large conical elevations with a terminal common cloacal aperture arise from each depression. Single apertures are sometimes more or less central but often at one or the other end. A shallow but extensive cloacal cavity is beneath the rela-

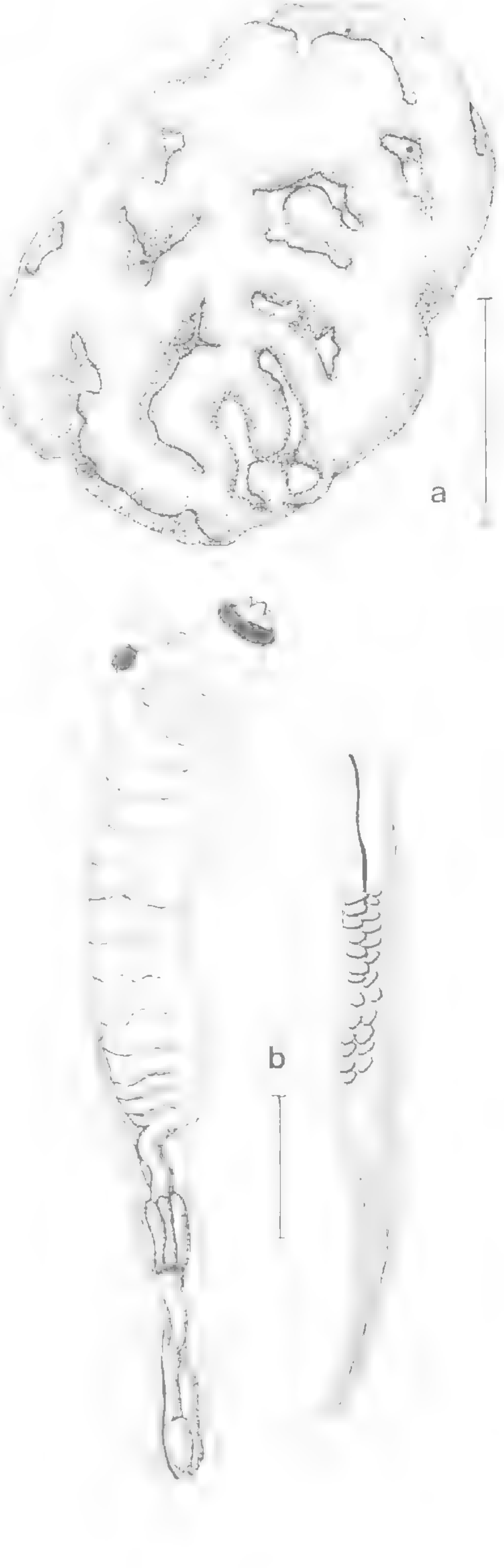


FIG. 71. *Aplidium crateriferum* — a, colony (QM GH5158); b, zooid (Heron I.). Scales: a, 2cm; b, 0.5mm.

tively thin surface test in the floor of each depression. Zooids surround each cloacal cavity, their branchial apertures at the base of the surface ridges, and protected by them. The atrial apertures are directed laterally to open into the cloacal cavity.

In some colonies a little sand is in the surface test around the apertures, but otherwise embedded sand is not present, and the surface is naked. In other colonies, sand is scattered throughout the test, amongst the zooids as well as in the zooid-free areas, and is on the external surface of the high ridges, although the surface of each depressed area is naked (QM GH5403).

Living colonies are said to be grey with red zooids, although photographs of specimens following their removal from the substrate are brown and yellow. In preservative the zooids, test and preservative are bluish-pink.

INTERNAL STRUCTURE: The zooids are long and thread-like, with the thorax (to 5mm) twice the length of the abdomen. The posterior abdomen is many times the length of the rest of the zooid. A long, conspicuous branchial siphon has a narrow bulging sphincter muscle at the top, near the base of the branchial lobes. This sphincter appears to have a blood sinus associated with it, and it is invariably pink and translucent.

There is a long pre-branchial area between the branchial tentacles and prepharyngeal groove and this effectively increases the length of the branchial siphon. The branchial tentacles cause a bulge about halfway down the siphon. Imperforate areas are anterior to the stigmata, and along each side of the endostyle. The atrial lip is usually a single pointed but quite fleshy lobe from the body wall anterior to the opening. The atrial aperture also has a sphincter muscle. About 15 fine longitudinal muscles are on the thorax and extend the whole length of the zooid. Fine transverse muscles are in the transverse vessels, but not in the parietal body wall. There are 18 to 21 short rows of up to 14 oval stigmata on the left and up to 10 on the right side of the branchial sac. The maximum number of stigmata (8 to 14) is in the fifth to eighth rows. Up to 4 more stigmata are on the left than the right. On the left the triangular dorsal languets are opposite the third to fourth stigmata i.e. almost halfway across the pharyngeal wall in the smaller, narrower zooids.

The short gut loop has the usual parts, with a slightly longer oesophagus than usual, and a relatively small stomach, with 5 distinct, deep folds in its wall. The posterior stomach also is short. Two conspicuous rectal caeca form a valve at the proximal end of the rectum. The posterior abdomen is long and thin. Two irregular longitudinal series of testis follicles are about halfway down it.

Single large embryos are in the thoraces of zooids collected in November, but not in May. The larvae are amongst the largest known for *Aplidium*, with the trunk 2mm long. The tail winds about three-quarters of the way around it. The long slender stalks of the 3 median adhesive organs are obscured by crowded epidermal vesicles which develop from the anterior part of the larval trunk.

REMARKS

The large, firm gelatinous colonies with surface depressions over the systems are one of the most conspicuous aspects of this species. The colonies are reminiscent of the colonies of *Lissoclinum patella* (see Kott 1980), *Synoicum castellatum* (see above) and *Aplidium clivosum*.

The sandy species *Aplidium caelestis*, with zooid openings protected by sand-filled swellings on the surface test, has similar narrow zooids with their atrial lip separate from the opening but they do not have the conspicuous surface depressions and circular systems of the present species.

The mostly temperate *Aplidium clivosum* also has similar zooids which open into deep surface depressions. However, it has zooids in double rows converging to the protruding common cloacal apertures, and fewer (14 to 18) rows of stigmata.

Sluiter's type specimen, from the Philippines, a large, fleshy mass, maximum dimension 10cm and up to 1.5cm thick with characteristic surface depressions and projecting cloacal apertures, closely resembles the present colonies. Millar (1975) describes similar colonies from this location. Other colonies from the type locality (Van Name 1918) are irregular with deep folds, but only shallow depressions, large systems with irregularly distributed zooids opening onto the flattened upper surface of the colony, and the surface thickly encrusted with foreign particles. These do not seem to be conspecific with the present species and are more like specimens of *Aplidium caelestis* (see below), which has similar zooids, but double row systems and embedded sand.

Tokioka's (1967) specimens from the Palau Is also appear to belong to some other species. They lack the characteristic surface depressions and the atrial lips extend from the upper rim of the opening rather than being separated from it as in the present species.

The narrow branchial sac, with wide bands of imperforate pharynx dorsally and ventrally is a characteristic of this species referred to by Sluiter (1909) in his description of the type. It should be noted that his figure of the branchial sac of the type (Sluiter 1909, pl.V7b) has been reversed — the larger number of stigmata and the dorsal languets are on the left, not on the right.

However, Sluiter appears to have overlooked the position of the atrial aperture and the sphincter muscles of both apertures, and miscounted the number of stomach folds (see Millar 1975). Sluiter has not always been accurate in his count of stomach folds (see *A. pantherinum*: Millar, 1962).

Aplidium depressum Sluiter, 1909
(Fig. 72)

Aplidium depressum Sluiter, 1909, p.102. Hartmeyer 1909, p.1499. Van Name, 1918, p.167. Kott, 1963, p.95. Kott and Goodbody, 1982, p. 515. **Not** Kott 1976, p. 60; 1981, p. 160.

DISTRIBUTION

NEW RECORDS: Queensland (Capricorn Group, QM GH890 GH916 GH2275 GH5680 GH5682 GH5690 GH5692 GH5693–702 GH5705–6).

PREVIOUSLY RECORDED: Queensland (Bargara — Kott 1963). Indonesia (Sluiter 1909; Van Name 1918). Hong Kong (QM G12796 Kott and Goodbody 1982).

These transparent, investing sheets, are probably more common than the records suggest. They are difficult to remove from the substrate and possibly are often overlooked by collectors.

DESCRIPTION

EXTERNAL APPEARANCE: Some colonies are thin, investing gelatinous sheets with a smooth upper surface, or they are irregular with the surface divided by shallow creases, or raised into convoluted ridges with common cloacal apertures along the ridges. One colony (QM GH5695) is a small cushion, trimmed to fit the back of a small crab on which it was found. In preservative, the small zooids are irregularly distributed and randomly oriented, usually lying at angles to one another. The test is translucent to glassy, firm and colourless. In life the zooids are maize yellow or orange to beige or pinkish beige, but they become white in preservative. *Prochloron* is found in the cloacal cavity and on the surface of some colonies (QM GH5682; see also Kott *et al.* 1984). Sand grains are sparsely scattered through the test, occasionally becoming crowded toward the base.

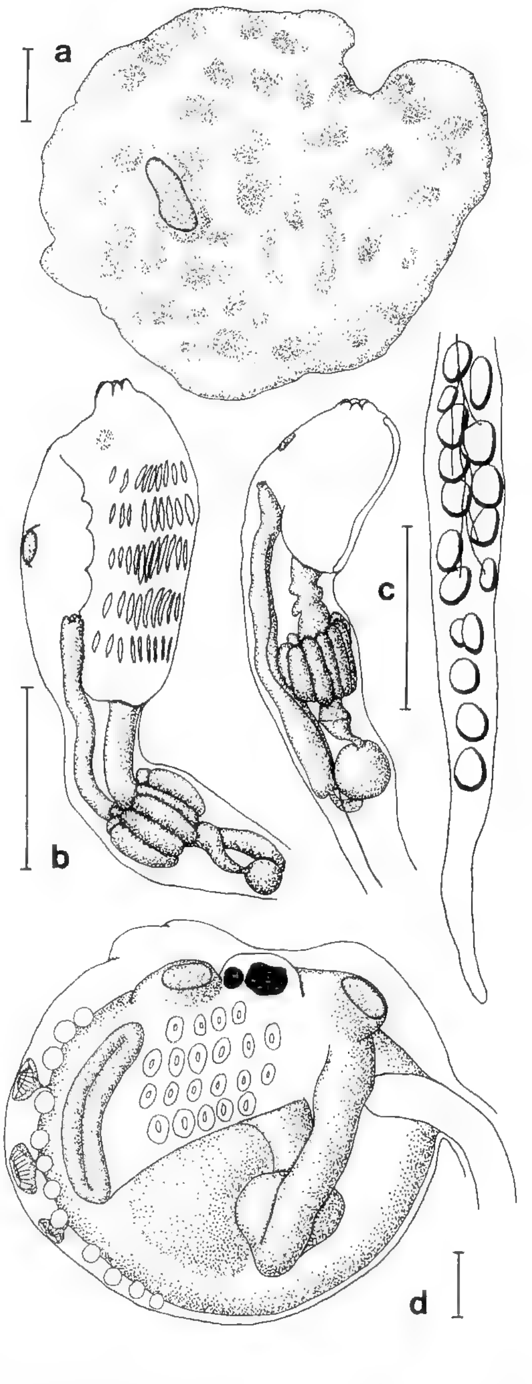


FIG. 72. *Aplidium depressum* — **a**, colony (QM GH890); **b**, **c**, thorax and abdomen, posterior abdomen separately (QM GH5697 QM GH5688); **d**, larval trunk (QM GH5693). Scales: **a**, 1mm; **b**, **c**, 0.5mm; **d**, 0.05mm.

Minute test cells appear as evenly spaced grains in the test.

INTERNAL STRUCTURE: Zooids are small, being no more than 3mm overall. The thorax and abdomen are of about equal length, and together are slightly shorter than the posterior abdomen which usually is relatively slender, tapering to its posterior end. The branchial aperture has 6 lobes. The atrial aperture is a single circular opening, sometimes on a short siphon, halfway down the thorax. There is no atrial lip. Stigmata are in 5 rows of up to 10, their length reducing at the dorsal end of each row.

The stomach wall has 11 distinct folds. A short thick duodenum and oval posterior stomach are in the post-pyloric part of the descending limb of the gut loop. The posterior abdomen is relatively short with a small ovary anterior to one or 2 rows of testis follicles. Up to 3 embryos are in the atrial cavity of colonies collected from Bargara in August and from the Capricorn Group from August to March (QM GH2276 GH5680 GH5683 GH5693–4 GH5702–3).

The larvae are amongst the smallest aplousobranch larvae known, with a spherical trunk only about 0.35mm in diameter. The greater part of the trunk is occupied by the developing adult organs — gut and pharynx. However, the cerebral vesicle is large in relation to the size of the trunk. A row of 7 or 8 epidermal vesicles is on each side of the median adhesive organs. Conspicuous test cells are in the surface of the larval test, tending to obscure the internal structure of the larva.

REMARKS

The principal characters of the present species are the transparent gelatinous test, the beige, yellow or pink zooids, the lack of an atrial lip, the 5 rows of stigmata, the relatively numerous stomach folds (12) and the minute spherical larval trunk.

The type specimen (Sluiter 1909) was gelatinous, with violet zooids seen through the test. Systems were not observed, although cloacal apertures were. The atrial siphon, without an atrial lip, is halfway down the thorax. Sluiter reported 9 rows of up to 14 stigmata in the branchial sac and numerous narrow folds in the stomach wall. Thus there is a discrepancy in the number of rows of stigmata and the colour between Sluiter's description and the newly examined material. There also is a discrepancy in the numbers of rows of stigmata in Van Name's (1918) specimens, with 6 or 7 rows of stigmata. Both Van Name and Sluiter may have had difficulty in determining the exact number of rows of stigmata in these small zooids, for most of the other characters conform with the newly recorded material. The ragged colony from Fiji (QM GH86) assigned to this species by Kott (1981), has been reexamined. It has, as reported, 8 rows of stigmata and a minute stomach with about 12 folds. There also is a narrow atrial lip from the upper border of the aperture which Kott overlooked. The colony is not conspecific with the present species. The colony (QM G12796) from Hong Kong (Kott and Goodbody 1982) appears to be correctly assigned.

Aplidium directum Kott, 1972
(Fig. 73)

Aplidium directum Kott, 1972c, p.246.

DISTRIBUTION

NEW RECORDS: Queensland (Dunwich, QM GH5517 GH5519; Cape Moreton, QM GH5614).

PREVIOUSLY RECORDED: New South Wales (Cronulla — AM Y1110–1 Kott 1972c).

The specimens are dredged from 6m to 140m from the sea floor.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are flat-topped, upright lobes, either separate or joined to a common base to form irregular, sandy masses up to 2.5cm high. The common base often is thin and keel-like and probably is buried in the substrate. Each separate lobe is about 1cm diameter, with a raised rim around its upper margin, surrounding a central depression containing a common cloacal aperture. Zooids are around the shallow common cloacal cavity beneath this depression.

Crowded sand particles are all over the surface of the colony and embedded throughout the test. Smaller sand grains only are on the surface in the terminal depression around the common cloacal aperture. In one extensive colony (QM GH5517) these smaller grains in the centre of each terminal lobe are black, apparently coal particles. Larger siliceous sand particles mixed with sparse black grains to give a grey colour are all over the remainder of the colony.

INTERNAL STRUCTURE: Zooids are thin and thread-like. The thorax and abdomen are of about equal length and together about 6mm. The branchial siphon has 6 distinct lobes. The atrial lip arises from the body wall just anterior to the aperture, which projects slightly on a short siphon

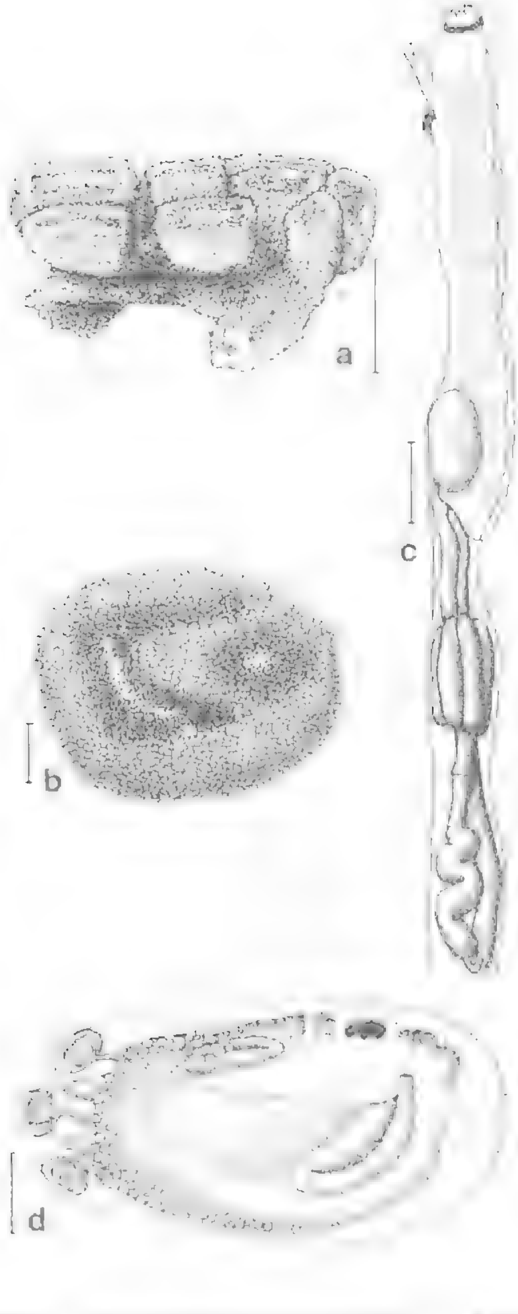


FIG. 73. *Aplidium directum* (QM GH5517) — **a**, colony; **b**, top of colony lobe showing depressions into which systems open with smaller grains of embedded sand; **c**, thorax, abdomen and embryo in atrial cavity; **d**, larval trunk. Scales: a, 1cm; b, 2mm; c, 0.5mm; d, 0.1mm.

with a sphincter muscle. The tip of the atrial lip is pointed or bidentate. There is a long unperforated band of pharyngeal wall both anterior and posterior to the perforated area. Short, wide stigmata are in 10 to 13 rows of up to 14 per row. The oesophagus is a narrow vertical tube. The stomach, also relatively long and narrow, has 5 well-defined folds. In extended zooids the post-pyloric part of the gut loop is relatively long. The descending limb has a long narrow duodenum and mid-intestine, but a relatively thick and slightly spiralling extent of gut in the lower one-third of the descending limb is in the position usually occupied by the short posterior stomach, well developed rectal caeca are at the proximal end of the rectum.

One or 2 embryos are in the posterior part of the atrial cavity in the material from Dunwich (collected in August), but not in the other specimen lot from Cape Moreton taken in the same month (QM GH5614). The larval trunk is about 0.5 to 0.6mm long. It has a conical median ampulla in each of the interspaces between the adhesive organs. An arc of epidermal vesicles is on each side of the median line around the anterior half of the larval trunk. The tail is wound about two-thirds of the way around the trunk. Ocellus and otolith are present.

REMARKS

The colony of this species resembles that of *Synoicum obscurum* and *Aplidium filiforme* n.sp. in the quantity of sand present, the size of the zooids, and the circular systems in lobes rising from the upper surface. *Aplidium filiforme* n.sp. is distinguished by having only 5 rows of stigmata a shorter branchial sac, a longer oesophagus, shallower stomach folds, 4 or 5 systems per colony lobe, and larvae without median ampullae.

The species is found in association with others superficially similar and sandy, viz. *Aplidium incubatum* n.sp., and *Botryllus stewartense* (see Kott 1985).

Larvae are not known from the New South Wales population — the type specimens of this species. However the similar morphology of these and the material from Moreton Bay indicate that they are conspecific.

Aplidium distaplium n.sp.
(Fig. 74)

DISTRIBUTION

TYPE LOCALITY: Victoria (Bass Strait, off Ninety Mile Beach, 10 km SW Seaspray, 560m off shore, calcenarite reef 12m, fast currents, coll. J.E. Watson 21.3.80, holotype QM G12728; paratype QM G12729).

Further Record: South Australia (Reevesby I., QM GH5602).

Description

External Appearance: The colonies are solid, sandy irregular masses. Sand is crowded throughout, obscuring the small zooids and their arrangement. Zooids are tightly enclosed in the sandy test.

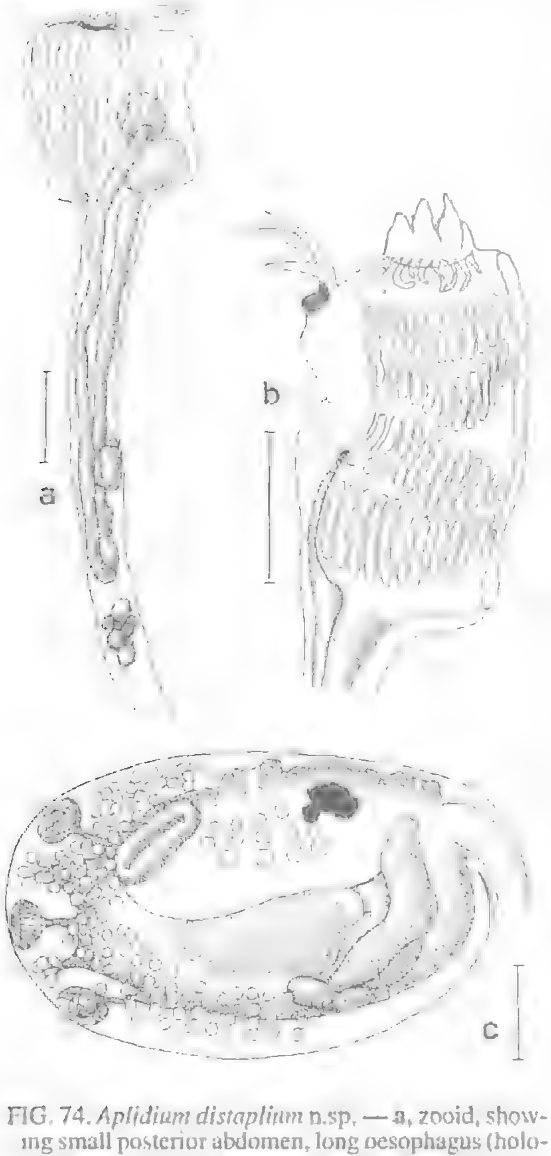


FIG. 74. *Aplidium distaplium* n.sp. — **a**, zooid, showing small posterior abdomen, long oesophagus (holotype QM G12728); **b**, thorax (paratype QM G12729); **c**, larval trunk (holotype QM G12728). Scales: **a**, **b**, 0.5mm; **c**, 0.1mm.

Internal Structure: Zooids are minute, the thorax, abdomen and posterior abdomen together being about 4mm long, of which the abdomen is about half the length, the thorax and posterior abdomen being relatively short. The 6 branchial lobes are triangular and the siphon is short. A flat atrial tongue, undivided, bi-, or tripartite, extends out from the upper rim of the small aperture. About 15 muscle bands extend from the thorax, although they are fine, and the zooid is delicate.

Stigmata are in 4 rows of 12, and these rows are arranged in 2 pairs as in *Sycozoa* (see Kott 1990). The oesophagus is an unusually long vertical tube, and the 5-folded stomach is in the posterior half of the abdomen. The post-pyloric part of the descending limb of the gut loop (with the usual duodenum, mid-intestine and posterior stomach) is not as long as the oesophagus.

Sometimes the posterior abdomen is short, with only an ovary developed. In the male phase it is longer, with a double row of male follicles.

Embryos (up to 4) are incubated in the atrial cavity. The larval trunk is 0.52mm long. A large conical median ampullae with epidermal vesicles branching off it is in each interspace between the adhesive organs. Also there is a median dorsal ampulla and a ventral one. Epidermal vesicles are also scattered in an arc in the test around the anterior half of the trunk on each side. The tail is wound about three-quarters of the way around the trunk on each side of the median line.

Remarks

The species resembles *A. solidum* in its solid hard sandy colony, although the larval trunk of the present species is longer. The presence of 4 rows of stigmata rather than 5, is unusual in this genus. In the related genus *Synoicum* only *S. bowerbanki* has a similar number of rows of stigmata (see above).

Aplidium elatum Kott, 1972

Aplidium elatum Kott, 1972b, p.177

Distribution

New Records: None.

Previously Recorded: South Australia (Elliston Bay — SAM E905 E906 Kott 1972b).

Description

External Appearance: Colonies form tall, undulating fan-shaped lamellae, 1cm thick to 6cm high. Sand is present throughout, and the colony is hard. Common cloacal apertures are randomly distributed over the surface and zooids are along each side of the cloacal canals converging to them. The surface test is raised slightly over the anterior ends of each of the zooids.

INTERNAL STRUCTURE: The anterior part of thoraces and the endostyles are orange in preservative. Zooids are about 3mm long, the thorax and posterior abdomen approximately equal in length and slightly longer than the abdomen. The branchial lobes are sharply pointed. The atrial aperture, opposite the fourth to sixth row of stigmata has a large lip divided into 3 large, muscular, leaf-like lobes from its anterior rim. The muscles in the atrial lip are longitudinal, extending down the centre of each lobe. About 12 longitudinal thoracic muscles extend posteriorly in 2 bands along each side of the zooid. Stigmata are in 8 rows of about 8. The stomach is short with about 15 longitudinal folds. The usual duodenum and mid-intestine interrupted by a posterior stomach comprise the post-pyloric part of the descending limb of the gut loop. Gonads are in 2 series in the posterior abdomen. Larvae are not known.

REMARKS

The sandy colonies of this species resemble those of *A. petrosum* n.sp. and *A. solidum*, although they are neither as branched, nor as extensive. The zooids, with their large atrial lips from the upper border of the opening, and 15 stomach folds resemble *A. opacum*, as does their arrangement in double rows of zooids converging to the common cloacal apertures.

Aplidium filiforme n.sp.
(Fig. 75)

Aplidium thomsoni: Kott, 1963, p.97 (part, specimens from Cockburn Sound). **Not** *A. thomsoni* Brewin 1950a.

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I, Blue Pools, coll. D. Parry 9.11.86, holotype QM GH5527; 9.11.85, paratype QM GH5528).

FURTHER RECORDS: Western Australia (Cockburn Sound — Kott 1963). Queensland (Capricorn Group, QM GH5511 GH5515 GH5523 GH5554–5).

DESCRIPTION

EXTERNAL APPEARANCE: The colony consists of upright, flat-topped sandy lobes that rise from the surface of a common basal mass, and aggregate together along their length through the sand attached to the surface test. They form a sandy platform up to 4cm in maximum dimension and about 1cm high. Groups of 4 or 5 systems open onto the upper surface of each lobe. In some colonies the tops of a number of lobes seem to fuse to form a cushion-like platform, with crowded systems opening on its upper surface. Each system consists of a wide, sessile cloacal aperture in the centre surrounded by branchial apertures obscured by the sand which is embedded in the test. Sand is not always present around the cloacal openings. The systems are usually quite conspicuous, even when sand is present on the upper surface, for the branchial apertures have small sand particles outlining them, while large sand grains are embedded around the outside of each system and in the centre around the common cloacal aperture. Living zooids have orange thoraces.

INTERNAL STRUCTURE: The zooids are minute, thread-like, about 0.3mm thick and about 7mm long. The thorax and abdomen together are about 3mm long and the posterior abdomen is at least twice that length. The branchial siphon is short although the branchial sphincter is large, bulging and conspicuous. The atrial aperture, with a short, stumpy tripartite lobe from the upper rim of the opening, is antero-dorsal. The 5 rows of stigmata have no more than 6 per row, although these could not be counted accurately. The oesophageal neck is longer than the post-pyloric part of the gut loop. The stomach has 5 distinct folds.

Ovary and testis are not mature in the one zooid at the same time. The ovary, when present, is a short distance from the posterior end of the gut loop — in the middle of the anterior third of the posterior abdomen. When the testis follicles are mature they are in a single row in the middle third of the posterior abdomen.

In the holotype colony 3 embryos are lined up in the atrial cavity. The most anterior of these is a tailed larva. The trunk length is surprisingly variable being 0.32 to 0.6mm. The adhesive organs are in the anterior mid-line. Epidermal vesicles, scattered 2 or 3 deep, in a long narrow arc along each side of the median line, branch off common stalks. Median vesicles also branch off one or 2 common stalks in each interspace between the adhesive organs. The arc of lateral vesicles extends well postero-ventrally and postero-dorsally.

REMARKS

This species, with its unusual lobed colony, small zooids with 5 rows of stigmata, 5 stomach folds, orange thorax and colourless abdomen and posterior abdomen resembles *Aplidium mernooensis* (Brewin, 1956) from Chatham I., New Zealand and one colony from New Caledonia (Monniot 1987). Like the type, the specimens from New Caledonia have single systems of zooids in each lobe of the colony, and 8 branchial lobes. Although Brewin records the height off the substrate of *A. mernooensis* as only 2mm, its zooids are said to be 8mm long. Thus it appears that the base of the colony was embedded in the

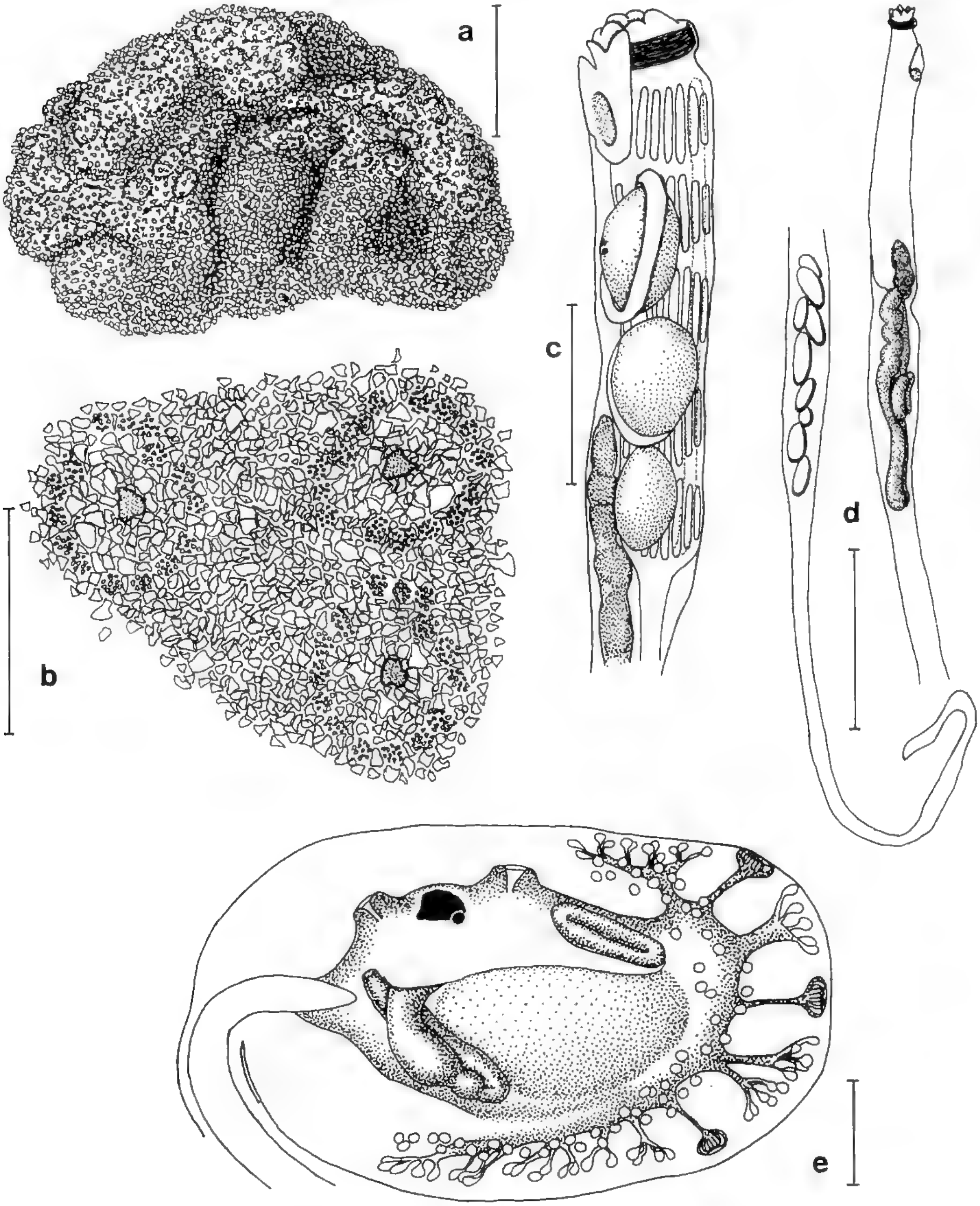


FIG. 75. *Aplidium filiforme* n.sp. — **a**, whole colony (QM GH5523); **b**, upper surface of colony lobes showing systems (QM GH5515); **c**, thorax with embryos in atrial cavity (QM GH5515); **d**, outline of whole zooid (QM GH5515); **e**, larval trunk (QM GH5555). Scales: **a**, 1cm; **b**, 5mm; **c**, 0.5mm; **d**, 1mm; **e**, 0.1mm.

substrate, and that it is much the same size as the present species. However, the present species has more than one system per colony lobe to distinguish it, and although *A. mernooensis* has sand externally, it lacks the embedded sand of *A. filiforme*. There also are more numerous stigmata in the Chatham I. colonies than in *A. filiforme*. Larvae from the New Caledonian colony (*A. mernooensis*: Monniot, 1987) have a trunk 0.65mm long with a wide lateral band of vesicles obscuring the anterior end of the trunk similar to the vesicles in *A. caelestis*, *A. clivosum*, *A. crateriferum*, and *A. griseum* n.sp. The vesicles in the narrow lateral arc of the present species are less numerous and are spread over a smaller area at the anterior end of the trunk.

The large bulging branchial siphon known in *A. crateriferum* and *A. clivosum* is an unusual character not usually present in species with zooids as small as those in the present species. Monniot (1987) records a strong branchial spincter in the New Caledonian specimen. The larvae and zooids of the present species are among the smallest known in the genus.

Aplidium bacculum also has only 5 rows of stigmata, but its terminal heads, onto which zooids open, are naked, its systems less regular, its stalks longer and the oesophagus about two-thirds of the length of the abdomen.

Aplidium fluorescum n.sp.
(Fig. 76)

Aplidium multiplicatum: Kott, 1963, p.103 (part specimen from Sarina).

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I., NE Point, rubble fauna, low tide, coll. P. Kott 4.5.85, holotype QM GH5243; Heron I., NE reef, rubble fauna, coll. P. Kott 14.11.85, paratypes QM GH5244; coll. P. Kott May 1987, paratypes QM GH5245; NE Heron reef, coll. P. Kott 2.11.86, paratypes QM GH5246; Heron I., The Canyons, coll. P. Kott 13.11.85, paratypes QM GH5247).

FURTHER RECORDS: Queensland (Sarina, AM Y1448; Lizard I, QM GH5630; Capricorn Group, QM GH5318–24).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are small, rounded to dome-shaped cushions, to about 1cm in maximum thickness. Only the colony from Sarina (AM Y1448) forms extensive investing sheets. Living test is translucent, or opaque-whitish, with green fluorescent particles around the branchial apertures and in the surface test. These particles give an azure-blue sheen to the colony. Zooids are 'buff pink', or 'maize yellow' (Ridgeway 1886), or pinkish white, with an orange stomach. In preservative the zooids are beige to white and the test is almost opaque, or translucent to glassy. One of the living specimens (holotype) was described as a 'translucent fluorescent potato'.

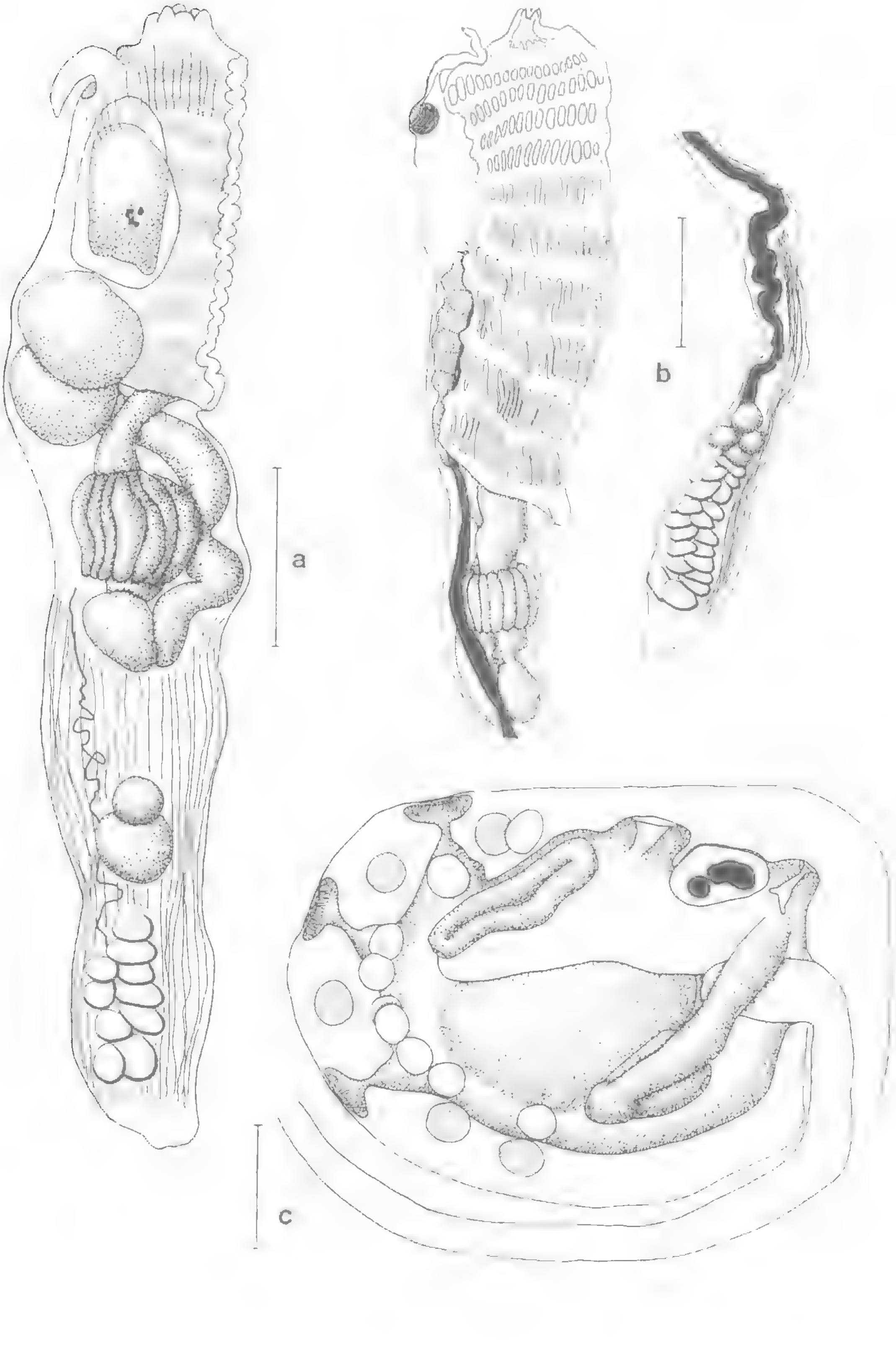
The test is firm and naked, and there is neither adherent nor embedded sand. The systems are circular, although often they are obscure in preserved specimens, with the zooids lying at various angles to one another in the firm test.

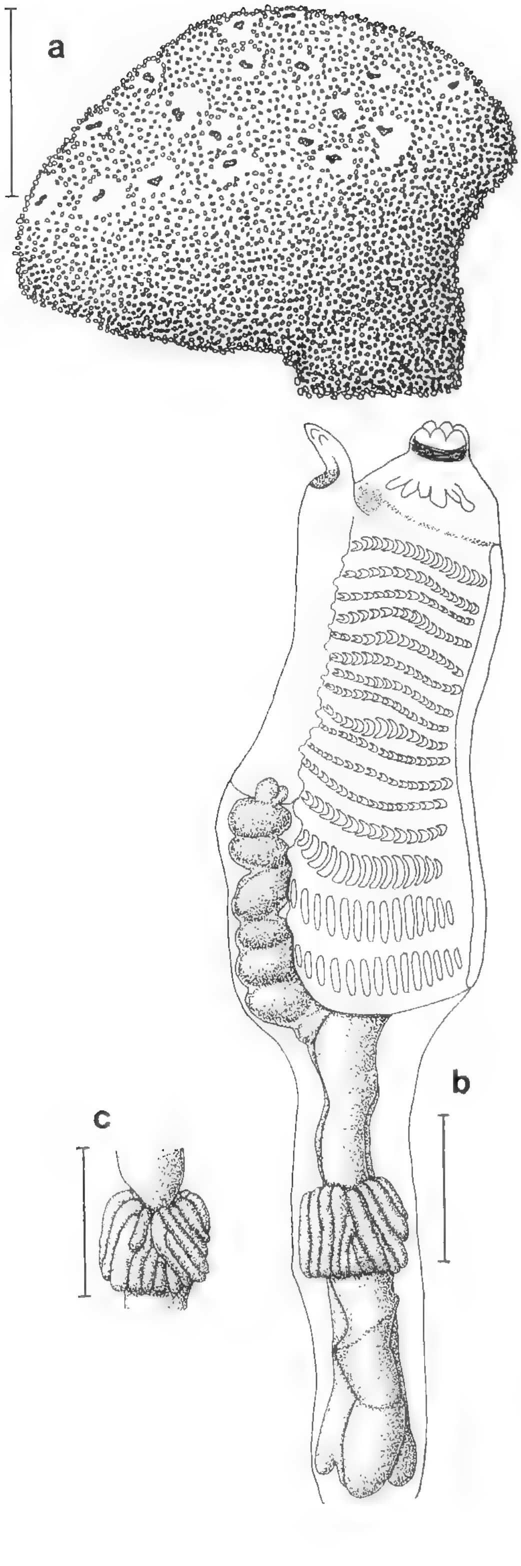
INTERNAL STRUCTURE: Zooids are about 6mm long when relaxed, the thorax and posterior abdomen of about equal length and the abdomen only a fifth of the total length. The branchial lobes are small and pointed and the branchial aperture almost sessile. The small and undivided atrial tongue arises from the upper border of the opening, which has a sphincter muscle. Fifteen to 20 longitudinal muscle bands are on each side of the thorax, and extend the length of the zooid, evenly spaced around it rather than forming a band on each side of the abdomen and posterior abdomen. The branchial sac has 10 rows of up to 16 stigmata. The moderately long stomach has 12 to 14 deep folds in its wall. The duodenum and proximal sections of the mid-intestine are wide, the latter being only slightly constricted from the oval posterior stomach.

Gonads are absent from the anterior half of the posterior abdomen, which is relatively short and thick and only occasionally larger than the thorax. The ovary is about halfway down the posterior abdomen, with the testis follicles in 2 irregular series posterior to it.

With only one exception (May 1987) the colonies from the Capricorn Group, all collected in April, May, August and November, have zooids with 2 or 3 embryos lined up in the atrial cavity. The larvae are small, the trunk being about 0.5mm long. They have the tail wound slightly more than halfway around the trunk. An ocellus and an otolith are present in the cerebral vesicle. There are 3 median adhesive organs on narrow stalks at the anterior end of the trunk, and up to 9 particu-

FIG. 76. *Aplidium fluorescum* n.sp. — a, b, zooids (paratypes QM GH5247, GH5244); c, larva (paratype QM GH5247). Scales: a, b, 0.5mm; c, 0.1mm.


a
b
c



larly large, spherical ectodermal vesicles separate from the lateral line on each side. Up to 3 embryos are in the Sarina specimens collected in August. Their larvae differ from the Capricorn Group ones only in having one more (total 10) epidermal vesicles in each of the lateral arcs. Ectodermal ampullae are never present.

REMARKS

The species is distinguished from others with naked colonies by its small zooids with the small atrial lip from the anterior rim of the opening and by the number of stomach folds and rows of stigmata. *Aplidium gelasinum* n.sp. is distinguished by its narrow thorax with only 8 stigmata per row. Its small larvae are also distinctive, and although similar ectodermal vesicles occur in other species (e.g. *A. multiplicatum*), there are fewer in the present species than in any others known.

Aplidium gastrolineatum n.sp.
(Fig. 77)

Aplidium flavolineatum: Kott, 1972b, p.177 (part, specimen from Waldegrave I.).

DISTRIBUTION

TYPE LOCALITY: South Australia (1km NW of Waldegrave I., Anxious Bay, 33°33'S, 134°46'E, rocky bottom, slow current, 23m, coll. S. Shepherd 11.5.71, holotype SAM E2584).

FURTHER RECORDS: South Australia (Pearson I. QM GH1292; Flinders I., QM GH2305).

DISTRIBUTION

EXTERNAL APPEARANCE: The holotype colony is an almost spherical cushion, 2.5cm diameter and 2cm high. It is fixed basally by a relatively broad sandy area. A thick layer of sand is present around the outer surface, being absent only from the circular depressed areas into which the systems open. Protruding common cloacal apertures are in the centre of each of these depressions. Zooids are in circles around each common cloacal aperture. The colony from Pearson I. lacks sand on the upper surface although it is present around the sides and base. It has the same circular systems and protuberant cloacal apertures. Sand is not embedded internally. The test is soft, white and translucent, and both colonies are distorted.

FIG. 77. *Aplidium gastrolineatum* n.sp. (holotype SAM E2584) — **a**, colony; **b**, thorax and abdomen; **c**, stomach from the left side. Scales: **a**, 1cm; **b**, 0.5mm; **c**, 0.5mm.

The zooids are tightly embedded in the test and a sheath of it, containing white opaque cells, clings to the zooids when they are removed. The living colonies are described as having a pink matrix with white zooids.

INTERNAL STRUCTURE: The zooids are robust, and the thorax and abdomen together are about 4mm long. The relaxed thorax is longer than the abdomen. The 10 fine longitudinal muscle bands on the thorax extend the length of the zooid in a wide band on each side. The 6 rounded branchial lobes are distinct. The atrial lip extends out from the upper rim of the aperture at the anterior end of the dorsal surface. It is thick and fleshy, with its tip divided into 3 rounded lobes. The stigmata are in 16 rows of up to 14. The stomach is relatively small, its diameter not markedly greater than that of the duodenum. Its wall has 24 mostly oblique folds. The stomach wall is more or less divided into 4 quarters with the folds in each quarter running obliquely to meet those of the adjacent quarters dorsally and ventrally, and in the middle of the mesial and lateral aspects. Three folds on the left side of the mid-dorsal line of the stomach, and 3 on the right of the mid-dorsal line do not reach the posterior end of the stomach, and further oblique folds in the middle of each side do not reach the anterior end. The duodenum and proximal end of the mid-intestine are wide. Rectal caeca are at the proximal end of the rectum.

Larvae are present in South Australian specimens collected in October (Kott 1972b, p.174 Fig. 30). They have a larval trunk 0.8mm long, and median and lateral ampullae between the adhesive organs. They lack epidermal vesicles.

REMARKS

The naked circular depressions each with a central protruding cloacal aperture, into which the systems open, are reminiscent of the surface of *Aplidium lunacratum* nom. nov. However, the latter species has only 5 stomach folds, and its atrial lip arises from the body wall anterior to the aperture, rather than from its anterior rim.

Aplidium incubatum n.sp. from Queensland also has circular systems opening into conspicuously naked surface areas. However, it has the surface of the colony partially divided, each division containing a system, and it has parallel longitudinal stomach folds.

Kott (1963, 1972a–c, 1975) erroneously assigned various specimens to the South African species *A. flavolineatum* Sluiter, 1898 on the basis of the number of gastric folds. Re-examination of these specimens has shown that they have other characters which distinguish them from one another, and from the African species (see *A. multilineatum* n.sp., *A. robustum* n.sp., *A. multiplicatum*, *A. uteute* and the present species). The present species is distinguished from the African *A. flavolineatum* by its oblique stomach folds and more numerous rows of stigmata. *Aplidium robustum* n.sp., which has similar numbers of stigmata and stomach folds, has more crowded systems and sessile cloacal apertures.

Aplidium gelasinum n.sp.
(Fig. 78)

DISTRIBUTION

TYPE LOCALITY: Queensland (far Northern Great Barrier Reef, Tydeman Reef, coll. AIMS Bioactivity Group 23.4.87 Q66 B2089, holotype QM GH5333).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a flat-topped cushion; 7cm in maximum dimension and 1cm high. In preservative, it has a white opaque deposit in the surface test, which emphasises the circular zooid systems, being more opaque around the outside of each system where the surface is raised into a rounded rim and the test is thicker — not being interrupted by either zooids or cloacal cavity. Each system is about 3mm diameter. The cloacal cavity is circular with a central protuberant aperture. White deposit is concentrated in the surface layer of test. Internally the test is gelatinous and translucent. The zooids are firmly embedded and the sheath of test immediately surrounding each contains opaque, white cells. The specimen is reported to have been orange with orange zooids in life.

INTERNAL STRUCTURE: The zooids have a long posterior abdomen, although the thorax and abdomen together are only about 3mm. The atrial lip, from the upper rim of the opening, has from one to 3 points. Stigmata are in 16 rows of only about 8 per row. The small, relatively short stomach has 16 to 18 longitudinal parallel folds. Duodenum, mid-intestine and posterior stomach are of the usual form. When contracted the posterior abdomen is pulled up into a coil behind the abdomen. Gonads are not mature in this specimen, and larvae are not known.

REMARKS

Superficially, the regular circular systems in this opaque, white colony resemble *Distaplia prolifera* Kott, 1990 and *Morchellium pannosum*.

The crowded small, regular circular systems also resemble those of *A. lunacratum* nom. nov., although the latter species is distinguished by its external layer of sand between the systems and its fewer stomach folds. *Aplidium protectans* has circular systems, but 8 branchial lobes, more numerous rows of stigmata, and fewer stomach folds. *Aplidium fluorescum* and *A. uteute* have naked cushion-like colonies with circular systems, and numerous stomach folds like the present species. However they are softer colonies, have more stigmata per row and lack the surface depressions of the present species.

Aplidium geminatum n.sp.
(Fig. 79)

Aplidium australiensis Kott, 1963, p.111 (part, specimens from Port Lincoln and Western Port).

DISTRIBUTION

TYPE LOCALITY: South Australia (Price I., Avoid Bay, coll. S. Shepherd 9.4.87, holotype QM GH4175; Port Bonython jetty, 6m, coll. G.A. Powell, paratype QM GH4229).

FURTHER RECORDS: Tasmania (Bass Strait, SAM E2593); South Australia (Port Lincoln — Kott 1963); Victoria (Westernport — AM U3914 Kott 1963).

Although other records are from relatively shallow water, the specimen from Bass Strait is from 92m.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies consist of spherical to oval heads (3 to 6cm diameter), each on a thick, sandy stalk, occurring singly or in clumps. Long, more or less parallel, sometimes branching cloacal canals are along the sides of the heads. Zooids are arranged in double rows, a row along each side of the canal. The canals open to a number of large cloacal openings around the upper margin of the head, or to a few terminal apertures. A wide zooid-free strip of test is between adjacent double rows of zooids. A layer of sand is present on the outer surface of the colony, including the stalk. It is absent only from a bare area around the cloacal apertures on the top of the head. Sand is not present internally. The contracted, preserved colonies have a conspicuously transversely wrinkled sandy stalk.

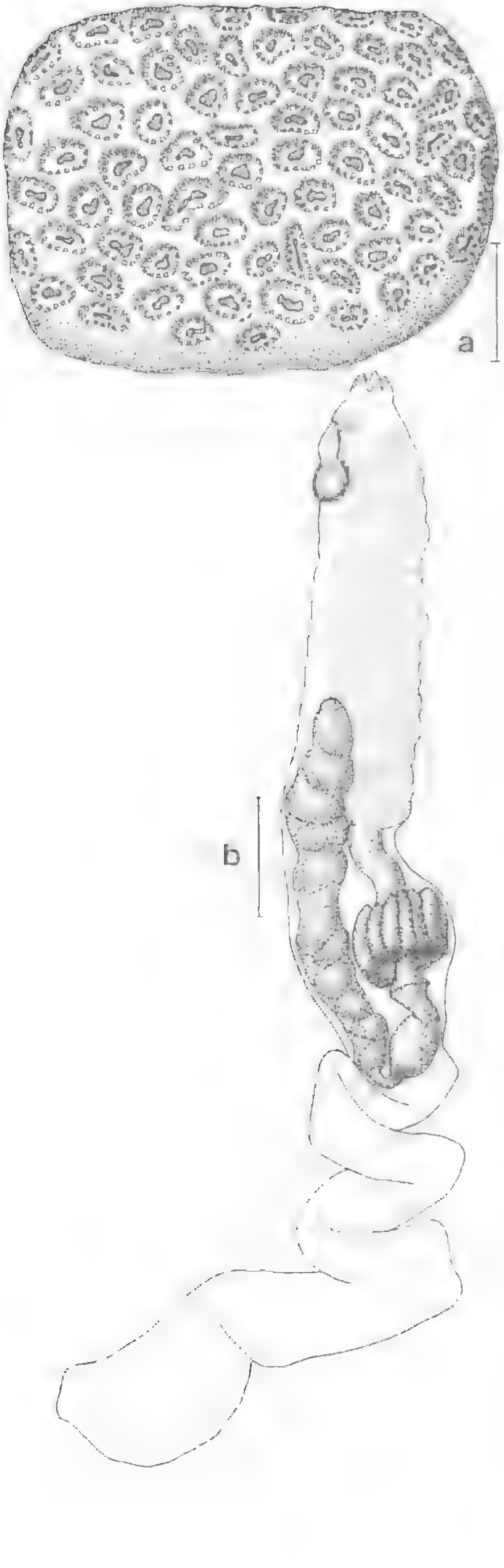


FIG. 78. *Aplidium gelasinum* n.sp. (holotype QM GH5333) — a, colony from upper surface; b, zooid. Scales: a, 1cm; b, 0.5mm.

The anterior ends of the zooids are perpendicular to the surface, but the posterior ends curve down into the stalk and cross one another.

INTERNAL STRUCTURE: Zooids are robust, the thorax and abdomen together being about 3mm long when contracted. The posterior abdomen is longer and varies in length. About 12 longitudinal thoracic muscles extend posteriorly, forming a wide band along each side of the abdomen and posterior abdomen. The 6-lobed branchial siphon is short. The atrial aperture is a conspicuous, anteriorly oriented opening with a large, conspicuous atrial lip, deeply divided into 3 long pointed lobes, produced from the upper rim of the aperture. In some zooids 5 or 6 conical points project from the body wall in a transverse row just behind the atrial aperture. Longitudinal thoracic muscles lie between these projections.

Fifteen rows of 10 to 12 large, oval stigmata are present in the wide pharynx. The relatively long barrel-shaped stomach has 20 to 23 parallel longitudinal folds. The duodenal area is relatively long and roomy, and an oval posterior stomach is in the descending limb of the gut loop near its bend.

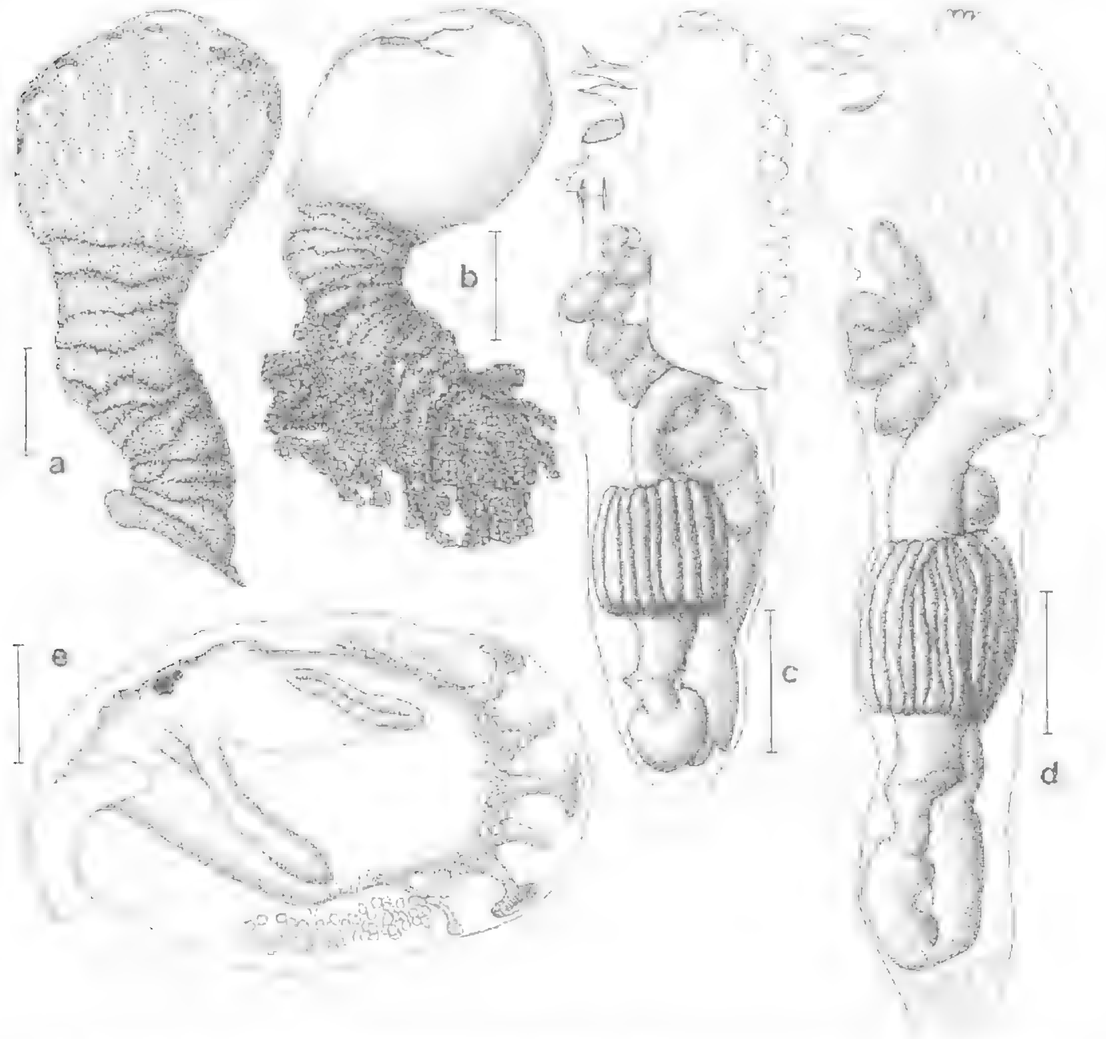


FIG. 79. *Aplidium geminatum* — **a**, **b**, colonies both showing thick sandy transversely wrinkled stalk (**a**, QM GH4175, indicating arrangement of zooids in vertical rows with a number of terminal cloacal apertures; **b**, SAM E2593 with 2 terminal cloacal apertures); **c**, **d**, thorax and abdomen (**c**, SAM E2593 showing transverse row of dorsal papillae; **d**, QM GH4175); **e**, larval trunk (AM specimen from Port Lincoln). Scales: **a**, **b**, 1cm; **c**, **d** 0.5mm; **e**, 0.2mm.

Gonads are in the long posterior abdomen. Larvae are not present in the newly recorded specimens taken in February and April. However, they are present in the type material collected in September and November (see Kott 1963). The larval trunk is 0.9mm long with a band of numerous epidermal vesicles from the antero-lateral ridges along each side of the 3 median adhesive organs and the median ampullae that alternate with them.

REMARKS

The stalked colonies with parallel, double row systems down each side resemble *Sycozoa* and some *Distaplia* species (e.g. *D. australiensis*). Amongst *Aplidium* the species has some characters it shares with *A. australiense* and *A. brevilarvacium*, notably the stalked colonies with double row systems converging to relatively few common cloacal apertures. Of these two species, *A. brevilarvacium*, with its common cloacal aperture on the upper surface of the head, and relatively few cloacal canals, most closely resembles the present species. However, the zooids of both *A. australiense* and *A. brevilarvacium* are smaller than in the present species and they have fewer stomach folds, and fewer stigmata. There are other differences in the size and shape of the colonies (see species descriptions below). A conspicuous character of the present species is the large atrial lip with its 3 long pointed lobes.

The protruding dorsal papillae in a transverse row behind the atrial aperture are at the level of, and may be homologous with, the dorsal median papillae present in species of *Polyclinum* and *Synoicum*.

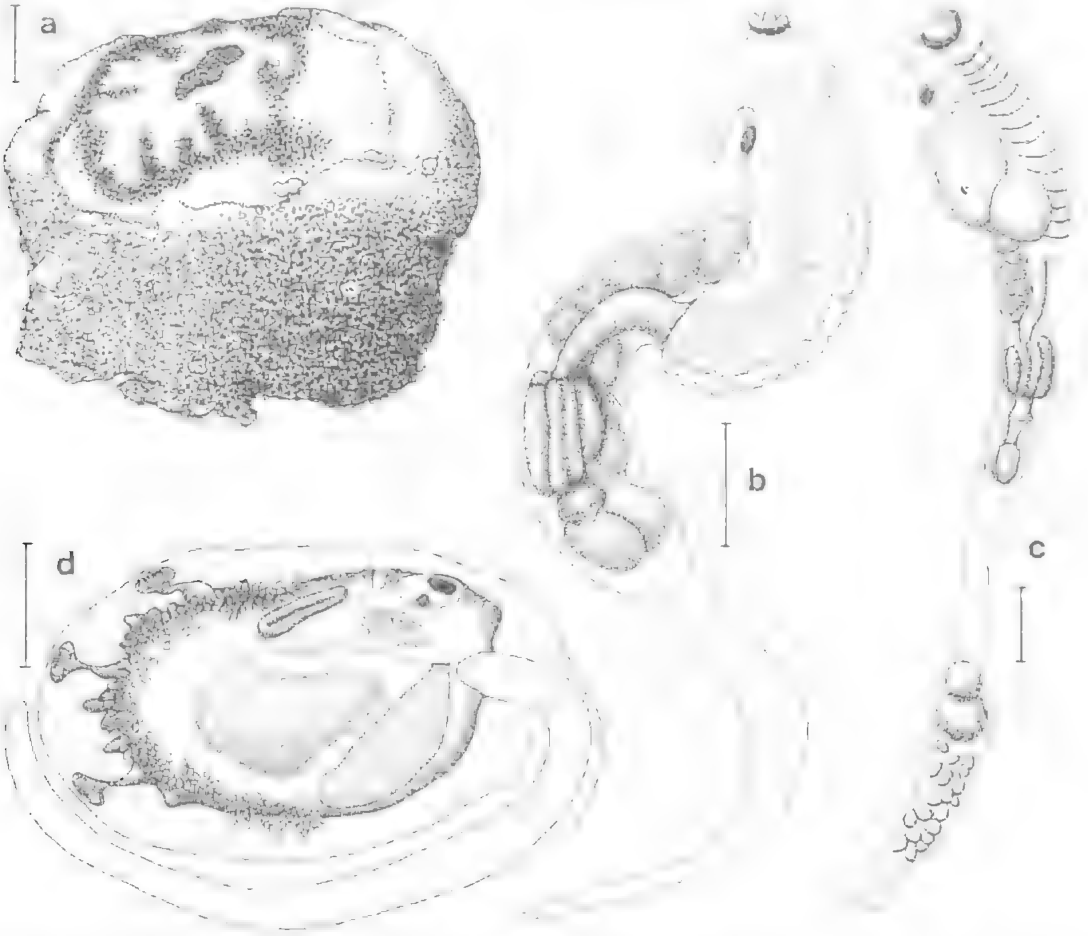


FIG. 80. *Aplidium griseum* n.sp. — a, colony (QM GH5171); b, c, zooids (holotype QM GH5212 GH5172); d, larva (QM GH5213). Scales: a, 2mm; b, c, 0.5mm; d, 0.2mm.

The larvae resemble those of *Aplidium opacum* with a band of numerous epidermal vesicles along each side of the median adhesive organs, similar numbers of stomach folds, and a similar large atrial lip. The form of the colonies and systems differ from those of the present species, and the zooids have fewer rows of stigmata.

Aplidium griseum n.sp.
(Fig. 80)

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I., under rubble, near reef edge, low tide, coll. P. Kott May 1985, holotype QM GH5212; May 1985, 1987, paratypes QM GH5214 GH5215).

FURTHER RECORDS: Queensland (Capricorn Group, QM GH5171–3 GH5213 GH5216–7 GH5529–31 GH5613 GH5668).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are small, upright (to 1.0cm high), almost cylindrical (to 1cm diameter), flat-topped lobes. Embedded sand is crowded in the lower half of the lobe and becomes less crowded in the top half. Sand is present also on a ridge around the periphery of the upper surface of each lobe, and is crowded into a line around each system where the branchial apertures open at the base of marginal ridges. As well as the peripheral ridge around the upper surface of each lobe the marginal ridges are on the upper surface separating the systems from one another. The thin threadlike zooids are in irregular or circular systems around 2 or 3 sessile common cloacal apertures on the upper surface of each lobe. Radial extensions from the peripheral test extend in toward the centre of a system and have zooids along each side. The regular circles of zooids are thus interrupted and the number of zooids in a system is increased.

Living colonies are 'Indian-', or 'prune purple' to 'blackish' or 'light translucent lavender', or 'Prouts brown' externally and 'poppy red' internally. Zooids are 'vermilion' (see Ridgeway 1886). In life, red pigment in the atrial lips can be seen through the translucent test. The preservative sometimes is stained reddish-orange. Brown spherical cells are in the test of preserved specimens.

INTERNAL STRUCTURE: The delicate zooids have fine longitudinal muscles extending their whole length. The branchial lobes are rounded and petal-shaped. The atrial lip from the body wall anterior to the small rounded aperture is narrow and pointed. Opaque brown pigment particles are around the zooid openings and along the endostyle. These particles probably cause the red colour in the living zooids. The thorax, is longer than the abdomen with 13 rows of up to 16 stigmata per row. The small stomach in the middle of the abdomen has 8 or 9 deep folds in its wall. Of these 2 or 3 do not extend the whole length of the stomach. Caeca at the proximal end of the rectum form a rectal valve.

The posterior abdomen is long and thin, with an anterior ovary and double row of male follicles in its posterior two-thirds.

In specimens collected in May, a tailed larva and a second less advanced embryo are in the atrial cavity. The larval trunk is 0.85mm long, with small, pointed median ampullae in each interspace between the 3 adhesive organs. The whole anterior end of the trunk is obscured by an arc of scattered epidermal vesicles in the larval test along each side of the mid-line.

REMARKS

The species is distinguished by its upright colonies, small stomach with 8 folds in the stomach wall, relatively wide thoraces with numerous (16) stigmata per row, and delicate musculature in the body wall.

Incomplete stomach folds that do not extend the full length of the stomach are known in other species of this genus e.g. *Aplidium multipapillatum* Millar, 1975. The latter species also has a similar number of stigmata in each row, but it has more stomach folds than the present species. Colonies resemble those of *Aplidium crateriferum* and *A. clivosum*, with systems opening into depressions on the surface of the robust colonies. However, the present species has more stomach folds.

The larva is like that of *Aplidium ritteri* with scattered vesicles around the anterior end, although the trunk of the present species is larger.

Aplidium incubatum n.sp.
(Fig. 81)

DISTRIBUTION

TYPE LOCALITY: Queensland (Point Lookout, in crevices on rocky platform, high tide, coll. P. Kott 12.5.87, holotype QM GH5309; paratypes QM GH5310).

FURTHER RECORDS: Queensland (Point Lookout, QM GH5311–2; Cape Moreton, QM GH5615).

The records are from 0 to 10m, from rocky substrates.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies vary in shape from extensive plates up to 2cm in maximum diameter to upright mushroom-shaped more or less flat-topped lobes (up to 1cm high). Sometimes the base of the colony is drawn out into a long, flattened extension which fits into narrow crevices and sometimes narrow stolons join the separate lobes of a colony to one another, or function as root-like processes fixing the colony in the substrate. Small circular systems of up to 10 zooids, and 5mm diameter are crowded in the colony and open on the upper surface. Large, sessile common cloacal apertures are in the centre of each system. The test above the systems is naked, pinkish-white and translucent. Sometimes sand is on the surface test separating single, or groups of, systems from one another.

Sand also is present on the surface test around the sides and base of the colony and varying amounts are embedded in the test amongst the zooids. The test is firm and transparent in preservative. In life, colonies are pink around the periphery of the systems, or red-orange with orange or salmon coloured zooids.

INTERNAL STRUCTURE: The zooids are robust, but the thorax and abdomen together are only about 2mm long, the thorax slightly longer than the abdomen. The posterior abdomen occupies about half the length of the zooid. The 6 branchial lobes are large and fleshy, with a small, pointed papilla in the centre of each lobe, sometimes

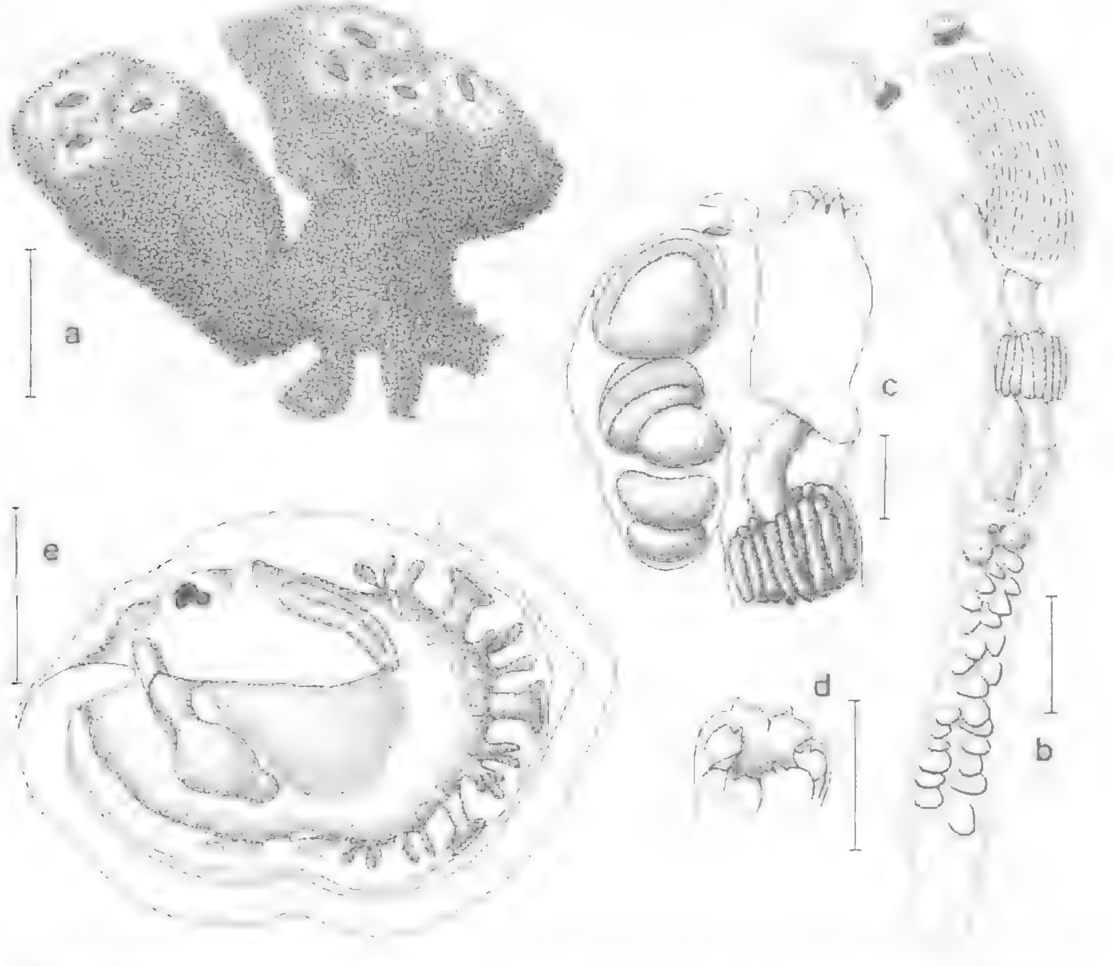


FIG. 81. *Aplidium incubatum* n.sp. — a, colony (holotype QM GH5309); b, whole zooid (paratype QM GH5310); c, anterior part of zooid with embryos in brood pouch (holotype QM GH5309); d, branchial lobes (paratype QM GH5310); e, larva (holotype QM GH5310). Scales: a, 5mm; b–d, 0.5mm; e, 0.2mm.

slightly depressed into its surface. The atrial lip is produced from the upper rim of the opening and is single or divided into 2 or 3 lobes. Twelve thick, conspicuous muscles are in the thoracic wall and extend the length of the zooid in a narrow band on each side. Broad, rectangular stigmata are in 9 or 10 rows with up to 15 per row.

The stomach has 25 folds in its wall. The oesophagus and post-pyloric part of the descending limb of the gut loop are of moderate length, an ovary is in the anterior part of the abdomen behind the gut loop, and the male follicles are in a long, irregular and rather loose bunch occupying most of the posterior abdomen.

Zooids of the holotype each have a large brood pouch, constricted off from the postero-dorsal corner of the thorax, with up to 6 embryos in a developmental sequence, lined up in it. The most advanced tailed larva is uppermost. It has a trunk 0.55mm long, and a tail wound three quarters of the way around it. About 16 epidermal vesicles are in a single arc on each side of the mid-line around the anterior half of the trunk.

A total of 7 epidermal vesicles in the interspace between the upper and middle adhesive organs branch off 2 common basal stalks, and 5 branch of 2 basal stalks in the lower interspace.

REMARKS

A. uteute and the present species have circular systems, a brood pouch and similarly arranged epidermal vesicles. However, the larvae of the present species lack the median vesicles, the zooids have fewer stomach folds and fewer stigmata per row than *A. uteute*, and the test has embedded sand, which *A. uteute* does not have. *Aplidium ornatum* n.sp. has sand around the border of the colony, like the present species, but is distinguished by its more numerous and scattered larval epidermal vesicles and lack of a brood pouch.

Aplidium inflorescens n.sp.

(Fig. 82)

? *Aplidium opacum* Kott, 1963, p.108 (part, lobed specimen from Balnarring Beach).

DISTRIBUTION

TYPE LOCALITY: South Australia (SW Point, Grindal I., NNE Cape Catastrophe 18m, coll. L. Hobbs, H. Brandon on RV *Ngerin* 29.9.89, holotype SAM E2588).

FURTHER RECORD: Victoria (? Balnarring Beach — AM Y1401 Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colony consists of multiple stalked heads branching from a sandy common base. Heads are hemispherical to 2.5cm diameter, and the thick stalks are of slightly less diameter and up to 1.5cm long. Sparse sand is embedded in, and is present on the surface of, the stalk, increasing in abundance toward the base. Sand is absent from the head. Zooids are arranged in double rows converging to a few common cloacal apertures on the terminal surface of each lobe.

INTERNAL STRUCTURE: The zooids are of moderate length, the thorax and abdomen together being about 4mm. The posterior abdomen is long and thread-like. The atrial lip is from the anterior rim of the aperture. It is undivided and usually its median longitudinal muscles are contracted causing the edge to be frilled. Stigmata are in 15 rows with 14 or 15 per row. The oesophagus has a slight prestomach enlargement. The stomach wall has 20 folds.

Up to 4 embryos are crowded in the atrial cavity of the type specimen. In the contracted zooid this causes the dorsal surface to protrude. Larvae are large, the trunk almost 0.9mm long, with median and lateral ampullae alternating with the adhesive organs. There are no epidermal vesicles

REMARKS

The colony of this species with its thick basal stalks and longitudinal rows of zooids converging to terminal cloacal apertures, resembles *Aplidium geminatum*, which also has a similar number of stomach folds, and is recorded from South Australian waters. The present species lacks the layer of external sand characteristic of *A. geminatum*, and its stalks are shorter, thicker, more branched and not so wrinkled. Further, the larvae of the present species lack the arc of crowded epidermal vesicles found in *A. geminatum*. They have, instead, well-formed lateral ampullae.

Aplidium brevilarvacium has similar cloacal systems but the heads are smaller and sandy, the stalks thinner and longer, and the stomach has only 10 folds, thus is readily distinguished from the present species.

The larvae of the present species are similar to those of *A. coniferum*, which is distinguished by its large undivided upright colony, and its zooids with only 5 stomach folds. *Aplidium lodix* n.sp. has a similar larva without vesicles, and with median and lateral ampullae, but its colonies are extensive and investing with branching rows of zooids converging to the randomly distributed common cloacal systems.

The colony assigned to *A. opacum* by Kott (1963) is in vegetative condition, and although the colony resembles that of the present species, zooids are not available to confirm its identity.

Aplidium jacksoni Kott, 1963
(Fig. 83)

Aplidium jacksoni Kott, 1963, p.110 (part, holotype).

DISTRIBUTION

NEW RECORDS: None.

PREVIOUSLY RECORDED: New South Wales (Port Jackson — AM U3917 Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a circular slab, about 12cm diameter and 2cm thick. Sand is embedded thickly in the surface layer of test, but is not present externally adhering to the outer surface. Sand is sparse in the lower half of the colony. Circular cloacal spaces are just below the surface, covered over by a thin layer of test, and with large, irregular, sessile cloacal apertures in the centre. Zooids are in wide circles of about 8 to 12 surrounding the cloacal cavities. Each branchial aperture opens on or inside a small upstanding papilla, which has one or more of the ventral branchial lobes embedded in it.

INTERNAL STRUCTURE: The zooids are robust, with a short thorax and a long posterior abdomen. The atrial aperture has a small pointed lip from the upper border of the opening. Branchial lobes are small and pointed. Stigmata are in 12 rows of 16. The wide stomach is relatively short with about 12 regular, parallel longitudinal folds. Two rows of male follicles are in the long, robust posterior abdomen. Larvae are not known.

REMARKS

Although it is not impossible that *A. jacksoni* occurs in Bass Strait, a naked, stalked, colony from off Devonport (Tasmania), assigned to this species by Kott (1963), is not conspecific. It is in the vegetative phase, and appears to be a colony of *A. coniferum* (see above).

FIG. 82. *Aplidium inflorescens* n.sp. (holotype SAM E2588) — a, colony; b, thorax showing embryos being incubated; c, larva. Scales: a, 2cm; b, 0.5mm; c, 0.2mm.

The present species is characterised by its distinct circular systems, with the position of the branchial openings indicated by a papilla on the surface of the colony. The zooids have some characters in common with *A. triggsense* which, however, has more crowded zooids and sand embedded in the basal layer of test rather than the surface.

FIG. 83. *Aplidium jacksoni* (holotype AM U3917) — a, surface of part of colony showing large sessile common cloacal apertures surrounded by the branchial apertures on small papillae; b, zooid. Scales: a, 5mm; b, 0.5mm.

Aplidium lenticulum n.sp.
(Fig. 84. Plate 13d–f)

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I. under coral slab 3m, coll. N. Coleman 26.11.74 AMPI 141, holotype QM GH5060. Heron I., coll. P. Fredrickson May 1975, paratype QM GH5061.

FURTHER RECORDS: Western Australia (Carnac I., QM G9475; Rockingham, QM GH5457). South Australia (Topgallant I, QM GH941). Queensland (Capricorn Group QM GH1497).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are robust sheets or slabs up to 20cm in maximum extent and to 2cm thick. The upper surface is divided into flat-topped, circular, oval or polygonal zooid-free elevations of varying diameter up to 1cm. These are separated from one another by narrow depressions. In the base of each depression is the thin layer of test forming the roof of the common cloacal canals. The zooids open along each side of these common cloacal canals in the angle between the base and sides of the depression. The ventral surface of each zooid is in the solid test beneath each elevated area, atrial apertures are in the base or sides of the cloacal canals and atrial lips are in the test above the canals. Sand is packed in the lower half of the colony and around the outer margin, but the upper half of the colony is completely or partially free of sand.

The sand occasionally spreads from the lower half of the colony into the test around the zooids and above them, into the outer margin of each elevation, thus protecting the branchial openings. Sometimes some small clumps of sand are scattered in the surface of each elevation and these may also be present in small papillae projecting from the upper surface. The sand is also occasionally present in the surface test above the cloacal canals, and around the large common cloacal apertures which appear to occur randomly at the junctions of cloacal canals. The cloacal apertures are conspicuous, projecting from the surface of the colony, with a large cloacal chamber beneath them. Brownish oval bodies (about 0.1mm long) are in the test especially crowded around the cloacal canals, in their base, walls and roof. They become more sparse toward the base of the colony. These contain granular material, but they do not appear to be faecal pellets.

In life colonies are said to have been black, greenish-black, red, aqua-blue (South Australian specimens) translucent gels, although all photographed specimens appear to be cream and red.

INTERNAL STRUCTURE: Zooids are robust. The thorax and abdomen are together about 3mm long, and of about equal length, but the posterior abdomen is at least twice the length of the rest of the zooid.

The branchial siphon is long with a large sphincter around the base of the lobes. Fine longitudinal muscle bands number about 12 on the thorax. The atrial lip arises from the body wall opposite the first row of stigmata, and the atrial siphon surrounded by a sphincter muscle, is opposite the fifth or sixth row. The tip of the atrial lip is invariably entire and pointed. The atrial lip is particularly long and broad. Zooids located in the vicinity of a cloacal aperture have their atrial lips inserted into the test around the rim of the opening.

An extent of unperforated pharynx is between the tentacular ring and the first row of stigmata. Also, bands of unperforated pharynx lie along each side of the endostyle, the perforated part being a relatively narrow part of the dorsum of the pharynx. Stigmata are in 16 to 20 rows of up to 8 per row.

The stomach has 5 folds although when inflated only slight anterior and posterior protrusions remain.

The posterior abdomen is long and thin, the test follicles in one or 2 series are usually separated from the posterior end of the abdomen by an interval of various lengths. The ovary is at the anterior end of the male follicles. It increases in size as it moves up into the atrial cavity from 0.7 to 1mm. It is a long, pointed, egg-shape, rounded at one end and tapering to a blunt point at the other. Embryos are present in the atrial cavities of specimens from Rockingham (collected in

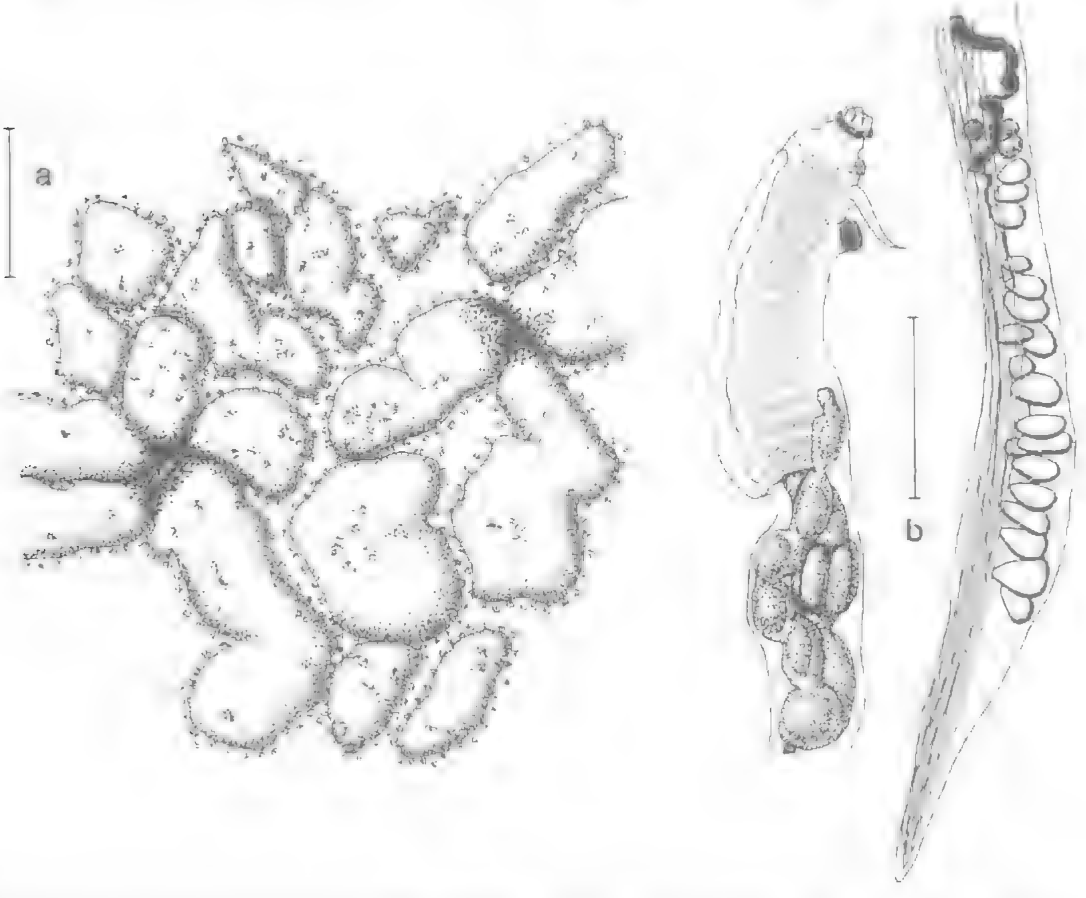


FIG. 84. *Aplidium lenticulum* (paratype QM GH5067) — a, part of colony surface; b, zooid. Scales: a, 5mm; b, 1mm.

March). Tailed larvae are in a Heron I. specimen collected in May (QM GH5061). They have median ampullae alternating with the adhesive organs, and a mass of epidermal vesicles obscuring the anterior end of the 1mm trunk. Only one embryo is incubated at a time in the posterior half of the atrial cavity.

REMARKS

As well as the narrow zooids with long thoraces, long branchial apertures and atrial siphons separated from the atrial lip by 3 or 4 rows of stigmata, the gelatinous, flat-topped elevations on the surface, surrounded by the cloacal canals and zooid openings, are characteristic.

The species is the opposite of such species as *A. clivosum* and *A. lunacratum* nom. nov. which, although they have similar zooids, have zooid-free surface elevations of the test that surround the systems rather than being surrounded by the systems as in the present species.

A line of sand outlines the zooid-free areas of test where the branchial apertures open to the surface also in *Aplidium tabascum* n.sp., although in the present species the sand grains in the margins of the elevated areas form a crowded band rather than a single line. Also the cloacal cavities of *A. tabascum* are more extensive, and the atrial lip is from the rim of the aperture and not separate from it as it is in the present species. *Aplidium solidum* has similar, though smaller systems, more embedded sand, and a different zooid.

The surface elevations and similar systems are found also in *A. cellis* Monniot 1987 from New Caledonia but its atrial lip is not separate from the opening, and the larvae of the 2 species differ.

Aplidium caelestis has similar zooids and oval bodies embedded in the surface test as the present species. However its long, crowded meandering systems separated by long, thin ridges, rather than the circular double rows surrounding polygonal areas, and the sandy colonies with surface as well as embedded sand, distinguish it.

The nature and role of the oval bodies is not known, although it is possible that they have sometimes been mistaken for faecal pellets (see *A. caelestis*, above).

Aplidium lodix n.sp.

(Fig. 85)

DISTRIBUTION

TYPE LOCALITY: Victoria (Western Port, Crawfish Rock, coll. J.E. Watson 14.11.78, holoytpe QM G12712).

FURTHER RECORD: South Australia (Perforated I., QM GH4144).

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a large sheet investing pebbles on an irregular substrate. It is uneven in thickness from 0.5 to 1cm. The maximum dimension of the colony is 6cm, and it is irregularly indented and lobed around the margin and smooth and even on the upper surface. The test is firm and translucent, without sand on the upper surface, although there is some on the base. There is no embedded sand. Moderately crowded zooids are arranged in circular to stellate systems. In preservative it is greyish, with whitish zooids.

INTERNAL STRUCTURE: Zooids are robust, to 6mm in length, with thorax, abdomen and posterior abdomen each about one third of the total length. The 6 branchial lobes are conspicuous and rounded. The atrial tongue arises from the anterior rim of the aperture. Numerous stigmata are present in 10 rows, although the exact number was impossible to count. The stomach has about 25 longitudinal, parallel folds.

Up to 6 crowded embryos are incubated in the atrial cavity. Larvae from the holotype have trunks 0.65 to 0.75mm long, with the tail wound half-way around. Ocellus and otolith are present. A lateral ampulla is on each side of each of the 4 median ampullae which alternate with the adhesive organs. A ventral median ampulla projects posteriorly, but there are no epidermal vesicles.

REMARKS

Superficially the preserved colony resembles *Aplidium opacum*. However, the latter species has more crowded zooids arranged in double branching rows, and its larva differs from the present species in having epidermal vesicles and lacking lateral ampullae. *Aplidium robustum* n.sp. is another temperate species with a similarly shaped and naked colony, circular systems of varying size, and robust zooids with about 20 stomach folds. It has up to 16 rows of stigmata, its thorax is longer than that of the present species and its larva has clumps of dorsal and ventral vesicles which are not present in *A. lodix*.

Aplidium inflorescens has lateral and median larval ampullae, lacks epidermal vesicles, but is distinguished from the present species by the form of its systems with apical common cloacal apertures.

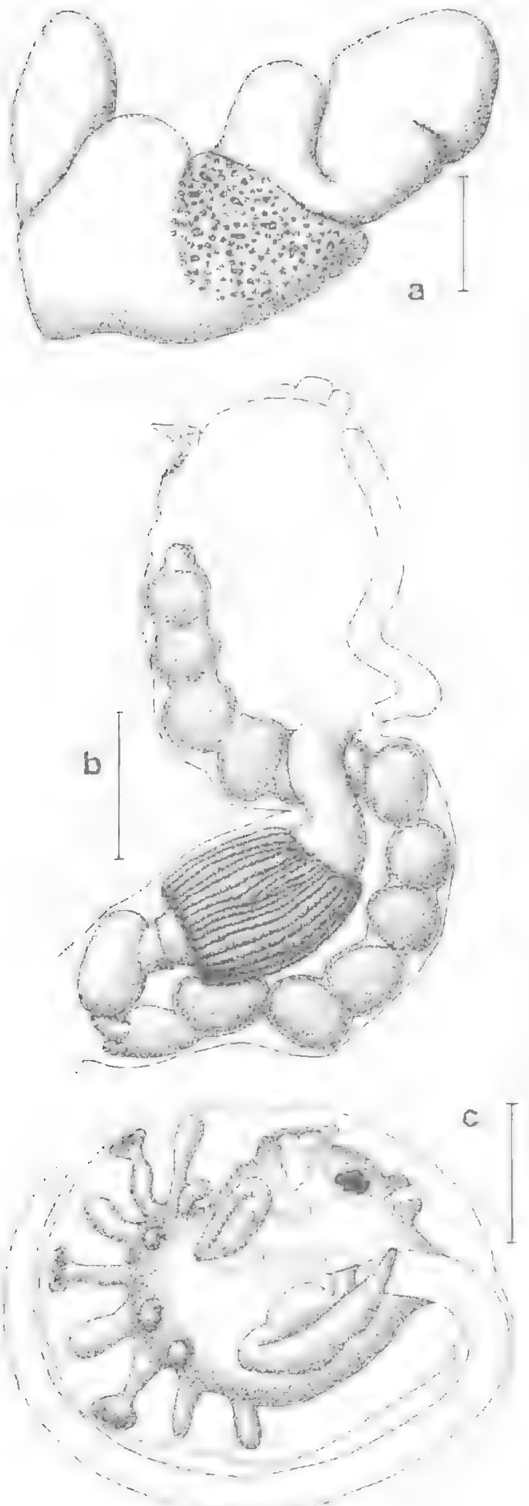


FIG. 85. *Aplidium lodix* n.sp. (holotype G12712) — a, colony with systems indicated on part of the surface; b, thorax and abdomen; c, larva. Scales: a, 1cm; b, 0.5mm; c, 0.2mm.

Aplidium lunacratum nom. nov.
(Fig. 86. Plate 14a-c)

Psammaplidium ordinatum Herdman and Riddell, 1913, p.885. Kott, 1963, p.99.
Not *Psammaplidium ordinatum* Sluiter, 1906, p.22.
Not *Aplidium ordinatum* Sluiter, 1914, p.35. Hartmeyer, 1909–1911, p.1471. Van Name, 1945, p.46.

DISTRIBUTION

NEW RECORDS: Western Australia (Cervantes, WAM 237–9.87); South Australia (Great Australian Bight, SAM E2563; Kangaroo I, QM GH5429; Beachport, QM GH5448; Cape Jaffa, SAM E2553 E2560 E2565, QM GH5446). Victoria (Portland Harbour, MV F59370).

PREVIOUSLY RECORDED: New South Wales (Manning River — AM G12216 holotype *A. ordinatum* Herman and Riddell, 1913).

The discontinuity in the records probably reflects collecting effort.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are irregular sandy mats, or upright wedges and lamellae up to 1cm thick with zooids opening on both sides, or cylindrical lobes of various sizes arising from common basal test with zooids opening only on the upper surface. Zooids are in evenly spaced circular systems of 5mm diameter. Branchial apertures are in a circle around the periphery of each system and a circular cloacal cavity is in the centre beneath the naked concavities on the surface of the colony. Crowded and relatively large sand grains adhere to the ridges between the systems, and usually to the outside of the conical common cloacal protuberance that rises from the centre of each surface concavity. A little fine sand is embedded in the naked test in the concavity around the base of each cloacal protuberance. Radial bands of red pigment from the cloacal aperture to the circumference of each depression are in the surface test. Sand is crowded throughout the remainder of the test. Zooids lie amongst the embedded sand. They are perpendicular at the surface but more posteriorly they cross one another. In thin lamellae or sheet-like colonies they bend at right angles so that the long narrow posterior abdomina extend through the fine sand in the middle layer of each colony lobe toward its point of fixation, or to where it branches off a

FIG. 86. *Aplidium lunacratum* nom. nov. — **a**, surface of part of colony (QM GH5446); **b**, cross section through the upper part of a zooid system (diagrammatic); **c**, thorax and abdomen (QM GH5429); **d**, extended zooid posterior part of posterior abdomen not shown WAM237.87); **e**, larval trunk (SAM E2563). Scales: **a**, 5mm; **b–d**, 1mm; **e**, 0.2mm.

basal plate. When such lamellae are broken across, the posterior abdomina can sometimes be pulled out in tufts like fine hair-like threads.

INTERNAL STRUCTURE: The zooids are muscular and often are contracted, although the posterior abdomen always is relatively long (up to 1cm or more). When relaxed, the thorax is 3 or 4mm long, and the abdomen about half of that length. Dark pigment cells are in the tip of the atrial siphon and in the branchial siphon of preserved zooids. Longitudinal musculature is strong with about 25 bands on the thorax.

The branchial siphon is short with 6 relatively shallow lobes around the aperture. It has circular muscles in a wide band along its length, and there is no narrow, bulging sphincter muscle. The atrial tongue is fleshy and pointed to long, wide and strap-like, with parallel longitudinal muscles. It arises from the body wall opposite the first row of stigmata, anterior to the atrial siphon which is opposite the second to third rows. A ring of muscles is around the forward pointing atrial aperture on its short siphon which opens into the base of the cloacal cavity around its outer margin. The prebranchial area between the prepharyngeal band and tentacular ring is wide, as is the imperforate pre-stigmatal and post-stigmatal parts of the pharynx. Also a wide band of unperforated pharyngeal wall is along each side of the endostyle.

Stigmata are in 10 to 15 rows of 12 to 15 per row. The stomach is small with 5 shallow folds, sometimes (if the stomach is flattened or inflated) difficult to distinguish and reduced to longitudinal glandular areas internally. The anal opening is opposite the seventh row of stigmata. Spherical to oval male follicles are in a long single or double series in the middle third of the long posterior abdomen. The ovary is just anterior to the testis follicles.

A single embryo is in the posterior half of the atrial cavity of specimens collected in January (SAM E2563). The larval trunk is 2.2mm long, more or less cigar-shaped, with the ocellus and otolith near its posterior end. Two median ampullae, one in each interspace, alternate with the adhesive organs. The anterior end of the trunk is obscured by numerous ectodermal vesicles that extend in bands, one along each side of the ventral and dorsal mid-lines from outside the base of the ventral and dorsal adhesive organs, respectively. The larva is pigmented red and is opaque.

REMARKS

Like *Synoicum castellatum*, the present species has large circular sytems, protruding cloacal apertures, atrial lips separate from the apertures, stomach folds flattened, and occasionally the stomach in the 'atopogaster' condition — with horizontal folds. However the internal glandular areas are all parallel and longitudinal and none are irregular as they are in the large stomach of *S. castellatum*. The present species also has close similarities with other *Aplidium* spp. It has the same long larval trunk (in the vicinity of 2mm) and a long narrow zooid with the atrial lip separate from the opening as in *A. crateriferum* and *A. clivosum* but it lacks their narrow, bulging branchial sphincters, has fewer rows of stigmata, and its systems are smaller. *Aplidium lunacratum* has circular systems (as in *A. crateriferum*) rather than stellate ones (as in *A. clivosum*).

Despite the circular systems of the present species being different from those of the sympatric *A. clivosum*, in which the double rows of zooids converge to the cloacal apertures, preserved colonies are readily confused with one another. Both species have naked surface depressions with central protuberant cloacal apertures and red test. In both the colony shape varies, and variable quantities of sand are on the upper surface. In *A. lunacratum* there seems always to be a single system per depression, as in some specimens of *A. clivosum* (SAM E2564–5). As well as the form of the cloacal systems the present species can be distinguished by its larger zooids, with more muscles, and fewer rows of stigmata but more per row (10 to 14 rows of up to 15). *Aplidium acroporum* has similar systems but smaller zooids, with only 5 rows of stigmata, 8 stomach folds and the atrial lip arising from the anterior rim of the aperture. *Aplidium protectans* has similar circular systems, a large roomy stomach, and larvae with median ampullae and dorsal and ventral vesicles, but its zooids differ in other respects, and its colony is naked and gelatinous.

Examination of the type specimen (AM G12216) of *A. ordinatum* Herdman and Riddell has shown that previous reports (see Kott 1963) of 8 folds in the stomach wall are incorrect. The zooids are contracted, and some of their details are obscured. Nevertheless, the relatively large stomach is seen to have the characteristic 5 shallow folds, the atrial aperture is on a short siphon just posterior to the muscular atrial lip, and each protuberant common cloacal aperture, in the centre of a circle of zooids, has sand embedded in it.

The name *Aplidium ordinatum* is a junior secondary homonym of *Psammaplidium ordinatum* Sluiter, 1906 (see also Van Name 1945) from the Antarctic and the name *Aplidium lunacratum* nom. nov. is accordingly proposed for this species.

Aplidium macrolobatum n.sp.

(Fig. 87)

Aplidium lobatum: Kott, 1963, p.97 (part, colonies from Heron I. and Sarina).

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I., north east, low tide on under surface or rubble, outer edge of reef, coll. P. Kott 2.11.86, holotype QM GH5169; 14.11.85, paratype QM GH5170).

FURTHER RECORDS: Queensland (Capricorn Group, AM Y1404, QM GH5166–8 GH5219 GH5276 GH5526 GH5544–9 GH5595–6 GH5606–7 GH5660 GH5663; Britomart Reef, QM GH380; Sarina — AM Y1445 Kott 1963; Lizard I., QM GH5550–1).

One colony from Heron I. (QM GH5663) was found on a small crab.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are investing sheets up to 0.5cm thick, or irregular masses with the upper surface and margin extending into rounded or flattened lobes. Sand is embedded throughout the test, although often it is relatively sparse and the colonies are predominantly gelatinous. Sand is less crowded internally than just below the surface, and is absent from the smooth outer surface of the colony. Branchial apertures on the upper surface have each of the 6 large triangular branchial lobes outlined in fine sand grains. The cloacal apertures are large, sessile or protruding from the surface. They vary in size and shape, some being irregular openings but others regular and circular and often they are particularly extensive long or crescent-shaped openings exposing an extent of the cloacal cavity or canal directly to the exterior.

The systems are either circular, occasionally separated from one another by slight depressions in the surface test (holotype); but in other colonies crowded double rows of zooids converge to irregular and randomly scattered cloacal apertures. In several well developed colonies (QM GH380, AM Y1445) the common cloacal apertures are along the upper rim of flattened colony lobes and double rows of zooids extend down each side of the lobes, almost parallel to one another. The test usually is firm, gelatinous and occasionally glassy in preservative.

In life the colony is cloudy, owing to the embedded sand. When living, the thoracic body walls of the zooids are mauve, purple, raspberry, 'pink', 'hazel', 'rose-red', or 'ruby' (Ridgeway 1886) but other parts of the zooids are colourless. Colonies, with pink or red colour seen through the embedded sand, have been described as 'turkish delight', 'pink lozenge' or 'pomegranate'. Zooids are pale pink in preservative.

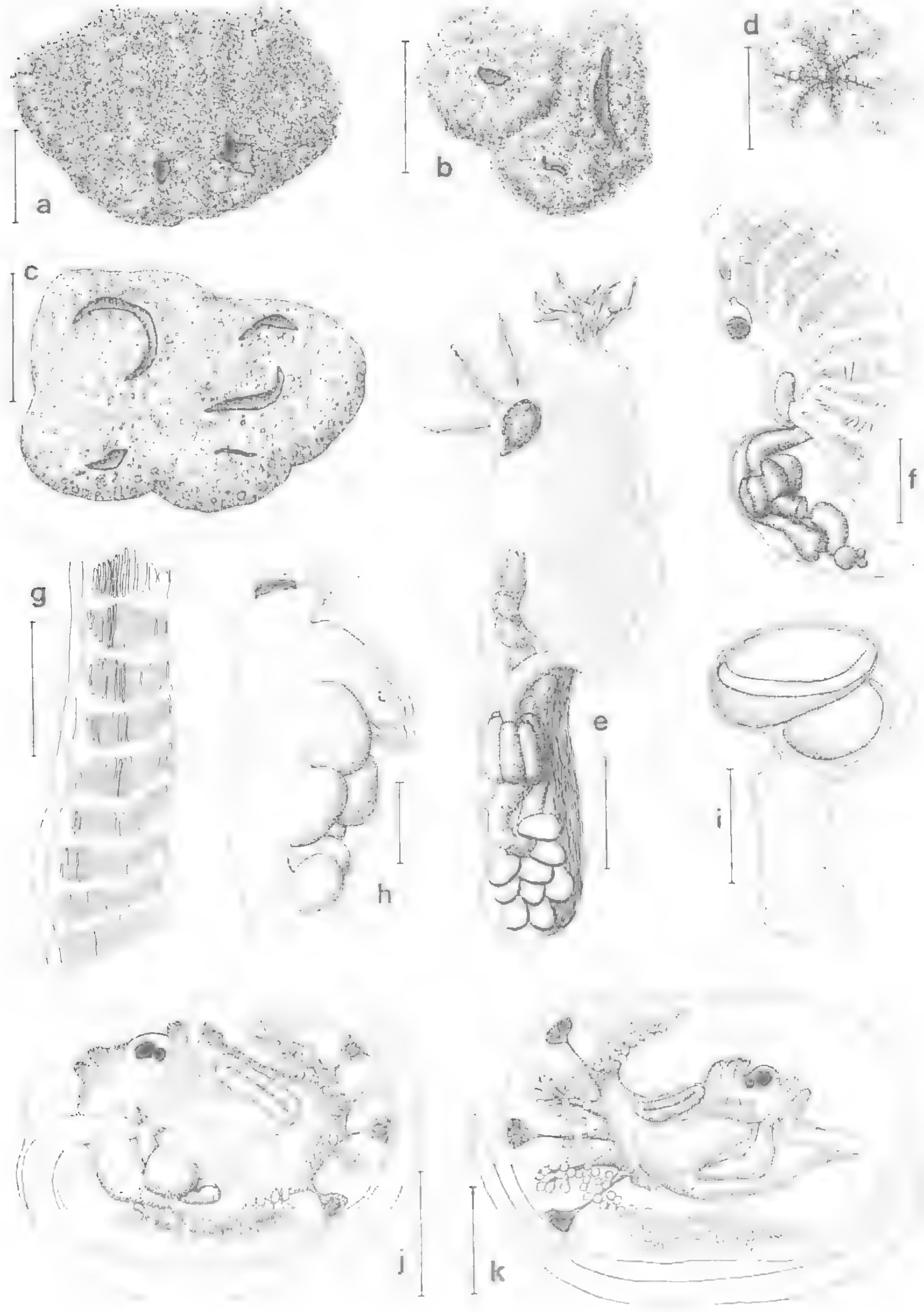
Prochloron is on the surface of some colonies and often large red and green spherical algal cells, 0.1 to 0.2mm in diameter are in the test between and around the zooids and in the floor of the cloacal cavities especially when these are exposed to the exterior (QM GH380 GH5606 GH5660 AM Y1445).

INTERNAL STRUCTURE: Zooids are small, 2mm long when contracted, the thorax and abdomen of about equal length and the posterior abdomen slightly shorter. Branchial lobes are large triangles with a narrow muscle band in the centre of each lobe, reaching to its pointed tip. The atrial lip from the upper rim of the opening is exceptionally large, and is divided into 3 to 5 long, pointed or straight-edged, leaf-like lobes with a narrow strap-like band of muscle fibres in the centre of each lobe. Both atrial and branchial lobes have a similar pointed tip into which the central muscle band is inserted. This tip sometimes appears as a pointed papilla projecting from the end of the lobe. When the muscles in it are contracted it is drawn back into the lobe, subdividing its terminal tip into 2.

Six to 10 strong longitudinal muscles are on the thorax of contracted specimens. These continue along the abdomen and posterior abdomen in 2 strong ventral bands. Nine or 10 rows of up to 15 stigmata per row are in the branchial sac. Stigmata are long and narrow, and are folded up when the delicate thorax is contracted.

The stomach wall has 5 deep folds. Sometimes the posterior abdomen is short, with up to 10 or more pear-shaped male follicles bunched in it. In other zooids, apparently in the female phase, a 3 to 10-egg ovary is about halfway down a long posterior abdomen, possibly after the testis follicles are spent (holotype). Male and female gonads are never present in the one zooid at the same time.

Up to 7 eggs and embryos are packed in the atrial cavity of the holotype and other colonies collected in August and November. The most advanced embryo is anterior. The larval trunk is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0.55 to 0.75mm long, the length increasing with maturity. A well developed ocellus and otolith are in the cerebral vesicle. Clusters of epidermal vesicles branch off the median ampullae that alternate with the 3 small, stalked adhesive organs. A band of small ectodermal vesicles is along each side of the adhesive organs. Further vesicles constrict off from posteriorly projecting stalks part of the way along the dorsal and ventral borders behind the adhesive organs on each side of the median line.

As the larvae mature, zooids degenerate and their remains persist as brood sacs in the test, each incubating one or 2 larvae.

REMARKS

The unusually large and lobed atrial lip, large branchial lobes, red body wall, and short posterior abdomen, with only male or female gonads present at a time, characterise this fleshy species which also contains variable amounts of embedded sand. A similar leaf-like atrial lip is known in the temperate species, *Aplidium elatum* Kott, 1972b. However, the latter species forms upright fan-shaped lamellae, has 8 rows of stigmata with only 8 per row and 15 stomach folds rather than the 5 of the present species. *Aplidium opacum* also has large lobes around the apertures, with muscle bands along the centre of each which sometimes subdivide the branchial lobes and crinkle the edges of the atrial ones. It is distinguished by its more numerous stomach folds and naked colonies without embedded sand.

Aplidium lobatum Savigny, 1816 from the Bay of Suez and Indonesia (see Michaelsen 1920) has a similar number of stigmata, stomach folds and a tripartite atrial tongue from the upper border of the opening. Like the present species, *A. lobatum* has a short posterior abdomen and only the male or female gonad present at one time. However, the colonies of *A. lobatum* have flat-topped oval areas separated by furrows into which the zooids open, and the species does not appear to be conspecific with the present one. *Aplidium tremulum* Sluiter, 1909, proposed as a junior synonym of *A. lobatum*, has a short atrial lip. Thus, although Michaelsen (1920) may have been wrong in proposing the synonymy of *A. lobatum* and *A. tremulum* apparently neither are conspecific with the present species.

The degenerate zooids acting as brood pouches in the test, appear to be characteristic of the present species.

Aplidium magnilarvum n.sp.
(Fig. 88)

DISTRIBUTION

TYPE LOCALITY: Western Australia (115 nautical mls SW Eucla 38°17'S, 129°37'E, 180m, coll. W. Zeidler and K. Gowlett Holmes 16.1.89, holotype SAM E2582, paratype SAM E2583).

FURTHER RECORD: Western Australia (SSW Eucla, SAM E2590).

The species has been taken from the same general area at 180 to 190m depth.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are hard, upright, round-topped, about 4cm high and 2-3cm maximum diameter, narrowing toward the base where an aggregate of root-like projections of the test form a holdfast. Sand is not so crowded internally as it is on the surface around the sides and roots of the colony where it adheres to the test to form a thick layer. The sand layer is thinner toward the upper surface.

The surface sand obscures the systems, and their form was not determined. In between the sand particles, the test is firm and glassy, sometimes with some brown pigment cells.

INTERNAL STRUCTURE: The zooids in the available material are entering the vegetative phase with trophocytes accumulating in the abdomen, and the thoraces disintegrating. Only in the holotype are there adult organs persisting in the zooids. In some of these zooids a single large embryo is incubated in the atrial cavity, although none of these appears to have any larval organs developed.

In these zooids, the thorax (contracted) and abdomen together are up to 4mm. The thorax is muscular with about 15 longitudinal muscles running the length of the zooid, forming a wide band along the ventral border of the abdomen and posterior abdomen. The circular atrial aperture is

FIG. 87. *Aplidium macrolobatum* n.sp. — a, colony (QM GH5545); b, upper surface showing circular systems and large, irregular, sessile cloacal apertures (holotype QM GH5169); c, upper surface showing elongate systems with long, open cloacal apertures and embedded symbionts (QM GH5606); d, showing branchial lobes outlined in sand grains (QM GH5167); e, f, zooids showing short, contracted posterior abdomina with testis follicles and oocytes respectively (QM GH5167, holotype GH5169); g, portion of branchial sac (QM GH5311); h, thorax showing embryos being incubated (holotype QM GH5169); i, embryo being brooded in thorax of degenerating zooid (QM GH5526); j, k, larvae (QM GH5315). Scales: a–c, 5mm; d–i, 0.5mm; j, k, 0.2mm.

antero-dorsal, directed anteriorly, with a muscular atrial lip arising from the body wall just in front of it. The atrial lip either is undivided or it has 2 additional points on each side of the longer median one.

Stigmata are in 21 long rows. The thoraces are wide and robust, and appear to have at least 20 stigmata per row, although the exact number was not determined. The oesophagus is relatively long, and the long elliptical prestomach occupies most of its length. The stomach is short and has 5 deep folds. The post pyloric part of the gut has a posterior stomach, and proximal and distal parts of the mid-intestine. There are short rectal caeca. The gut is narrow in these specimens, however, and probably is not functional.

The large embryo completely filling the atrial cavity in some of the holotype zooids is up to 2mm long.

REMARKS

These small, upright bulbous colonies, with their basal holdfasts are unique, distinguished from *A. coniferum* by their hard, sandy consistency, the single large embryo in the atrial cavity, and more numerous stigmata in each row. This new species may be confined to locations at more than 100m depth on the southern continental shelf.

Aplidium miniscululm n.sp.

(Fig. 89a,b)

Aplidium depressum: Kott 1976, p.60.

DISTRIBUTION

TYPE LOCALITY: Victoria (Portsea Pier, 2m, Panel 7-2 coll. G. Russ 24.2.76, holotype QM G11920).

FURTHER RECORD: Victoria (Westernport — Kott 1976).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are soft, jelly-like flat-topped cushions to more extensive sheets lobed on the upper surface. They are found on stalks and fronds of weed. The holotype is from an experimental fouling panel. Zooids are in circular to elongate systems, and are clearly seen through the transparent but slightly brownish test. Their arrangement often is obscure in preserved

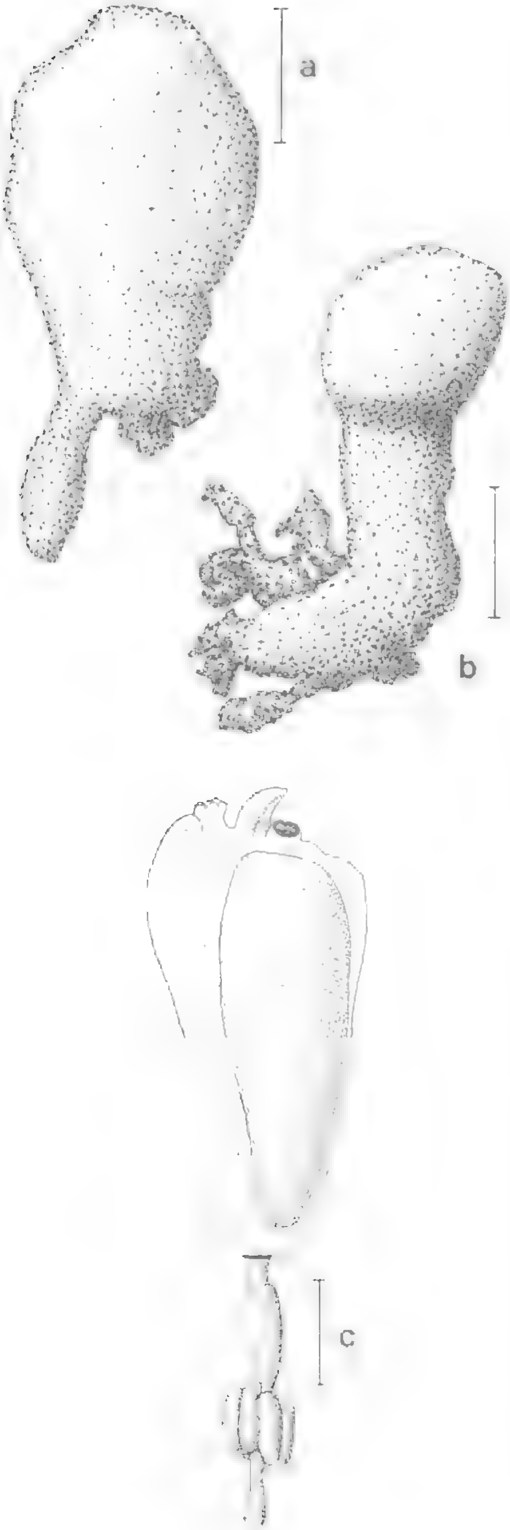


FIG. 88. *Aplidium magnilarvum* n.sp. — **a**, **b**, colonies (holotype SAM E2582, E2590); **c**, thorax and abdomen showing embryo being incubated in atrial cavity (SAM E2590). Scales: **a**, **b**, 1cm; **c**, 0.5mm.

material. Sand particles are embedded in the test, but are not crowded.

INTERNAL STRUCTURE: Zooids are small, to about 3mm, of which the thorax and abdomen are about half. The small, terminal branchial aperture has 6 pointed lobes, and the small atrial aperture has a single, short, pointed lip projecting out from the upper rim of the opening. Five rows of 10 to 12 stigmata are in the pharynx. The gut loop is short, with a small stomach with 10 deep folds in its wall. An oval posterior stomach is at the posterior end of the descending limb of the gut loop. A large rectal valve is present at the junction of the mid-intestine and rectum (at the base of the

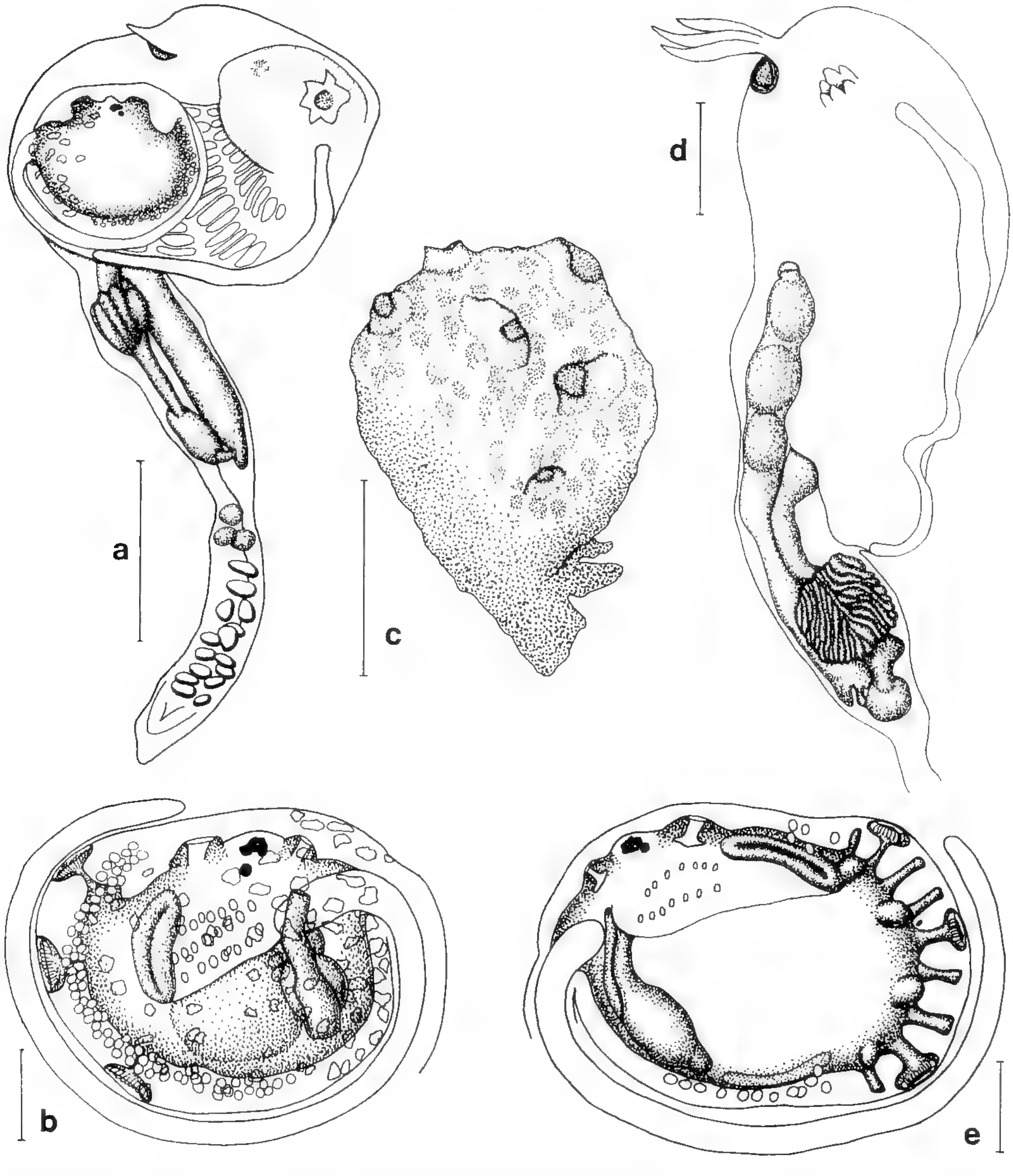


FIG. 89*Aplidium minisculum* n.sp (holotype QM G11920)—**a**, zooid with embryo in atrial cavity; **b**, larva *Aplidium multilineatum* n.sp. — **c**, colony (holotype AM U3954); **d**, zooid (holotype AM U3954); **e**, larva (*A. flavolineatum*: Kott 1963 Cape Vlamingh, Rottnest I.). Scales: **a, d**, 0.5mm; **b**, 0.1mm; **c**, 5mm; **e**, 0.2mm.

ascending limb of the gut loop). The short posterior abdomen has a 2 or 3 egg ovary anterior to an irregular double row of male follicles.

In the holotype colony a single larva is in the atrial cavity, causing the short thorax to be almost spherical. These zooids also have mature male follicles, sperm in the vas deferens and some small oocytes in the ovary.

Larvae are almost spherical with a double row of ectodermal vesicles along each side of the median short-stalked adhesive organs, 3 rows of stigmata and large conspicuous test cells in the larval test. These test cells are absent from the anterior end of the larval trunk and become more crowded posteriorly. The larval trunk is about 0.4mm long.

REMARKS

Kott (1976) assigned the specimens from Westernport Bay to *A. depressum* on the basis of their similar colonies, small zooids, and similar numbers of rows of stigmata, numbers per row and numbers of stomach folds. Although there are similar test cells in the larval test, the larvae of *A. depressum* are smaller than those of the present species and have only a single row of 7 or 8 vesicles along each side of the adhesive organs. The zooids of *A. minisculum* also differ from those of *A. depressum* in the presence of an atrial lip.

Aplidium multilineatum n.sp.

(Fig. 89c–e)

Aplidium flavolineatum: Kott, 1963, p. 5 (part, AM U3954, ? AM U3955).

DISTRIBUTION

TYPE LOCALITY: Western Australia (Rottnest I., Salmon Bay, inner pool, low tide, coll. P. Kott 18.11.51, holotype AM U3954).

FURTHER RECORDS: Western Australia (? Cape Vlamingh, Rottnest I. — Kott 1963). ? Tasmania (Hunter I. — AM U3955 Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a flat-topped cushion, 1cm in diameter, with a naked upper surface and a sandy base. Some sand is embedded in the test around the zooids but it is sparse, and is absent altogether from the surface test in the centre of the circular systems of zooids where large, plain-rimmed common cloacal openings protrude from the surface. The systems are numerous, about 8 being present in the small holotype. The test is soft and transparent in the preserved colony.

INTERNAL STRUCTURE: Zooids are delicate, with a large thorax twice the length of the abdomen and broader as well. The posterior abdomen is long and narrow. Fine longitudinal muscles are on the thorax. An atrial lip divided into 2 or 3 narrow, pointed branches, arises from the anterior rim of the antero-dorsal atrial aperture. Stigmata are in 10 rows of up to 16. The stomach is small with about 30 narrow, mostly oblique folds that are interrupted where they meet along lateral, mesial, dorsal, and ventral longitudinal lines which divide the stomach wall into 4 sections. The usual duodenum, mid-intestine and posterior stomach are in the descending limb of the gut loop. A rectal valve is at the proximal end of the rectum.

Embryos are not present in the holotype. Slide-mounted larvae are available from colonies from Cape Vlamingh (Rottnest I.) and Hunter I. (Tasmania). These were from colonies which, with the present colony, were assigned to *A. flavolineatum* by Kott (1963). The colony from Hunter I. (AM U3955) appears to have dried out at some time and neither the systems nor the structure of the zooids could be discerned. The specimen from Cape Vlamingh has not been located for reexamination. Thus the identity of these larvae cannot be confirmed, and they are only provisionally assigned to the present species — on the assumption that colonies from which they were taken were conspecific with the reexamined colony, viz. the holotype of the present species.

The larvae from both Hunter I. and Cape Vlamingh have a trunk 0.9mm long, with the tail wound about three-quarters of the way around it. There are median ampullae alternating with the adhesive organs, and those in the 2 interspaces are each divided into 2. Four lateral ampullae are present on each side of the median line, one near the base of each of the median ones. A trail of epidermal vesicles extends posteriorly from behind the dorsal and ventral median ampullae. A large ocellus and an otolith are in the cerebral vesicle.

REMARKS

The cushion-like colony with transparent test, and circular systems has some resemblance to *Aplidium uteute*, although the zooids and the systems appear larger, and the common cloacal apertures more protuberant. *Aplidium uteute* also has numerous stomach folds, but they are longitudinal rather than oblique, and it has a wide thorax with more stigmata than the present species. Larvae of *A. uteute* with single series of epidermal vesicles around each side of the median line, and vesicles between the adhesive organs, are completely different from the larvae provisionally assigned to the present species.

Aplidium gastrolineatum has circular systems and oblique stomach folds but the stomach folds are fewer than in the present species, and the thorax is longer with about 16 rows of stigmata. The South African species *A. flavolineatum*, to which the holotype of the present species was assigned by Kott (1963), has a similar number of stomach folds, but they are not oblique.

The larvae provisionally assigned to the present species have median and lateral ampullae and dorsal and ventral vesicles like those of *A. robustum* and *A. ornatum*, but the median ones are subdivided and there are 4 lateral ones rather than only 2 (as in the latter 2 species). *Aplidium robustum* has a similar colony, but sessile cloacal apertures and fewer stomach folds.

Aplidium multiplicatum Sluiter, 1909
(Fig. 90. Plate 14c–f)

Aplidium multiplicatum Sluiter, 1909, p.101. Tokioka, 1967, p.35 (part). Kott and Goodbody, 1982, p.514.
Amaroucium multiplicatum: Van Name, 1918, p.165. Nishikawa, 1984a, p.112.
Not *Aplidium multiplicatum*: Millar, 1963, p.693 (>?). Kott 1963, p.103.
Not *Amaroucium multiplicatum*: Tokioka 1953, p.180. Nishikawa and Tokioka, 1976, p.379. Nishikawa, 1990, p.89.
Aplidium opacum Kott, 1963, p.108 (part, from NSW and SW Australia).
Aplidium flavolineatum: Kott, 1963, p.105 (part, specimens from NSW and AM U3956 from Rottnest I.); 1972c, p.246.
Aplidium californicum: Monniot, 1987, p.518.
? *Aplidium multiplicatum*: Renganathum and Monniot, 1982, p.259.

DISTRIBUTION

NEW RECORDS: Northern Territory (Darwin Hbr., QM GH5361). Western Australia (Cockburn Sound, WAM 46.72 22.75 29.75 143.75 227.82). South Australia (Yorke Peninsula, SAM E2540 E2587; St Vincent Gulf, SAM E2594). New South Wales (Port Hacking QM GH31).Queensland (Capricorn Group, QM GH1359 GH5108–27 GH5470 GH5218 GH5224 GH5241–2 GH5275 GH5281 GH5532–8 GH5540–1 GH5646; Whitsunday Is, QM GH5366; Lizard I., QM GH5539; far northern Great Barrier Reef, QM GH5337).

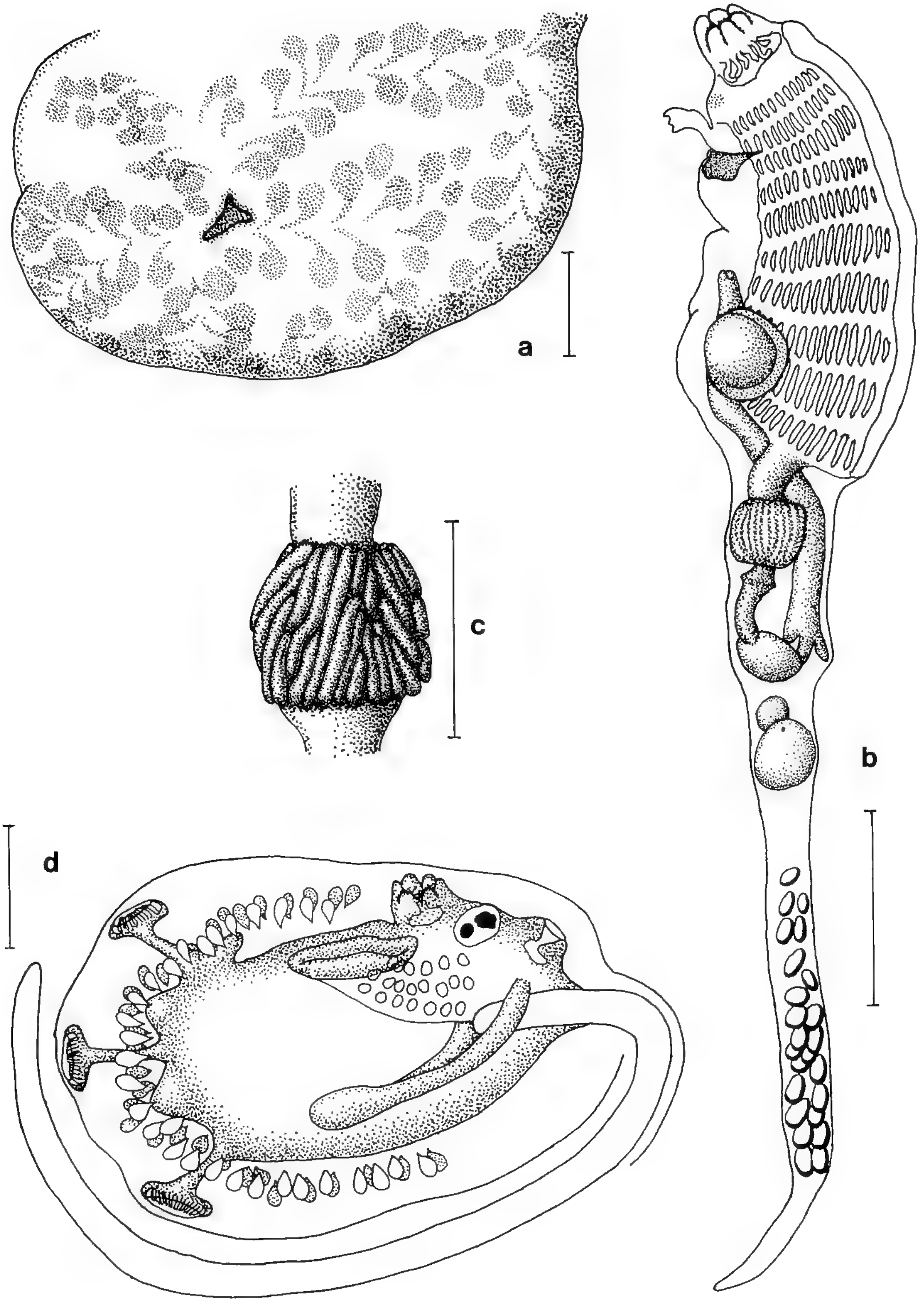
PREVIOUSLY RECORDED: Western Australia (Southwestern — AM Y1394 Kott 1963). New South Wales (Jervis Bay — AM Y1439; Port Hacking — AM Y815 Y823 Kott 1972c; Port Jackson — AM Y1423 U3931 U3956 Kott 1963). Kiribati and the Palau Is (Tokioka 1967); Phillipines (Van Name 1918); Truk and Ponape Is, Majuro Atoll (Nishikawa 1984a). Hong Kong (Kott and Goodbody 1982).

Despite confusion in the definition of this species which resulted in its being placed in synonymy with eastern Pacific and S. African species, the range appears to be Indo-West Pacific. It is especially common in tropical, usually reefal, habitats of the western Pacific. It extends into the temperate waters of south-western Australia, but not across the southern coast of the continent.

DESCRIPTION

EXTERNAL APPEARANCE: The species forms cushion- or plate-to spreading sheet-like colonies, to 7cm in maximum dimension and 1cm thick, with irregular borders. The upper surface is often even and horizontal. A colony from the Great Barrier Reef (QM GH5470) is a glassy dome, 6cm high, with the surface deeply divided into lobes of varying size and shape; and the specimen from Darwin Harbour (QM GH5361) has the upper surface raised into high, zooid-free round ridges between the double rows of zooids. In other parts of the colony, however, systems are more crowded. Zooids are crowded, along each side of canals that converge to a few large, sessile common cloacal apertures with irregular borders. The living specimens have translucent, slightly cloudy test coloured orange, pale apricot, 'poppy red', 'salmon' 'pinkish buff', 'yellow-buff', 'cream-buff' (Ridgeway, 1886). Zooids are crimson, 'scarlet vermilion', 'geranium red', 'scarlet', 'ruby', 'coral reef' (Ridgeway *loc. cit.*) brilliant or bright orange, or pink. When embryos are present they are a dark maroon colour. In preservative the test is translucent but cloudy, cream with pink zooids and mature eggs and embryos (but not tailed larvae) are a translucent brownish colour. Opaque white (possibly blood) cells are in the sheath of soft test around the zooids, and are crowded together to form a white band around the branchial siphon. The test is particularly soft, jelly-like, is easily torn, and the surface is smooth.

In some colonies green *Prochloron* cells and diatoms are in the common cloacal cavity, in the canals converging to them and on the outer surface of the colony. The species is one of the 5 or


a
b
c
d

6 *Aplidium* spp. which sometimes have *Prochloron* in the cloacal cavity (see Kott *et al.* 1984: *Aplidium* sp.3).

INTERNAL STRUCTURE: Zooids are small, the contracted thorax and abdomen together being about 2mm long. The posterior abdomen is short (about one-third of the total zooid length). The opaque white corpuscles that are such a feature of this species are in the body wall of the pharynx and atrial lip as well as around the base of the branchial siphon, and in the test around the zooid. The body wall is delicate with about 12 fine longitudinal muscle bands. Transverse muscle fibres are in the transverse vessels betwen the rows of stigmata.

The 6 branchial lobes are variable, but they usually are long, and are either pointed or rounded. The atrial lip, from the upper rim of the opening contains longitudinal muscles and is of various lengths. Its tip either is pointed and undivided, or is divided into 3 or 4 separate points. There are 9 to 11 rows of 14 to 20 stigmata. Twenty-two longitudinal folds are in the wall of the small stomach which is about halfway down the abdomen. The stomach folds are sometimes irregular, interrupted, and slightly oblique on the outside or ventral border of the stomach, but elsewhere they are longitudinal and parallel.

Bunched testis follicles occupy about three-quarters of the length, of the posterior abdomen, leaving the anterior quarter free of male follicles. In relaxed zooids the follicles are spread out into 2 irregular rows. A small ovary is behind the gut loop, anterior to the testis. Up to 2 embryos are in the atrial cavity of zooids collected in August from Darwin, May from the northern Great Barrier Reef, October from the Whitsunday Is, and January, April, May, August, October and November from the Capricorn Group. Some specimens from Port Hacking (AM Y815) have up to 7 embryos packed into the atrial cavity of specimens collected in June. When zooids are particularly contracted the embryos project out from the body wall in what could be mistaken for a brood pouch. The larval trunk is up to 0.9mm long, and the tail is wound about two-thirds of the distance around it. On each side of the 3 median adhesive organs, is a single arc of up to 30 large epidermal vesicles. Small conical median ampullae alternate with the adhesive organs in all except some of the smaller (0.6 to 0.7mm long trunk) and almost spherical larvae from the Capricorn Group, which also have fewer (14 to 20 rather than 20 to 30) epidermal vesicles in each lateral arc. The same opaque white corpuscles are in the larval test as those in the test sheath around the zooids, and in a band around the branchial siphon. These sometimes obscure the larval organs, especially those at the anterior end of the trunk

REMARKS

The characteristic of this species are the opaque white corpuscles clustered around the branchial siphon and the zooid, and scattered in the cloudy, soft gelatinous test, as well as long, double row systems, numerous stomach folds, the moderately wide thoraces (with up to 16 stigmata per row), and larvae with lateral arcs of numerous (14 to 30) epidermal vesicles.

The discrepancy in larval size, and in the number of epidermal vesicles, between smaller almost spherical larvae from the Capricorn Group and the larger ones from the same as well as all other locations is puzzling. The only other difference observed is in the size (and probably the age) of the colonies. These Capricorn Group specimens, taken at low tide from rubble near the edge of the reef, are smaller than the colonies taken from other locations by SCUBA divers.

Sluiter's type specimens of *A. multiplicatum* are irregularly lobed plates 3cm in maximum diameter and 5 to 6mm thick, glassy and transparent, with the yellowish-white zooids showing through the test. Systems were not identified. Sluiter records delicate muscles, 7 rows of 10 stigmata, 18 longitudinal stomach folds and a short posterior abdomen with bunched male follicles.

Van Name (1918) reported larger specimens from the Philippines with more complex systems and 7 to 10 rows of up to 16 stigmata per row, with the same number of stomach folds (18–20) and double series of testis follicles. As in specimens of this and other species, the arrangement of the gonads and the length of the posterior abdomen changes with development of the zooid and with its state of contraction.

Aplidium multiplicatum: Kott, 1963 came from 2 locations in Queensland. Zooids from both locations are smaller than those of *A. multiplicatum* with only 6 or 7 rows of stigmata. Colonies from Sarina (AM Y1448) are specimens of *Aplidium fluorescum*. The colonies from Currumbin (AM U3994), with a layer of sand on the surface,

FIG. 90. *Aplidium multiplicatum* — a, part of small colony, indicating zooids along each side of the cloacal canals which converge to the common cloacal apertures (QM GH5113); b, zooid (QM GH5110); c, stomach, showing interrupted folds; d, larva (QM GH5361). Scales: a, 2mm; b, 1mm; c, 0.5mm; d, 0.2mm.

appear to be colonies of *A. ornatum* with circular systems and sand around the margin of the colony. *Aplidium multiplicatum*: Millar, 1963 is also wrongly assigned. The 3 specimens have circular systems, about 25 stigmata per row and 21 stomach folds. The larvae have lateral ampullae but no vesicles. It is possible that more than one species is involved. The number of rows of stigmata and number per row suggest *A. uteute* is one of the species, but the larvae and the number of stomach folds do not support that view.

Specimens assigned to *A. multiplicatum* by Tokioka (1967) also may include more than one species. In specimens only 2.0cm in maximum dimension, and not more than 1cm thick, there are some with circular, and others with more complex systems, a range of colours from 'pale brown', 'reddish brown', to 'purplish brown' (Tokioka 1967), 7 to 10 rows of stigmata, 10 stigmata per row (in zooids from Kiribati) up to 30 (larger zooids from Palau Is), and 20 to 35 stomach folds. The range in these characters is greater than could be regarded as intraspecific variation and greater than could be regarded as the effects of growth, especially when the range in colony size is relatively small. The larvae of the small colony from Kiribati, and the zooids figured from both Kiribati and the Palau Is (Tokioka 1967, Figs 8a–d, 9a,b) appear to be *A. multiplicatum*. Colonies with more numerous stigmata and stomach folds could be other species such as *A. uteute*, which resembles the present species in the colour of its zooids and embryos. However, *A. uteute* has median as well as lateral larval epidermal vesicles, more stigmata in each row and more stomach folds than *A. multiplicatum*.

Nishikawa and Tokioka (1976), Nishikawa (1990), Tokioka (1953) and Rho (1975) have assigned specimens from Japanese waters with 7 to 11 rows of stigmata, and 20 to 25 stomach folds to *A. multiplicatum*. The number of stigmata per row, and the arrangement of larval epidermal vesicles and ampullae do not fall within the ranges recorded for the present western Pacific species.

Tokioka (1953, 1967) proposed that the eastern Pacific *Aplidium californicum* (Ritter and Forsyth, 1917) is a synonym of the present species. However, the Californian species has sand embedded in the test, an atrial lip separate from the opening, fewer stigmata per row, and lacks the characteristics pigmentation of the present species (see Kott and Goodbody 1982, Nakauchi 1987, Millar 1988). *Aplidium californicum*: Monniot, 1987 from New Caledonia has the characteristic naked colony, pigmentation, stomach wall, branchial sac and larval form of *A. multiplicatum*.

In Australia *Aplidium opacum* is the species most closely related to the present one and specimens have been confused. It has similar colonies with crowded zooids in long branching double-row systems. Zooids are sheathed in a layer of soft test containing opaque white cells which are similar to those in *A. multiplicatum*, and are crowded around the branchial siphon in much the same way. The zooids also are similar, although the present species usually has more stigmata per row but fewer rows than *A. opacum*. *Aplidium opacum* has firmer test, and the larvae have long finger-like median ampullae that project between the adhesive organs, as well as a band of numerous lateral vesicles (rather than the single series arc that occurs in *A. multiplicatum*). Re-examination of some of the specimens from New South Wales and south-western Australia assigned to *A. opacum* by Kott (1963) has shown them to belong to the present species. Larvae of the south-western Australian specimen are characteristic of *A. multiplicatum* (see Kott 1963, p.110, Fig. 22). The ranges of *A. multiplicatum* and *A. opacum* overlap on the eastern and western coast, but the former is not recorded from southern Australia, and the latter species does not extend into the tropics (see *A. opacum*, below).

Kott (1963) wrongly assigned colonies of the present species and others (viz. *A. gastrolineatum*, *A. multilineatum* and *A. robustum* n.sp.) to the S. African *A. flavolineatum*.

Aplidium opacum Kott, 1963
(Fig. 91. Plate 15a–c)

Aplidium opacum Kott 1963, p.108 (part, holotype AM U3929).
Aplidium pliciferum: Kott, 1963, p.106; 1972a, p.13; 1976, p.62.
Aplidium foliorum Kott, 1975, p.5.

DISTRIBUTION

NEW RECORDS: Western Australia (Rockingham, QM GH5461). South Australia (Great Australian Bight, SAM E2591; Port Bonython, QM GH4234–6, Perforated I., QM GH4194; Spencer Gulf, QM GH5440–1; Yorke Peninsula, SAM E2540 E2571 E2587; St. Vincent Gulf, SAM E2484 E2586 E2594). Tasmania (SE Fluted Cape, SAM E2589). New South Wales (Port Hacking, QM GH31).

PREVIOUSLY RECORDED: South Australia (Great Australian Bight — Kott 1975; St. Vincent Gulf — Kott

1972a). Victoria (Balnarring Beach — AM U3929 holotype Kott 1963; Westernport — Kott 1976).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are large and fleshy sometimes almost spherical or flattened upright masses to 8cm high and 6cm diameter. More often they are flat-topped, extensive cushions often with the surface partly divided. Crowded zooids are perpendicular to the surface, but posteriorly criss-cross one another in the test.

In preservative the test is soft, but firm, gelatinous and translucent white with minute opaque cells, possibly blood corpuscles, in a soft layer of test that sheaths each zooid. These opaque cells are especially crowded around each branchial aperture.

In photographs of well-developed living colonies zooids are seen to be in crowded, branching double rows, with large branching primary cloacal canals separating areas packed with zooids and secondary cloacal canals. Large, sessile common cloacal apertures are scattered over the surface at the junction of the primary canals. Zooids are cream (QM GH5441) or pink (QM GH5440). One colony (QM GH4194) is described as an 'orange morph'; and one is bright yellow (SAM E2586). At least 2 colour variants occur, both translucent, one pink or orange and one yellow or yellowish cream.

INTERNAL STRUCTURE: Zooids are relatively long and robust. The thorax and abdomen even when contracted are together up to 5mm long and the posterior abdomen is from twice to many times that length. About 15 strong longitudinal muscle bands extend from the thorax to the posterior end of the abdomen. The branchial siphon is short, often with well-developed bifid lobes. The atrial aperture, beside the third row of stigmata, has a fleshy muscular atrial lip, usually deeply divided into 3 equal, pointed lobes, from the upper border of the opening. Muscles are along the centre of each lobe, and when these are contracted the lobes are frilled and crinkled along the edges. The atrial lip is often (but not always) large and conspicuous.

Stigmata are in 12 rows with up to 12 in each row. The stomach is of moderate length with 20 narrow, sometimes interrupted folds. The thick duodenum, mid-intestine and oval posterior

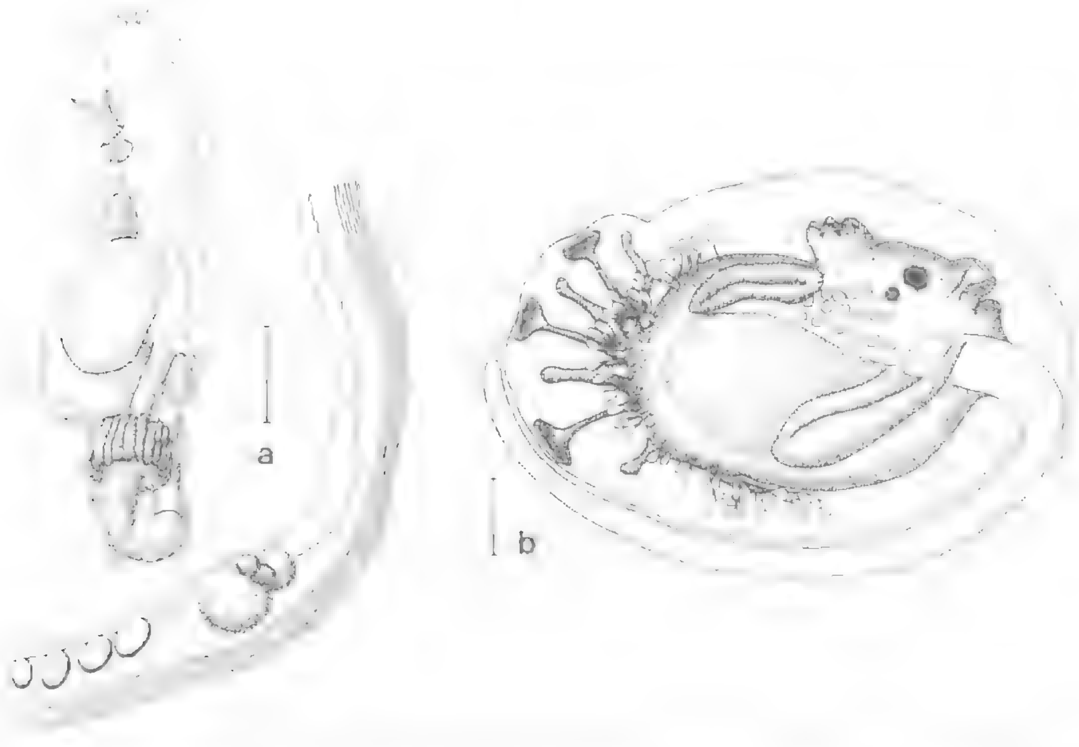


FIG. 91. *Aplidium opacum* — **a**, zooid, showing anterior part of posterior abdomen and embryos being incubated (QM GH5441); **b**, larva (QM GH4234). Scales: **a**, 0.5mm; **b**, 0.1mm.

stomach are characteristic of the genus, and there are 2 pronounced rectal caeca. Gonads are in the posterior part, or the whole of the narrow posterior abdomen, with the small ovary anterior to the long double series of male follicles.

One to 3 embryos are incubated in the top of the abdomen and in the atrial cavity, but only one at a time develops to a tailed larva. They are present in specimens from South Australia collected in February (QM GH5441 GH4234 SAM E2586), April (QM GH4236 GH4194), May (QM GH4235) and November (SAM E2571). Larvae have a trunk about 0.7mm long and a sturdy tail reaching to the anterior end of the trunk. Ectodermal vesicles (about 35) are crowded in an arc along each side of the adhesive organs. These vesicles are not in a single series, and clumps of them branch off a single stem from the larval ectoderm. Narrow, pointed, median ampullae alternate with the adhesive organs.

REMARKS

Both the zooids and the large gelatinous colonies, with randomly scattered, sessile common cloacal apertures, and crowded branching systems of zooids in the present species are similar to *Aplidium multiplicatum*. These species also have in common the cloudy opaque cells in a sheath of soft test around each zooid, and about 20 stomach folds. The zooids of *A. opacum* are larger than those of *A. multiplicatum* however, and although they have the white opaque cells in a sheath around the zooids, they do not form as wide a band around the branchial aperture as in *A. multiplicatum*. The branchial sac of the present species is relatively narrower than that of *A. multiplicatum*, which has up to 20 stigmata per row but fewer than 12 rows. Larvae differ from those of *A. multiplicatum*, having long median ampullae and clumps of lateral vesicles in lateral bands (rather than a single arc of vesicles on each side).

Kott (1963) assigned several colonies to this species which have subsequently been found not conspecific with the holotype. A colony from Balnarring Beach (AM Y1401) made up of several lobes joined to a common base is probably a specimen of *A. inflorescens* (see above). The colonies from western Australia and Port Jackson (AM Y1423 Y1439) are specimens of *A. multiplicatum* as is the larva figured by Kott (1963, Fig. 22). Colonies from Tasmania with zooids in which the atrial aperture is separate from the atrial lip are also erroneously assigned to this species and appear to be colonies of a *Polyclinum* sp.

Kott (1963) assigned specimens of the present species from Cockburn Sound to *Aplidium pliciferum* (Redikorzev, 1927). The latter species, known from coastal waters of Japan, including the Inland Sea (Tokioka 1953), has large colonies with branching double row cloacal systems as in the present species, and zooids and larvae which also appear to be similar to the Australian species. Only the stomachs are different, having from 25 to 32 fine pleats in the Japanese species, while the Australian one has 20 to 24. Thus the number of stomach folds appears to be the principal character separating these species, which are indigenous to temperate Australian and Japanese waters respectively. Despite their resemblance to one another, they apparently have different geographic ranges, and are separated from one another by the tropics.

Aplidium foliorum Kott, 1975 was thought to be distinguished by its large tripartite atrial lip. An identical lip now is known to be characteristic of the present species, although its length varies to some extent according to the position of the zooids relative to the cloacal apertures and according to their state of contraction. *Aplidium macrolobatum* has similar large lobes around the apertures, but it has sand embedded in the test, and only 5 stomach folds.

Aplidium ornatum n.sp.
(Fig. 92)

? *Aplidium multiplicatum*: Kott, 1963, p.103 (part, specimens from Currumbin).

DISTRIBUTION

TYPE LOCALITY: Queensland (Wistari Reef, NW corner, low tide under rubble near reef edge, coll. P. Kott 3.11.86 holotype QM GH5157).

FURTHER RECORD: ? Queensland (Currumbin — AM Y3994 Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colony is small (5mm high), mushroom-shaped, with a flat top about 1cm in diameter. The diameter reduces toward the base. Sand is present around the outside of the colony but is absent from the upper surface and internally. Zooids are arranged in circular to elongate systems opening on the upper surface. The 3 or 4 common cloacal apertures are large and protruding, sometimes in the centre of a circle of zooids, but sometimes at one end of a double row of zooids. In life the zooids are 'ruby' and the test 'isabella' coloured (Ridgeway 1886).

INTERNAL STRUCTURE: The zooids are vertical, with the long posterior abdomina extending into the base of the colony. Thorax and abdomen are together about 3mm long. The atrial tongue from the upper rim of the opening is undivided or divided into 3 pointed lobes. There are 12 rows of stigmata, and the maximum number per row is about 10, although the holotype is contracted and the exact number difficult to determine. The stomach wall is folded longitudinally into 25 folds.

Two large embryos are in the atrial cavity of the holotype. The larval trunk is 0.66mm long. In each interspace between the middle and the dorsal and ventral adhesive organs respectively, is a median ampulla with a bi-lobed lateral ampulla on each side. Dorsal and ventral clusters of numerous epidermal vesicles extend posteriorly from the anterior end of the larval trunk. The tail is relatively short, extending about two-thirds of the way around the trunk.

REMARKS

The distinctive characters of this species are its relatively narrow thorax, numerous stomach folds, and larvae with epidermal ampullae and numerous vesicles. *Aplidium incubatum* has a similar colony to the present species, but its circular systems are more regular and its larvae have median and lateral vesicles rather than the ampullae of the present species.

Aplidium multiplicatum, which it otherwise resembles in the colour of the zooids, and the bran-

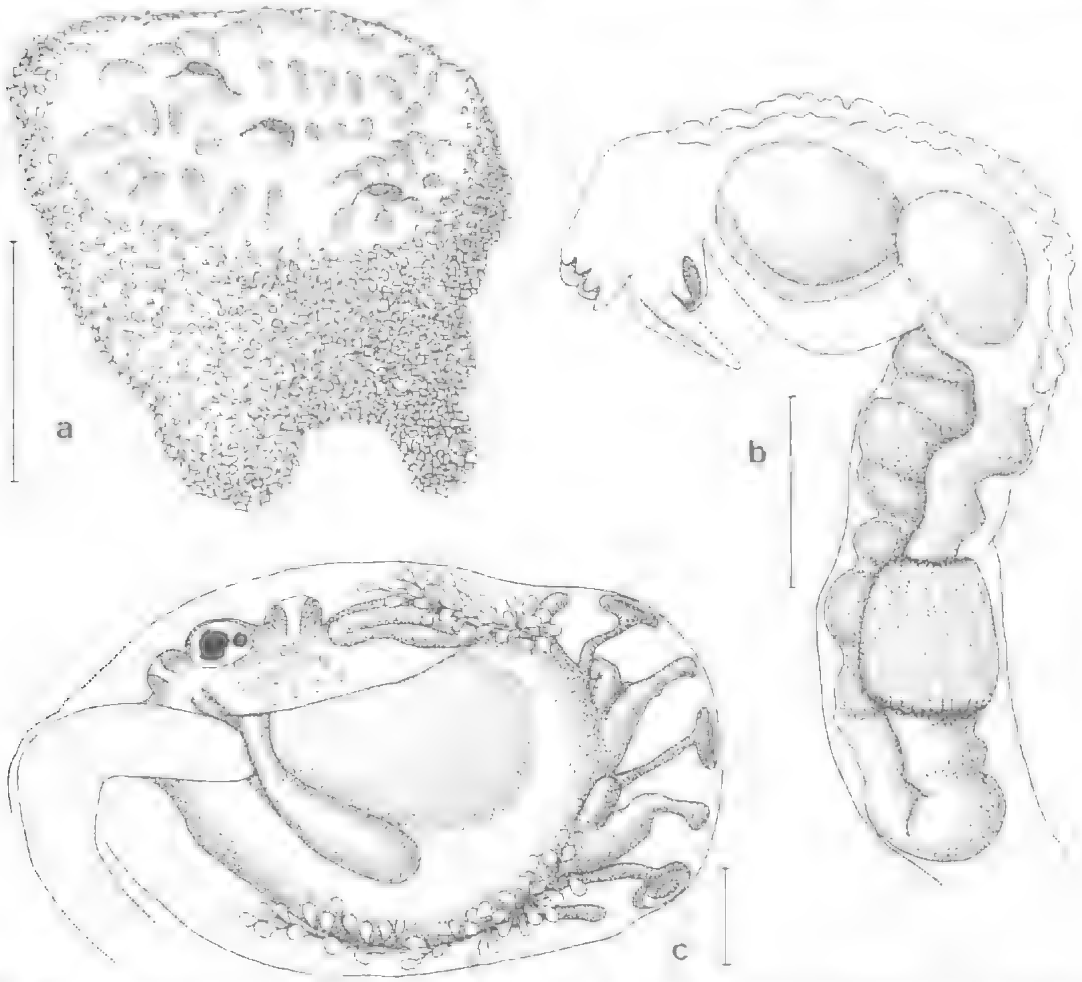


FIG. 92. *Aplidium ornatum* n.sp. (holotype QM GH5157) — **a**, colony; **b**, thorax and abdomen; **c**, larval trunk. Scales: **a**, 5mm; **b**, 0.5mm; **c**, 0.1mm.

chial sac and stomach folds, is distinguished by having single arcs of epidermal vesicles in the larval trunk, sand absent from around the border of the colony, a softer test, opaque white pigment particles around the branchial apertures and long branching double-row systems. The specimen from Currumbin assigned to *A. multiplicatum* by Kott (1963) has sand around the base and sides of the colony, but not in the upper suface or embedded. The zooids are small, contracted, and appear to be arranged in circular systems. The atrial lip is from the upper rim of the aperture, and there are 18 stomach folds. Other details of their morphology are obscured.

Aplidium uteute has numerous stomach folds, but is distinguished by its smaller circular systems, completely naked colonies, more numerous stigmata per row but fewer rows, single arcs of larval epidermal vesicles, and, usually, the absence of red pigment from the thorax. *Aplidium altarium* (Sluiter, 1909) has numerous stomach folds and colonies of similar dimensions to the present one, but the 9 or 10 rows of stigmata have about 25 per row, the posterior abdomen is short with bunched male follicles, and unlike the present species, the colony is transparent.

Aplidium paralineatum n.sp.
(Fig. 93)

DISTRIBUTION

TYPE LOCALITY: Tasmania (45 nautical mls NNE of Sister I., 39°00'S 148°25'E, 92m, sand bottom, epibenthic sled, CSIRO Statn 22, coll. W. Zeidler 14.10.84, holotype SAM E10648).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The specimen is a long (3cm), narrow cushion, broken at one end. It probably is a piece from a longer colony. A conical prominence about 1cm high with a terminal common aperture is at the other end. Zooids are in parallel double rows, a row along each side of the long, straight cloacal canals that run the length of the colony, converging to the large, sessile cloacal aperture. Long ridges separate the double rows of zooids from one another. The test is relatively soft, although sand is embedded throughout. Along the under surface the test is produced into fine root-like processes, which, with their adherent sand, create a felt-like mass holding the colony in the sandy substrate. The colony appears to have been organised in a single

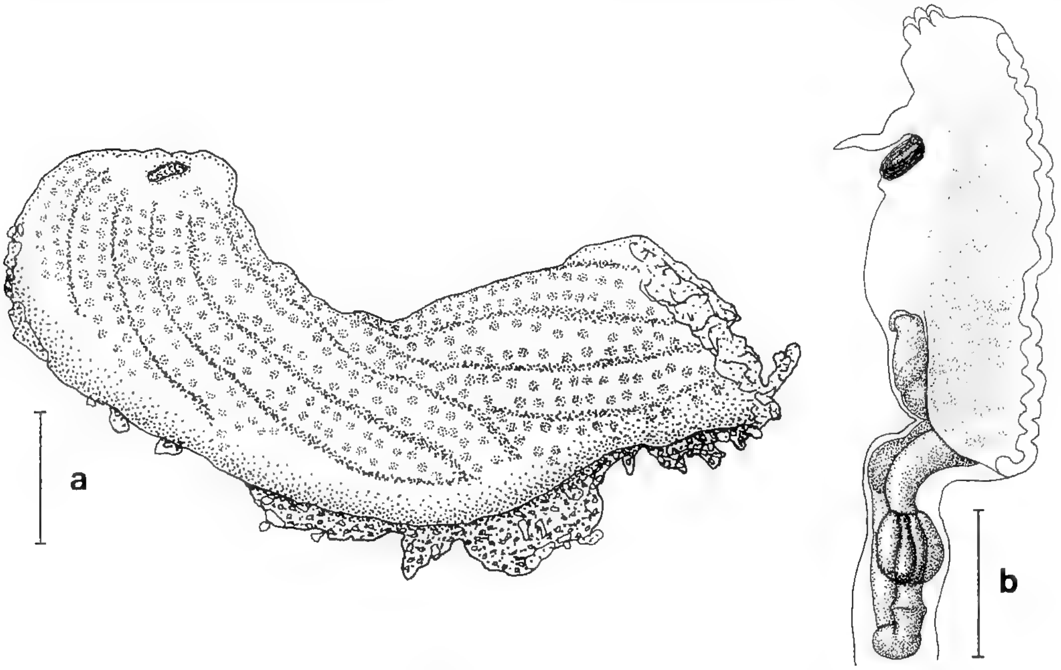


FIG. 93. *Aplidium paralineatum* n.sp. (holotype SAM E10648) — **a**, colony; **b**, thorax and abdomen. Scales: **a**, 5mm; **b**, 0.5mm.

cloacal system, although there may have been a second cloacal aperture at the mutilated end.

INTERNAL STRUCTURE: The zooids are robust. However, the thorax and abdomen together are only about 3mm. The posterior abdomen is long and threadlike. The atrial tongue is relatively small, pointed, and produced from the anterior rim of the aperture. There are 15 rows of stigmata although these zooids are too contracted to determine the number in each row. The stomach is small with 5 deep folds in its wall. A single series of testis follicles are in the posterior end of the long posterior abdomen.

REMARKS

The species is distinguished by its long double row systems and sessile colonies. Similar long systems are in the stalked colonies of *A. australiense* which, however, has more numerous stomach folds than the present species.

Aplidium parastigmaticum n.sp.
(Fig. 94)

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I., reef slope 10m, coll. S. Cook 28.4.88, holotype QM GH5603).

FURTHER RECORD: Queensland (Heron I., QM GH5604)

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are sessile spheres about 3cm in diameter. The test is firm and translucent, with some sand on the ridges between the systems. Living zooids are vermilion with buff coloured branchial apertures. In preservative both zooids and test are pinkish.

Zooids are arranged in circular to star-shaped systems, about 7mm in diameter. The cloacal cavity is large, with some peripheral extensions to reach the zooids in the outer periphery of each of the systems. The test is soft, and the zooids all lie parallel to one another. Sand is embedded in the basal test, but not elsewhere.

INTERNAL STRUCTURE: Zooids are large and robust, about 7mm in overall length even when contracted. In the contracted zooid the posterior abdomen is about half and the thorax is slightly more than one quarter of the total zooid length.

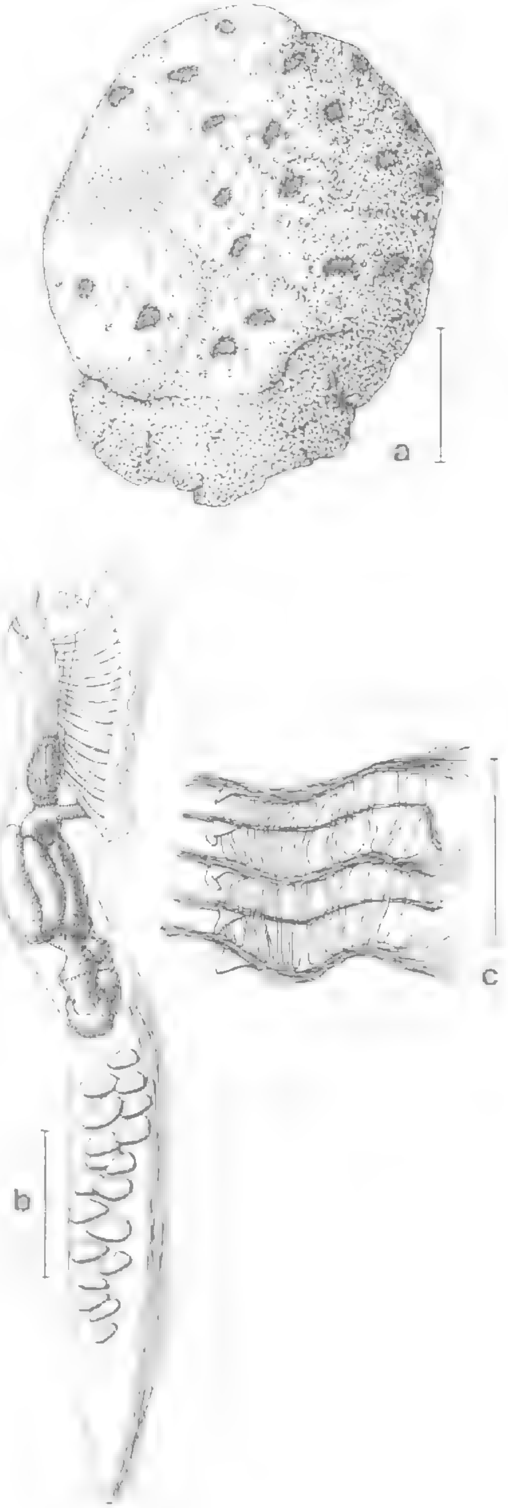


FIG. 94. *Aplidium parastigmaticum* n.sp. (holotype QM GH5603) — **a**, colony; **b**, zooid; **c**, portion of branchial sac showing muscle fibres in primary transverse and parastigmatic vessels. Scales: a, 1cm; b, 1mm; c, 0.5mm.

The longitudinal muscles tend to form a band in the dorsal half of each side of the thorax, and then continue in a wide band along the ventral part of the abdomen and posterior abdomen. Their contraction causes the thorax to curve around the shortened dorsum. Strong transverse muscle fibres are in the primary transverse and parastigmatic branchial vessels. They separate into short terminal branches on each side of the endostyle. The branchial aperture is 6-lobed, and the atrial aperture has a fleshy lip from the upper border of the opening. The tip of the atrial tongue is either undivided, or divided into 2 or 3 lobes. The forward pointing atrial aperture opens from a pouch

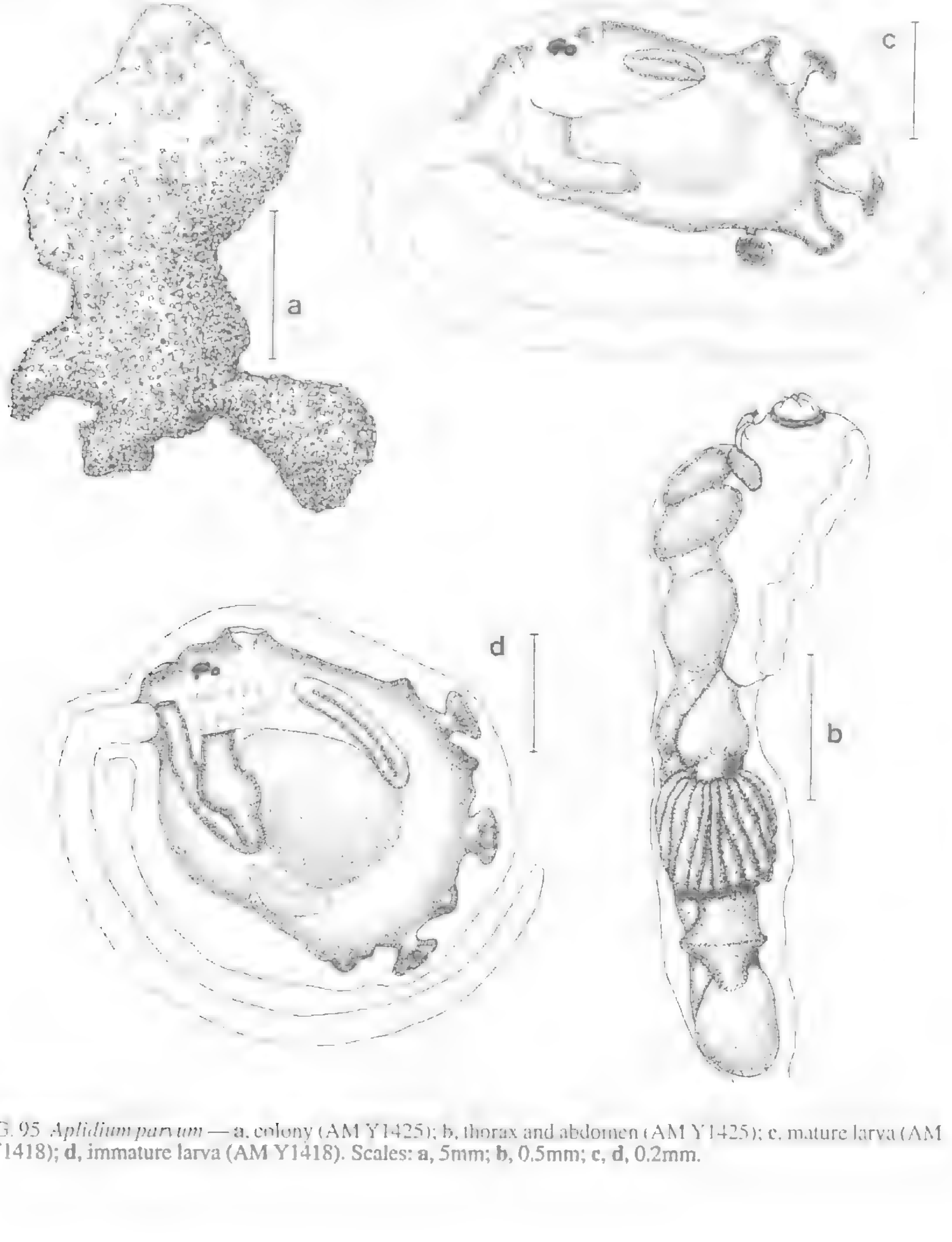


FIG. 95 *Aplidium parvum* — **a**, colony (AM Y1425); **b**, thorax and abdomen (AM Y1425); **c**, mature larva (AM Y1418); **d**, immature larva (AM Y1418). Scales: **a**, 5mm; **b**, 0.5mm; **c**, **d**, 0.2mm.

in the atrial cavity, which does not contract with the contraction of the dorsal part of the zooid. The stigmata are in 18 rows, with about 12 per row. Each row is crossed by a conspicuous parastigmatic vessel. A dorsal languet is on each parastigmatic, as well as on each primary transverse vessel.

The stomach at mid-abdominal level, has 5 distinct longitudinal folds. The male follicles are in two longitudinal series.

REMARKS

The red zooids in the translucent test resemble *A. uteute* which, however, has close circular systems (rather than the star-shaped ones of the present species) and more numerous stomach folds. The parastigmatic vessels, the atrial lip from the upper border of the opening, the pouch that forms beneath the atrial aperture when the zooid is contracted. The large stomach with 5 folds, and the parastigmatic vessels all occur in the temperate *Aplidium amorphatum* which is distinguished by its 8 branchial lobes, distinct circular systems, and poorly developed gastric folds. *Aplidium protectans*, which extends further north than *A. amorphatum* but has the same large zooid and atrial and branchial apertures, has distinct circular systems opening to depressions in the surface, and lacks parastigmatic vessels.

Some features of the present colony, such as the stellate systems, and surface sand between them, are reminiscent of *A. clivosum*. However, the atrial lip is separate from the aperture in *A. clivosum*, the zooids are larger than those of the present species and there are no parastigmatic vessels. It appears, therefore, that the colony is a member of a formerly undescribed species.

Aplidium parvum Kott, 1963
(Fig. 95)

Aplidium parvum Kott, 1963, p.112.

DISTRIBUTION

NEW RECORDS: None.

PREVIOUSLY RECORDED: Western Australia (Albany — AM Y1425 Kott 1963). Victoria (San Remo — AM Y1418 Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are small spherical transparent heads on short stalks to 1cm high overall. The zooids are arranged in longitudinal rows, converging to a common cloaca on the top of the head.

INTERNAL STRUCTURE: Zooids are small, the length overall extending to about 6mm. The posterior abdomen is up to twice the length of the remainder of the zooid. The short branchial siphon has 6 lobes around the aperture. The atrial aperture has a short, undivided lip from the anterior rim of the opening. Stigmata are in 12 rows of about 8. The short stomach has 18, mostly parallel, folds. The oesophagus has a pronounced prestomach enlargement at its distal end. Three embryos are incubated in a brood pouch that projects from the thorax in the syntypes (AM Y1418) collected in October.

The larval trunk is 0.8mm long. Anteriorly, single median ampullae are in the interspaces alternating with the adhesive organs. These median ampullae have columnar cells on them, and when well developed they become flat-ended rather than conical, the stalks of the adhesive organs become shallower and saucer-shaped, with long, slender stalks.

REMARKS

The small colonies, zooids and larvae are all distinctive. Although the systems resemble those of *A. altarium*, *A. geminatum*, *A. inflorescens* and *A. brevilarvacium*, the colonies are smaller, and stomach folds and stigmata are fewer. Like the present species the larva of *A. inflorescens* lacks epidermal vesicles. However, its trunk is about twice the length of that of the present species, and is further distinguished by the presence of lateral as well as median ampullae. *Aplidium geminatum*, *Aplidium altarium* and *Aplidium brevilarvacium* have different larval epidermal vesicles from the present species, and larger larval trunks (about 1mm long). Further, *Aplidium altarium* has appreciably more stigmata per row than the present species, *A. brevilarvacium* has fewer stomach folds (10), and in *A. geminatum* the stomach folds are more numerous.

Aplidium petrosum n.sp.
(Fig. 96. Plate 15d–f)

DISTRIBUTION

TYPE LOCALITY: South Australia (Cape Jaffa, Margaret Brock Lighthouse, coll. AIMS Bioactivity Group 18.2.89, holotype QM GH5454).

FURTHER RECORDS: South Australia (The Gap, QM GH4165–6; Hopkins I., QM GH4190).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are rigid, sandy, flat lamellae, about 1cm thick, which divide and curve to form a large 3-dimensional maze. Zooids open on both sides of the lamellae. They are arranged along each side of cloacal canals that surround circular to elongate zooid-free areas. Common cloacal apertures are at the junctions of the cloacal canals. The test is slightly depressed over the cloacal canals in the preserved specimens. Sand is densely packed in the test and obscures the systems. Zooids, lying parallel to one another, are tightly enclosed in the test.

INTERNAL STRUCTURE: Zooids are small and slender, the thorax and abdomen together being about 2mm long. The branchial siphon is short and the aperture small with 6 short, rounded lobes. The small atrial lip is pointed or bipartite and projects from the anterior rim of the opening. Stigmata are in 9 rows with only 6 per row, in the narrow thorax. The stomach is long and narrow with 5 longitudinal folds. The posterior abdomen is about twice the length of the rest of the zooid, with male follicles in double rows; or when the zooid is contracted, drawn up into a bunch behind the gut loop.

Three embryos are being incubated in the atrial cavity of specimens collected in April (QM GH4165). The larval trunk is about 0.8mm long. Single large, conical, median ampullae alternate with the adhesive organs; which have slender stalks that expand into a cone at the base. A wide band of epidermal vesicles is along each side of the median line around the anterior half of the trunk.

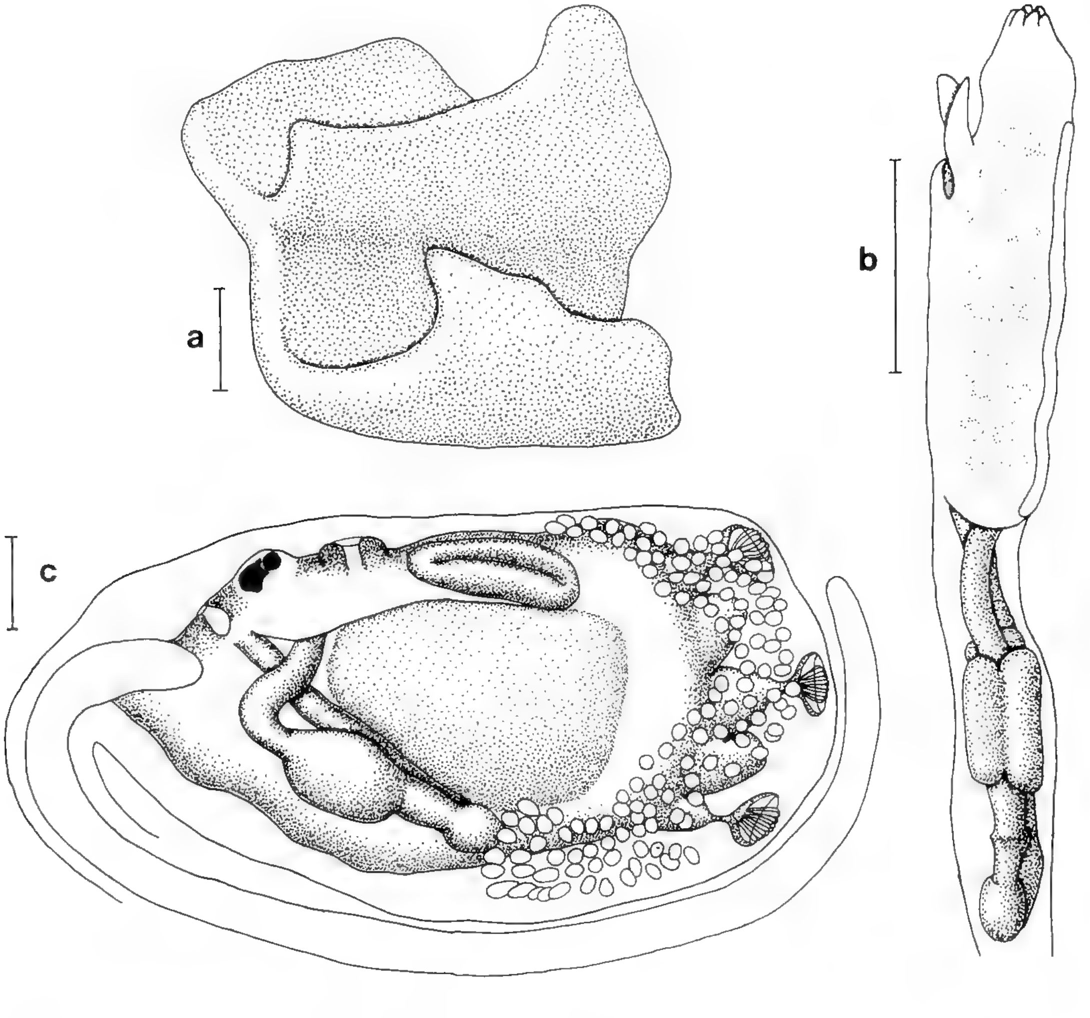


FIG. 96. *Aplidium petrosum* n.sp. — **a**, part of colony (QM GH5454); **b**, thorax and abdomen (QM GH5454); **c**, larval trunk (QM GH4166). Scales: **a**, 1cm; **b**, 0.5mm; **c**, 0.1mm.

REMARKS

Colonies forming stiff sandy lamellae are known also for *A. solidum* from the eastern and north-western coasts. They also have similar zooids, arranged in similar systems. The present species is distinguished by its more branched colony (*A. solidum* having upright lamellae rather than a 3-dimensional maze); and by the larvae which are larger than those of *A. solidum* (0.5 to 0.6mm long trunk) and have median ampullae (not present in *A. solidum*).

Aplidum ritteri have similar zooids with the atrial lip from the upper rim of the opening, but also have smaller larvae than those of the present species and long straight cloacal canals.

Aplidium protectans (Herdman, 1899)
(Fig. 97. Plate 16a,b)

Amaroucum protectans Herdman, 1899, p.73.
Aplidium protectans: Kott, 1963, p.102.
Aplidium longithorax Monniot, 1987, p. 525.

DISTRIBUTION

NEW RECORDS: Queensland (Capricorn Group, QM GH5562 GH5574; central Great Barrier Reef, QM GH5362 GH5378; Lizard I., QM GH332 GH5553 GH5611–2; far nothern Great Barrier Reef, QM GH5336).

PREVIOUSLY RECORDED: New South Wales (Montague South — Kott 1963; Port Jackson — Herdman 1899). New Caledonia (Monniot 1987).

The species is recorded from 0 to 100m depth.

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are firm, gelatinous naked domes, spheres or cushions 2.5cm to 6cm in maximum dimension. The test is translucent both living and in preservative, and the zooids are pink, yellowish or orange. Circular systems, each of from 10 to 16 zooids are evenly distributed around the outer surface of the colony, and are slightly depressed into the surface in preserved colonies. The common cloacal apertures are in the central of each system. Systems are well spaced and never crowded. They appear as regular daisy-like patterns over the surface of the colony.

INTERNAL STRUCTURE: Zooids are large and robust, the thorax and abdomen even in contracted specimens together being more than 4mm long, and the posterior abdomen about the same length. The branchial siphon has 8 rounded lobes, the atrial siphon is produced out toward the central common cloacal aperture and an undivided, fleshy atrial lip arises from just above the sphincter muscle in the rim of the opening. In some zooids the atrial lip appears to be part of the rim of the siphon, but in others the atrial siphon is close to, but separate from its lip. The blunt tip of the atrial lip is divided into 3 to 6 characteristically regular, short, finger-like rounded lobes. The body wall is muscular with about 20 longitudinal bands on each side of the thorax, extending along the length of the zooid in a wide lateral band on each side. Stigmata are in 18 to 24 rows with about 20 per row. The oesophagus is relatively long, opening into a long barrel-shaped stomach with 5 shallow folds about one third of the way down the abdomen. When contracted the stomach wall tends to be drawn into horizontal folds. There is a short thick duodenum, but the remainder of the post-pyloric part of the descending limb of the gut loop is long, curving around in a corkscrew spiral, which may be a homologue of the posterior stomach, although it is longer than usual. A narrow, short section of mid-intestine intervenes between this thick distal end of the descending limb and the rectum. The rectal caeca are not well developed.

Two or 3 large eggs are present just behind the gut loop, separated from the pear-shaped male follicles which are in one or 2 longitudinal series in the remainder of the posterior abdomen or, if the longitudinal body muscles are sufficiently contracted, bunched. Up to 3 embryos, brown in preservative, are lined up in the posterior part of the atrial cavity of specimens collected in August (QM GH5362) and tailed larvae are present in colonies from Lizard I. collected in June (QM GH5553). The larval trunk is 0.8–0.9mm long. It has single median ampullae between and dorsal and ventral to the adhesive organs, and 4 clusters of epidermal vesicles, one on each side of the dorsal and ventral mid-lines behind the adhesive organs.

REMARKS

The large zooids in conspicuous circular systems, larvae with median ampullae and ventral and dorsal clusters of vesicles, and fleshy colonies are characteristic. Kott (1963) also noted the tendency for the stomach to collapse in horizontal folds in contracted zooids from a specimen from NSW waters - which was found on a crab.

Polycitor giganteum (also found on crabs) has similar large, firm, gelatinous colonies which may be a convenient consistency for the crab to hold in place and trim to an appropriate regular size and shape.

Colonies and zooids resemble *Aplidium amorphatum* in having 8 rather than 6 branchial lobes. The present species has firmer colonies a longer thorax and abdomen, and it lacks parastigmatic vessels. Larvae, although smaller, have median ampullae and dorsal and ventral vesicles like *A. lunacratum*.

Aplidium indicum (Renganathan and Monniot, 1984) from India has a similar fleshy colony to the present species and equally shallow stomach folds. However, the small, extended zooids of the Indian species were not seen to be arranged in circular systems, and have fewer rows of fewer stigmata than the present species.

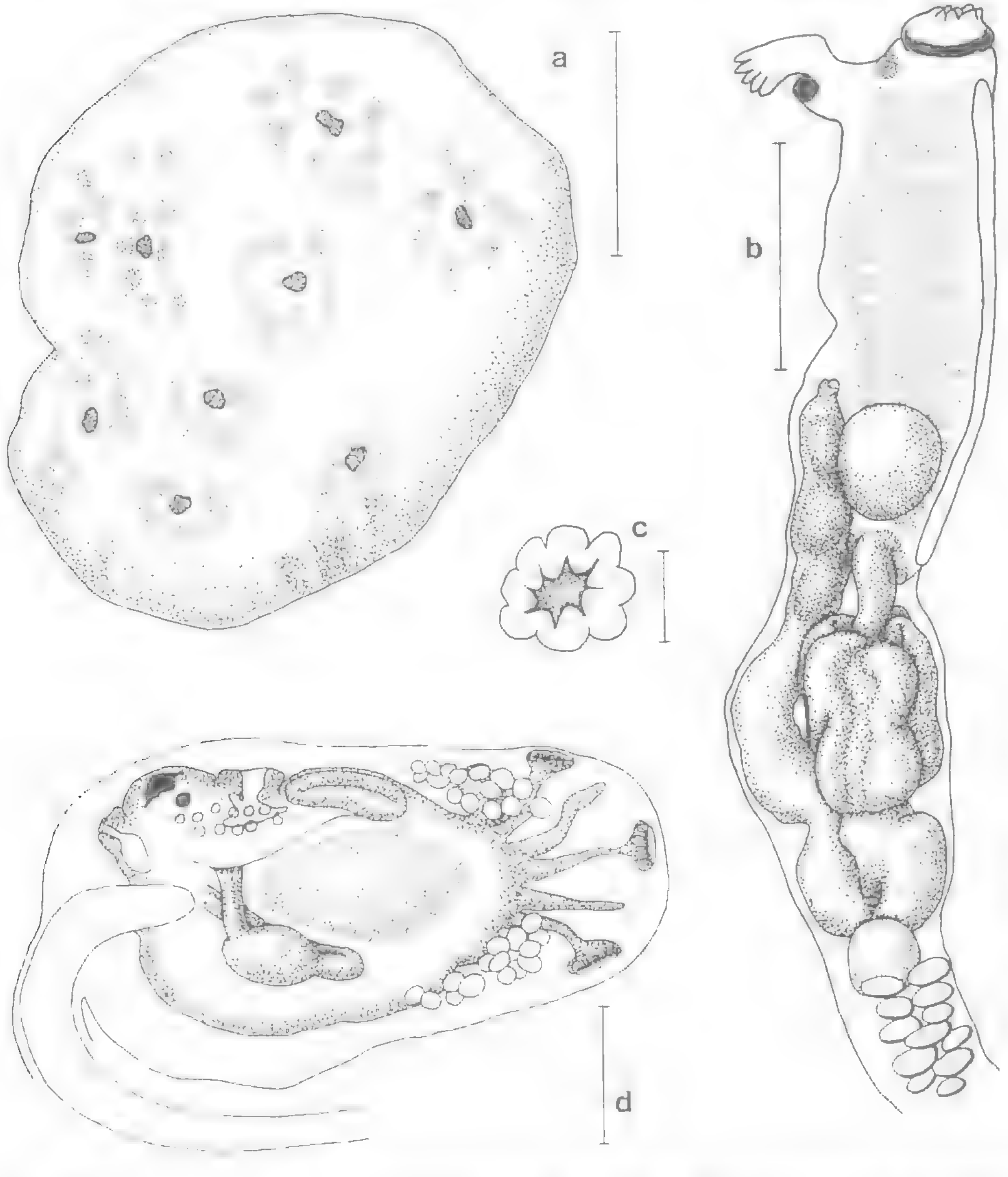


FIG. 97. *Aplidium protectans* — a, small colony (QM GH5329); b, thorax, abdomen and anterior part of posterior abdomen showing digitiform tip of atrial lip and large stomach (QM GH5553); c, branchial aperture from above

Aplidium ritteri (Sluiter, 1895)
(Fig. 98)

Amaroucium ritteri Sluiter, 1895, p. 10.
Aplidium lobatum: Tokioka, 1967, p.22. ? Nishikawa, 1984a, p.110. Monniot, 1987, p.525. Monniot and Monniot, 1987, p.73.

DISTRIBUTION

NEW RECORDS: Queensland (Capricorn Group, QM GH5649 GH5660 GH5685 GH5704 GH5779–81).

PREVIOUSLY RECORDED: Queensland (Torres Strait — Sluiter 1895). Western Pacific (Palau Is, New Caledonia — Tokioka, 1967, Monniot, 1987; Truk, Ponape — Nishikawa 1984a). French Polynesia — Monniot and Monniot 1987).

The species is a tropical one.

DESCRIPTION

EXTERNAL APPEARANCE: The colonies are investing sheets or lumpy and massive with a relatively even surface and sand embedded throughout. The ridges that separate the long double rows of zooids are relatively inconspicuous, and the zooid openings along each side of the cloacal canals between these long ridges often are obscured by the embedded sand. Common cloacal apertures are at the junctions of 2 or more canals. Living colonies, are described as 'sandy with pink', and 'solid, sandy'.

INTERNAL STRUCTURE: Relaxed zooids are about 3mm long. The thorax is about half the total length and the abdomen and posterior abdomen each half of the remainder. The 6 branchial lobes are well-formed and triangular. The atrial aperture is small and rounded with a short, pointed atrial lip from the anterior rim of the opening. A conspicuous bulging sphincter is behind the branchial lobes. The body muscles are strong and the short posterior abdomen is often drawn up into a short clump behind the abdomen.

Stigmata are in 11 or 12 rows of up to 8 in the narrow pharynx. The most ventral and dorsal in each row are short. The oesophagus is moderately long, and the stomach is divided into 5 by the deep folds in its wall. There is a long, narrow duodenum, narrow proximal part of the mid-intestine and an oval posterior stomach in the end of the descending limb of the gut loop.

The posterior end of the posterior abdomen is curiously flattened and straight edged. Up to 8 male follicles alternate with one another, or they are in a single series in the relaxed posterior abdomen; when the zooid is contracted they are bunched together. Male and female gonads are not present together in the one zooid. Embryos are incubated in the atrial cavity of specimens collected in November (QM GH5649) the tailed larva is small, the trunk 0.47 to 0.57mm long, with the tail wound three-quarters of the way around it. The adhesive organs are relatively deep

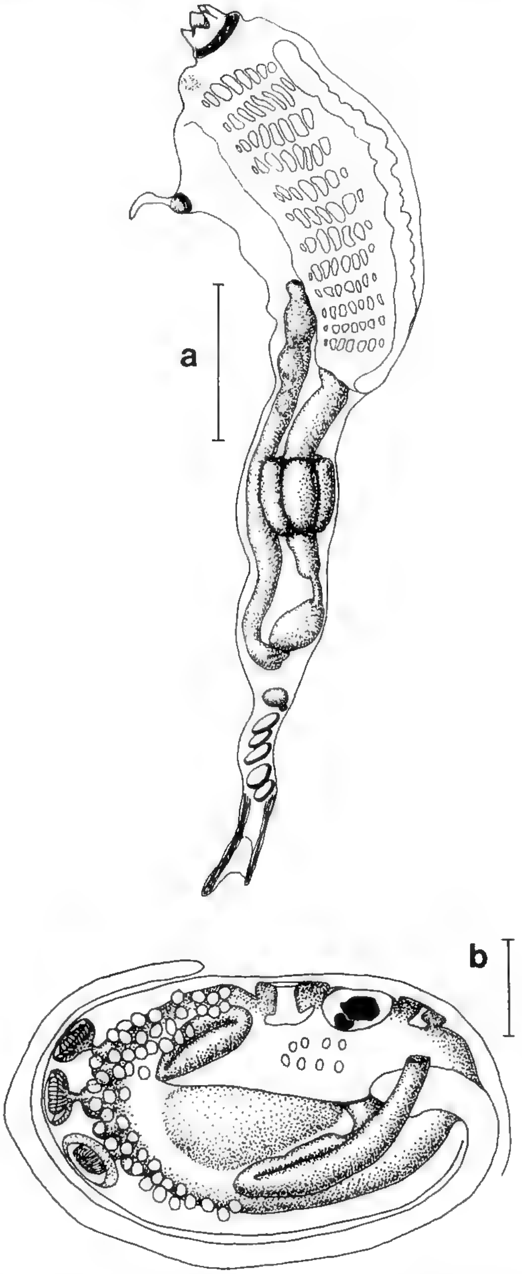


FIG. 98. *Aplidium ritteri* — **a**, zooid (QM GH5779); **b**, larva (QM GH5649). Scales: **a**, 0.5mm; **b**, 0.1mm.

axial cones in epidermal cups. The base of their stalks expand into wide cones. Short median ampullae alternate with them. The anterior end of the larval trunk is obscured by a long, wide lateral arcs of epidermal vesicles.

REMARKS

The specimens described above have all the characters of the type from Torres Strait, with the atrial lip from the upper rim of the opening, about 12 to 14 rows of 6 or 7 stigmata, 5 stomach folds, and furrows and ridges on the upper surface of the colony. The species has much in common with the Red Sea *Aplidium lobatum* Savigny, 1816 with which it often has been confused. The principal differences between these species are the larger branchial sac of *A. lobatum*, with up to 12 stigmata per row, and the division of the upper surface of the colony into more or less regular flat-topped, oval cushions, separated from one another by narrow furrows (see Michaelsen 1920). *Aplidium macrolobatum* n.sp. has a longer atrial lip, more stigmata per row, and median vesicles in the larva as well as lateral ones.

In Australian waters the temperate and east-coast species *Aplidium solidum* has much in common with the present one, having sandy colonies, the atrial lip from the upper rim of the aperture, 12 rows of up to 7 stigmata, 5 stomach folds and bunched male follicles in a short posterior abdomen with a flattened straight-edged tip. *A. ritteri* has straight rows of zooids in contrast with the curved ones surrounding circular zooid-free elevation of the test in *A. solidum*. Although this appears to be a minor difference, the larvae constitute more compelling evidence that the species are separate — the larvae of *A. solidum* lack median ampullae but their trunk length (0.4 to 0.5mm) overlaps the range in the present species.

Aplidium caelestis has similar sandy colonies, but more distinct long, double-row systems and zooids with the atrial tongue separate from the aperture.

Aplidium robustum n.sp.
(Fig. 99. Plate 16c)

Aplidium flavolineatum: Kott, 1975, p.5.

DISTRIBUTION

TYPE LOCALITY: Western Australia (King George Sound, Albany, small breaking reef, south of Mt Martin, 35°0.8'S 117°57.0'E, 2.0m, in small crevices in flat base rock, coll. AIMS Bioactivity Group 27.3.89, holotype QM GH5467; paratype QM GH5506).

FURTHER RECORDS: South Australia (Great Australian Bight — SAM E2595 Kott 1975). Tasmania (Dunnalley, TM D1866).

DESCRIPTION

EXTERNAL APPEARANCE: Colonies are sessile, spherical or conical to 8cm high and 6cm in greatest (basal) diameter. The test is soft and gelatinous, but turgid and opaque, cloudy beige in preservative. In life the colony is pink around the common cloacal apertures and white over the zooids. Zooids are in circular, oval or elongate systems around and converging to the common cloacal apertures, which are numerous, large, sessile, and scattered randomly over the surface. They are said to 'turn to slits' when the colony is touched. Sand is present on the basal surface of the South Australian specimen, which is smaller than the others.

The zooids are perpendicular to the surface but posteriorly criss-cross one another in the centre of the colony. A sheath of soft test containing opaque white corpuscles clings to the zooids.

INTERNAL STRUCTURE: Zooids are robust, the contracted thorax and abdomen together being about 3mm and about equal in length. When relaxed the thorax probably is longer than the abdomen. About 15 longitudinal muscles are on the thorax and extend the length of the zooid. The 6 branchial lobes are small and round. The atrial lip from the upper rim of the aperture has a fleshy lip divided into 2 or 3 pointed lobes, or undivided with or without smaller lobes on each side. Stigmata are in 14 to 16 rows of up to 12. The oesophagus is moderately long, and the relatively small stomach, in the middle third of the abdomen, has 20 longitudinal, parallel folds in its wall. The duodenum, mid-intestine and posterior stomach are in the posterior third of the descending limb of the gut loop. There are rectal caeca at the proximal end of the rectum.

Up to 3 embryos are in the atrial cavity of the type material, of which one may be a well-developed tailed larva. The larval trunk is long (1mm), and almost cigar-shaped. The tail reaches to its anterior end. A lateral ampulla is on each side of the conical or cylindrical median ampullae that is in each interspace between the adhesive organs. The median ampulla between the middle and ventral adhesive organs is divided into 2. A cluster of epidermal vesicles is along each side of the mid-dorsal and mid-ventral lines, but not around the anterior end of the trunk.

Up to 6 embryos are lined up in the atrial cavity of the South Australian specimen. The tailed larvae are smaller (trunk 0.8mm long) and the lower median ampulla is not subdivided but otherwise they are similar to the larvae of the type specimens.

REMARKS

The species resembles *A. opacum* in having a sheath of soft test containing opaque white corpuscles clinging to the zooids, large fleshy colonies, and the same number of stomach folds. However zooids of the present species are more robust than those of *A. opacum*, with more rows of stigmata. They also have a larger larva with lateral ampullae and fewer vesicles than *A. opacum*.

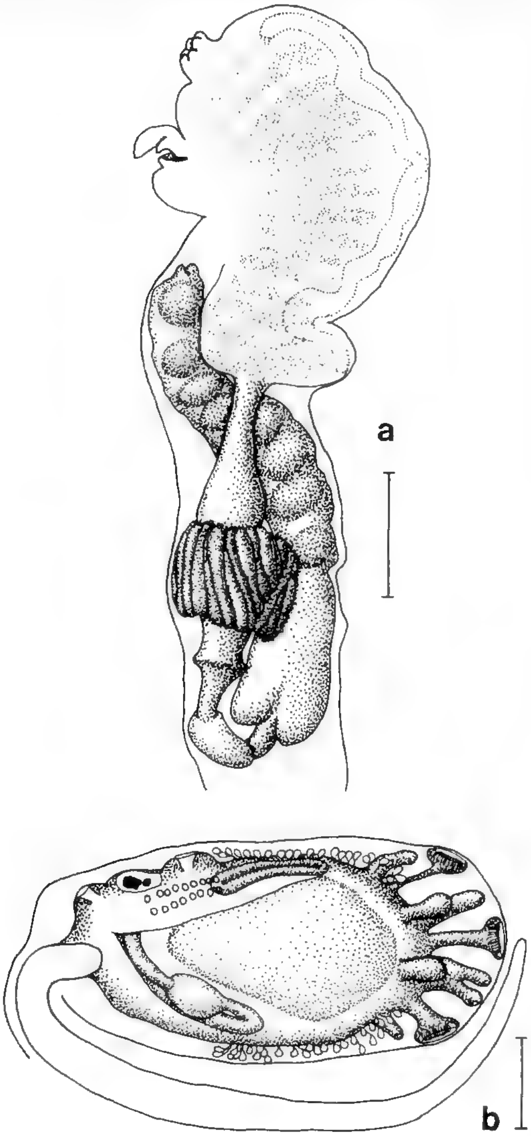


FIG. 99. *Aplidium robustum* n.sp. (holotype QM GH5467) — **a**, thorax and abdomen; **b**, larva. Scales: **a**, 0.5mm; **b**, 0.2mm.

The present species has larger opaque white cells around the zooids and firmer test than *A. multiplicatum*, and it lacks the characteristic single arc of lateral vesicles in the larval trunk.

In the distribution of epidermal vesicles this species resembles *A. ornatum* from tropical waters, although the latter species is smaller than the present one and is a different shape.

The smaller colony (*A. flavolineatum*: Kott, 1975) from South Australian waters with a layer of sand on its under surface and smaller larvae than the type may be found not to belong to the present species. However, at this stage it is possible that its differences represent no more than intraspecific variation. It was assigned to *A. flavolineatum* by Kott (1975) on the basis of its large number of stomach folds. However, the South African species has more numerous larval lateral ampullae and a brood pouch.

Aplidium gastrolineatum has many characters in common with the present species, but its common cloacal apertures are protuberant rather than sessile, and its larvae are different.

Aplidium rosarium n.sp.
(Fig.100)

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I., Blue Pools, rubble fauna, low tide, coll. P. Kott 8.8.82, holotype QM GH 5224).
FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The firm, gelatinous colony is wedge-shaped, with a little sand embedded basally. When living the holotype was rose-purple, but in preservative it is white and cloudy, with beige-pink zooids. Zooids are along each side of long canals converging to the cloacal apertures.

INTERNALSTRUCTURE: The zooids are robust, with up to 4 embryos crowded in the atrial cavity. The longitudinal thoracic muscles are strong and the thorax and abdomen of contracted zooids are together only 2mm. The 6 branchial lobes are triangular and conspicuous. The atrial lip is fleshy and arises from the upper rim of the aperture. It has a central band of longitudinal muscles that extend into the tip, which is pointed or divided into 3 small terminal lobes.

The stigmata are in 12 rows of about 12 per row. The short stomach wall has 20 folds. The posterior abdomen is about twice the length of the rest of the zooid.

Larvae are of moderate size, the trunk being 0.6mm long, with 2 rows of stigmata in the larval pharynx. A single arc of about 20 vesicles is along each side of the median line around the anterior end of the trunk. In immature larvae, a few median vesicles branch off the tip of the median ampulla which is in each interspace between the adhesive organs. The ampullae subsequently disappear and the stalk of each median vesicle appears to be independent, and attached directly to the larval ectoderm.

FIG. 100: *Aplidium rosarium* n.sp. (holotype QM GH5224) — **a**, zooid; **b**, larva. Scales: **a**, 0.5mm; **b**, 0.1mm.

REMARKS

Aplidium ornatum has a similar gelatinous colony, but its branchial sac is narrower and its large larvae have posterior vesicles and median and lateral ampullae, and lack the anterior arc of lateral vesicles that is present in *A. rosarium*. The larvae resemble those of *A. filiforme*, but colonies differ, and the zooids have more rows of stigmata.

The present species has some affinities with *A. altarium* but its larvae are smaller, the pharynx narrower and more muscular, and the stomach smaller with fewer folds. *Aplidium uteute* has circular systems, a brood pouch and more numerous stomach folds distinguishing it from the present species. Some aspects of the larvae suggest a relationship with *A. incubatum*, however the larval trunk of the latter species is larger, has more median vesicles and, the zooids have more stigmata and stomach folds, and are arranged in circular systems. Thus, despite the fact that only the holotype is available, the species is readily distinguished from other known species.

Aplidium rubricollum Kott, 1963
(Fig. 101, Plate 16d)

Aplidium rubricollum Kott, 1963, p. 103 (part, not specimens from Western Australia AM Y1403 < ? *A. solidum*); 1972a, p.15; 1972b, p.176.

DISTRIBUTION

NEW RECORDS: South Australia (Avoid Bay, QM GH4191; Port Noarlunga, QM G9304).

PREVIOUSLY RECORDED: South Australia (Reevesby I. — AM Y1417 holotype Kott 1963; Upper St. Vincent Gulf — SAM E2579 Kott 1972a; Pearson I. — Kott 1972b). Balnarring Beach — AM Y1415 Kott 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies range from small cushions investing weed or rubble to regular oval cushions to 5cm in maximum extent but never more than 1cm thick. Sand is embedded in the internal test, becoming sparse in the upper layer around the thoraces. Sometimes it is completely absent from the upper surface of the colony, but in other colonies only the test above the systems, including the protruding common cloacal apertures, is naked. Zooids are crowded along each side of relatively short canals that converge to the protruding cloacal apertures which are scattered over the surface, about 5mm apart. Red pigment cells are said to have been present in the surface layer of test in the living and freshly preserved specimens, and the colourless zooids are conspicuous, interrupting these. In the long-preserved specimens a brownish deposit in the surface test may be the remains of these red cells.

INTERNAL APPEARANCE: Zooids are small, with 10 fine longitudinal muscles. The atrial lip has an undivided tip which becomes bidentate through the contraction of a median band of muscles. The lip arises from the body wall close to, but separate from the opening, which is on a short protruding siphon, often flattened antero-posteri-

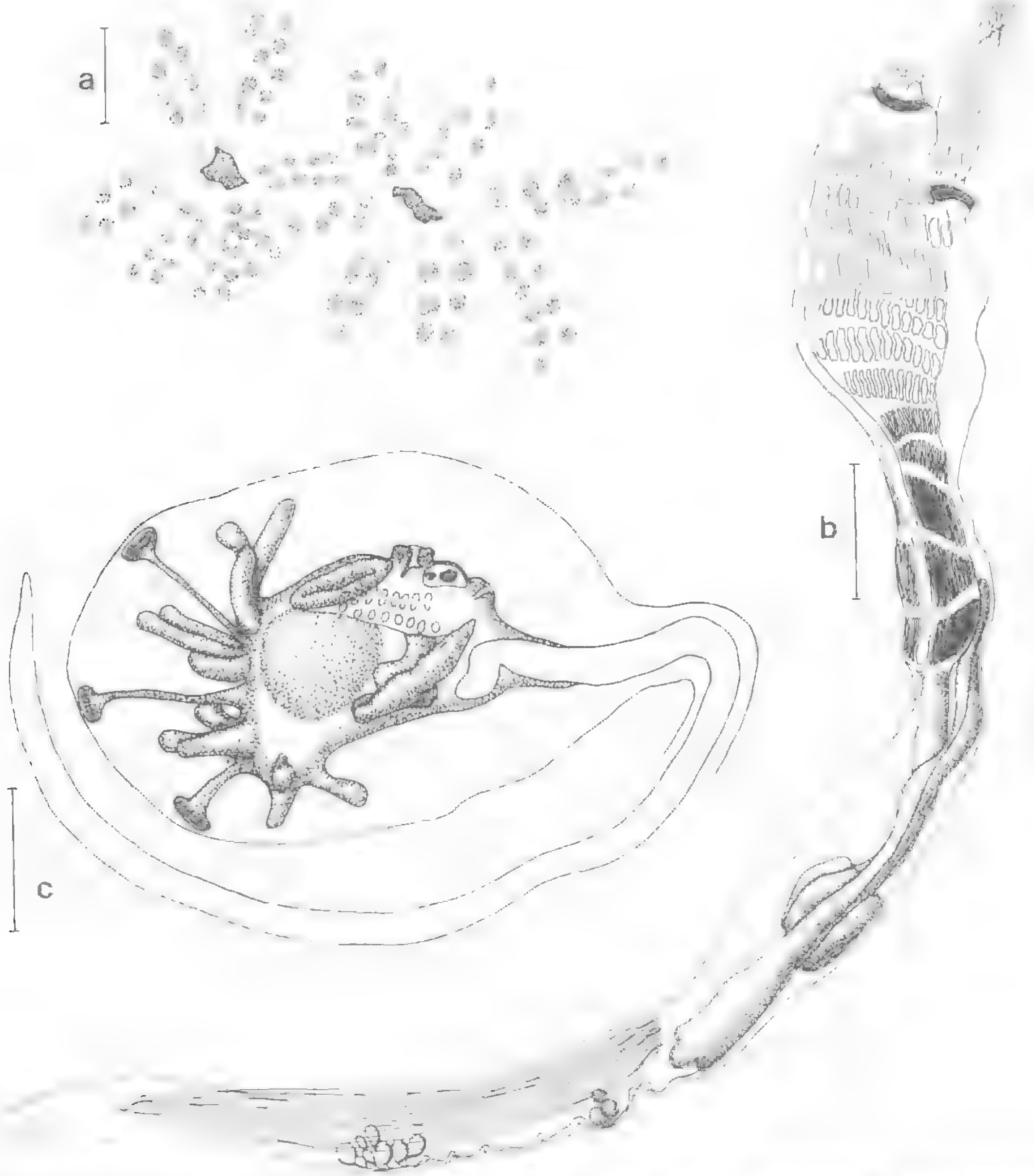


FIG. 101: *Aplidium rubricollum* — **a**, surface of colony showing 2 systems (QM GH4191); **b**, zooid (holotype AM Y1417); **c**, larva (holotype AM Y1417). Scales: a, 2mm; b, 0.5mm; c, 0.2mm.

orly. Stigmata are in 11 or 12 rows of up to 14. The stomach is short with 5 deep folds.

One specimen collected in February (QM G9304) and the holotype collected in December contain single, large embryos in the atrial cavity. The larval trunk is 0.7mm long. It has median and lateral ampullae, but no epidermal vesicles.

REMARKS

The systems and the colonies resemble those of *A. clivosum* except that the canals converging to the cloacal apertures are not so numerous, the zooids and systems are smaller, and the larvae lack the vesicles that obscure the anterior end of the trunk in *A. clivosum*. The zooids are small and, like those of *A. clivosum*, have the atrial aperture separate from the opening, but the present species has relatively shorter and wider thoraces with up to 12 rows of 14 stigmata while *A. clivosum* has up to 18 rows of about 12 stigmata. Colonies assigned to *Aplidium caelestis* (see above) often superficially resemble those of the present species. However, *A. caelestis* has a narrower thorax with fewer stigmata per row, the systems have longer double rows of zooids and the larvae contain epidermal vesicles.

Aplidium solidum (Herdman, 1899)
(Fig. 102)

Psammaplidium solidum Herdman, 1899, p.85.
Psammaplidium lobatum: Herdman, 1899, p.85
Psammaplidium fragile Herdman, 1899, p.86
Psammaplidium incrustans Herdman, 1899, p.87.
Aplidium solidum Millar: 1963, p.1.
Aplidium arboratum Kott, 1963, p.96.
Synoicum investum Kott, 1963, p.90.
Aplidium lobatum: Kott, 1976, p.61.
? *Aplidium rubricollum* Kott, 1963, p.103 (part, specimen from Rottnest I. AM Y1403).
Not *Amaroucium solidum* Ritter and Forsyth, 1917, p.486; Van Name, 1945, p.49. The species name is a secondary homonym and accordingly a *nom. nov.* is required for this species.

DISTRIBUTION

NEW RECORDS: Western Australia (Dampier Archipelago, QM GH5411). New South Wales (Jervis Bay, QM GH5778; Batemans Bay, AM Y2278; Bass Point, QM GH5620; Arrawarra, QM GH5777). Queensland (Point Lookout, QM GH5782).

PREVIOUSLY RECORDED: New South Wales (Botany Bay — AM U3941 Herdman 1899; Millar 1963). Queensland (Bargara — holotype AM U3928, paratype QM G4937 *S. investum* Kott, 1963).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies form extensive rigid, sandy sheets, lobes and lamellae from about 3mm to 2cm thick. These branch and fuse with one another in a vertical plane. Along their upper border the lamellae terminate in rounded margins. The upright lobes and lamellae form when the sheet is folded, fuses back to back, and extends up in the vertical plane. Sand is embedded throughout.

Zooids appear to be fairly evenly placed and close to one another, along the sides of narrow, shallow canals. Circular or oval, raised zooid-free areas sometimes are between (or surrounded by) the double rows of zooids. Common cloacal openings are scattered over the surface of the colony at the junction of the canals. The colour of the colonies is dominated by the sand, although the zooids are pinkish in preservative.

INTERNAL STRUCTURE: The zooids are small, seldom more than 4mm even in relaxed condition. Thorax, abdomen and posterior abdomen are of about equal length. Fine longitudinal muscle bands extend the length of the zooid. A sphincter muscle is at the base of the 6 pointed branchial lobes. The small, circular atrial aperture has a small lip, undivided or divided into 2 or 3 pointed lobes, from the anterior rim of the opening.

Stigmata are in 9 to 12 rows of about 6. The long, narrow stomach has 5 folds. The posterior stomach is large, oval, at the distal end of the descending limb of the gut loop. The posterior abdomen is relatively short, with a single series of up to 7 male follicles in a single longitudinal series or sometimes bunched up behind the anterior ovary. However, even when it is not contracted, the extremity of the posterior abdomen has a truncated flat appearance. A small ovary is often present anterior to the testis follicles.

Two to 5 embryos are crowded into the atrial cavity of specimens from Botany Bay from Jervis Bay in February (QM GH5778) and from South Australia in April (QM GH4165). Larvae are small, the trunk 0.4 to 0.5mm long with the tail wound half to three- quarters of the way around it. A mass of epidermal vesicles surround the 3 median adhesive organs and obscure the anterior end of the trunk, but there are no median ampullae. The base of stalks of the adhesive organs expand into a cone.

REMARKS

Like the present species, *Aplidium acroporum* n.sp. has small zooids with the atrial lip from the rim of the opening. However it has 8 stomach folds (rather than 5), and circular systems with zooids surrounding the cloacal cavity (rather than along each side of narrow canals).

The specimen from Rottnest I. appears to have been wrongly assigned to *A. rubricollum* by Kott (1963). Both colony and zooids resemble those of the present species except in the colour (pink with red zooids), which they have retained over a long time (40 years) in preservative. The colour of the living colony is not known. Although brown to orange living specimens of *A. solidum* are known the colour of the embedded sand dominates their

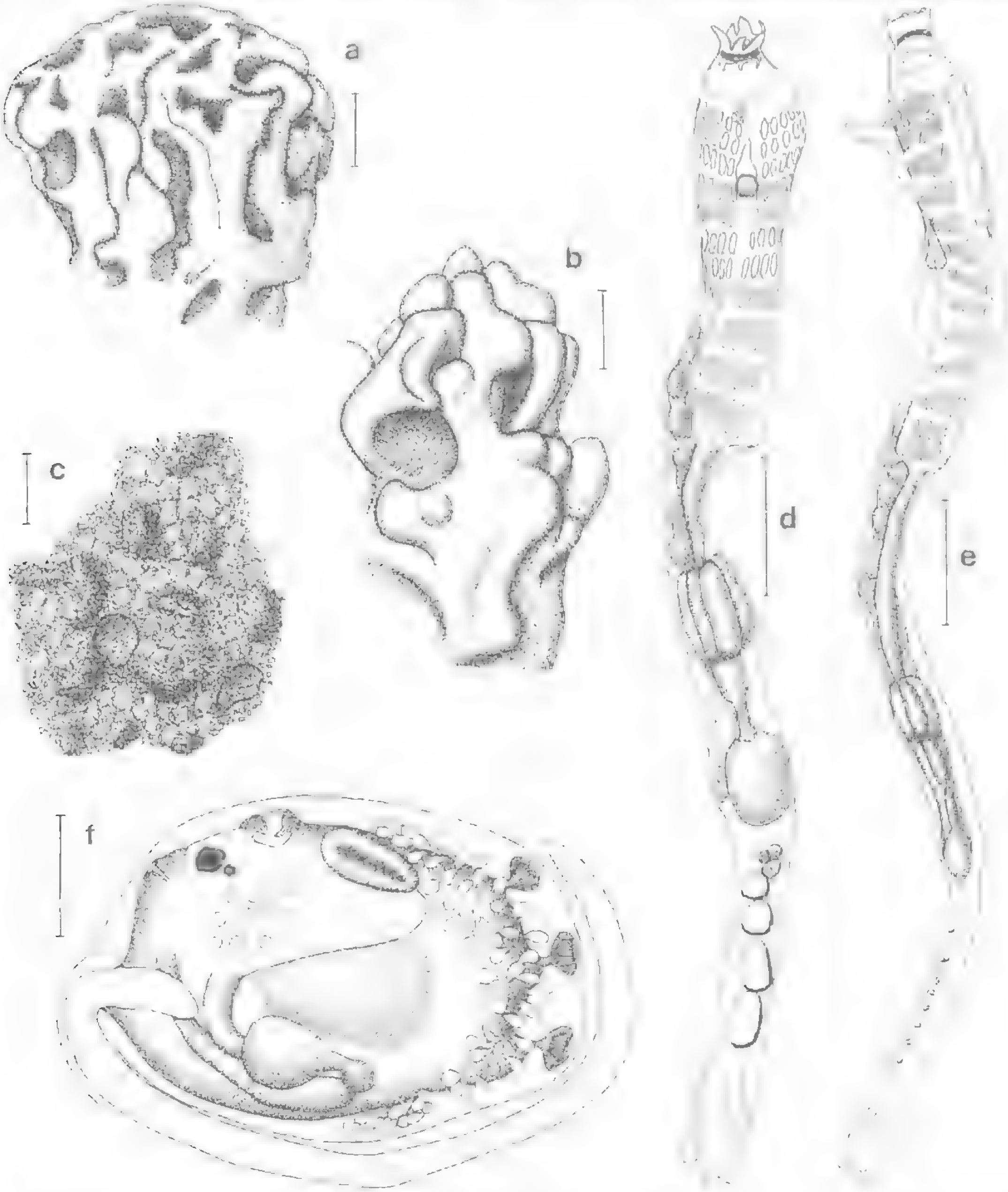
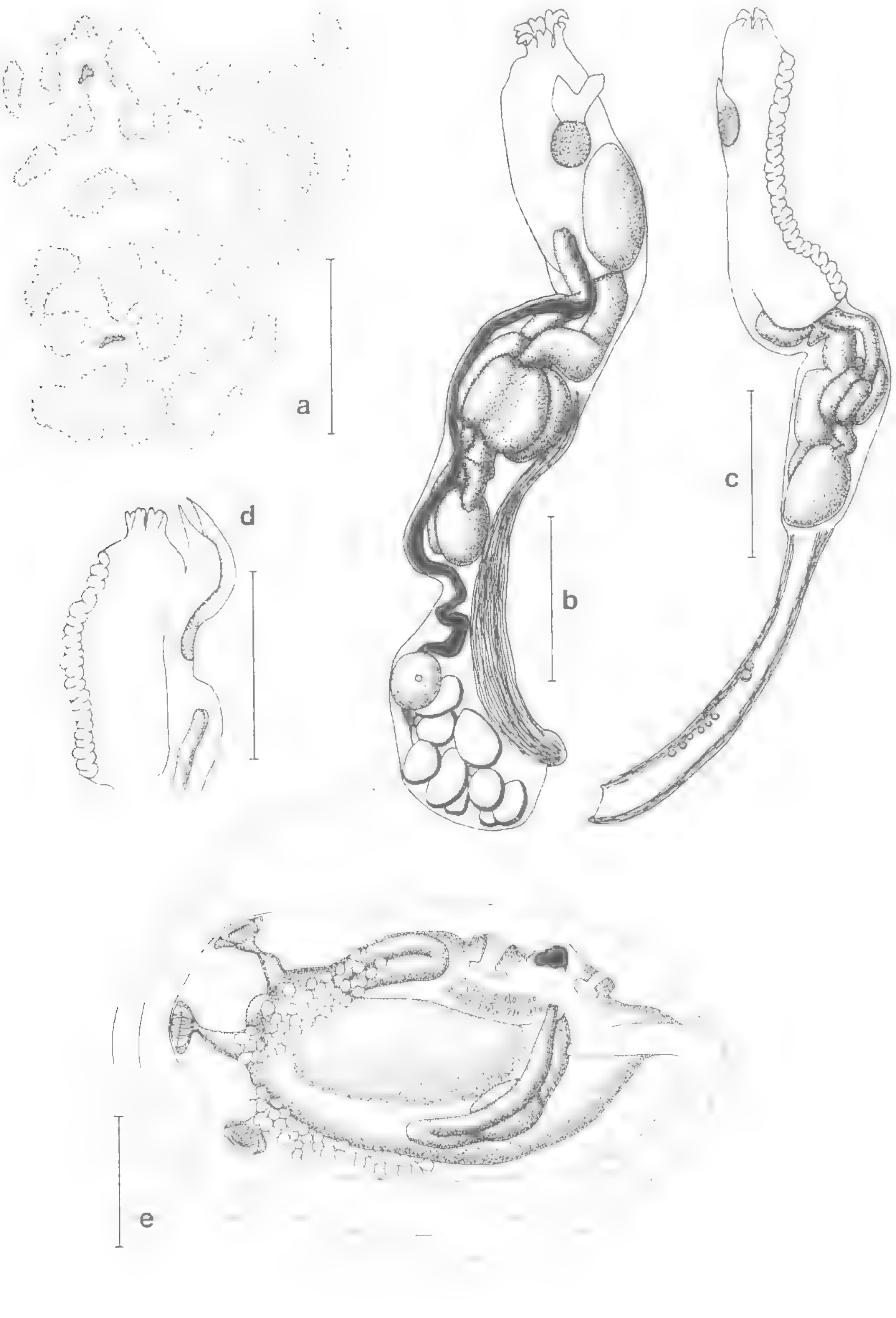


FIG. 102: *Aplidium solidum* — **a**, **b**, parts of colonies (QM G4937, AM U3941); **c**, surface of colony showing cloacal apertures at junction of the cloacal canals that surround the small zooid-free test areas (QM GH5782); **d**, **e**, zooids (QM GH5777 GH5782); **f**, larval trunk (QM G4937). Scales. **a**, **b**, 2cm; **c**, 2mm; **d**, **e**, 0.5mm; **f**, 0.1mm.


a
b
c
d
e

colour in preservative. Therefore, the specimen from Western Australia is unusual and despite similarities in its morphology it may not be conspecific with *A. solidum*.

The sandy investing colonies resemble some of *Aplidium caelestis*, although cloacal canals of the present species surround circular areas rather than the long ridges of *A. caelestis*, which also has colonies that are thicker and do not fold back to form upright lamellae as they do in the present species. Further *A. caelestis*, has zooids with longer branchial siphons, the atrial lip separate from the opening, and testis follicles in a double series in a long (rather than short, truncated) posterior abdomen.

The species resembles *Aplidium ritteri* in its sand-filled colonies, small zooids with narrow thoraces, small atrial lip from the upper rim of the opening: and short, truncated and flattened tip of the posterior abdomen. The systems of *A. ritteri* are in long and relatively straight double rows, and the larvae have a trunk 0.5 to 0.6mm long, with median ampullae as well as lateral vesicles. *Aplidium petrosum* from South Australian waters has similar systems as well as similar zooids to the present species, but is distinguished by its more complex colonies and larger larvae with median ampullae.

Aplidium tabascum n.sp.
(Fig. 103, Plate 16e,f)

DISTRIBUTION

TYPE LOCALITY: Queensland (Heron I. reef, 15m, coll. N. Coleman 5.8.77, AMPI 207, holotype QM GH5208; Heron I, reef, 9m, coll. N. Coleman 16.7.73, AMPI 85, paratype QM G9726; coll. P. Fredrickson, paratype QM GH5542; Erskine I. 5–10m, coll. Roche (SLV 12) 21.3.76, paratype QM G9727).

FURTHER RECORDS: Queensland (Capricorn Group, QM G9725 GH5513 GH5543; Swain Reefs, MV).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies form large fleshy mats or sheets to 7cm or more in maximum dimension. The surface has a 'marbled' appearance owing to irregularly shaped zooid-free areas of test, between and around which are slightly depressed areas where a relatively thin layer of surface test covers the cloacal canals. Sparse but evenly distributed sand grains are in the zooid-free solid parts of the test and sand grains are crowded into a line along the margins of these areas where zooids line the cloacal canals and the branchial apertures open to the exterior. Sand is also crowded around the margins and in the base of the colony, but is not present on the upper surface either over the common cloacal canals or the zooid-free areas they surround. Large common cloacal apertures are in the depressed areas over the common cloacal spaces and appear to be randomly distributed.

Sometimes the solid test areas are isolated from one another, forming islands surrounded by common cloacal cavities and zooids. In other specimens they are long and curved and meander through the colony between and around the cloacal spaces.

The colonies are a bright red-orange colour in life. Although a trace of the orange pigment at first persists in the preserved colony, subsequently they are white. In fresh material, the red pigment is in minute crowded spherical cells in the test and the zooids but these are not present in preserved specimens.

INTERNAL STRUCTURE: Zooids are small and narrow, 2 or 3mm long, although when contracted they are shorter with the posterior abdomen bunched and drawn up alongside the gut loop. The 6 branchial lobes around each branchial aperture have bands of muscles which sometimes are drawn in to subdivide the tip of each lobe. The atrial lip from the upper rim of the aperture is undivided or divided into 2 or 3 pointed lobes of varying size. Fine longitudinal muscle bands are on the thorax, and extend the length of the abdomen and posterior abdomen in a wide ventral band. The stigmata are in 15 rows with up to 8 per row. The stomach wall has 5 folds. The gut loop is relatively short. The posterior abdomen is club-shaped when the zooid is relaxed, with a long neck anteriorly and about 8 large male follicles in a single series in the expanded posterior part. When contracted, however, the testis follicles are bunched, and the posterior abdomen is drawn up alongside the gut loop. An ovary with 2 or 3 large oocytes is anterior to the testis follicles.

One or 2 embryos are in the atrial cavity of zooids collected in July and August (QM G9726 GH5208 GH5513) but none in March or December. The larval trunk is oval, about 0.6 to 0.8mm long, with the tail wound the whole way around it. On each side of the median line dorsal and ventral clusters of epidermal vesicles extend pos-

FIG. 103: *Aplidium tabascum* n.sp. — a, surface of colony showing almost continuous line of sand particles around each area of zooid-free test containing sparse embedded sand (QM GH5513); b, zooid (gut loop twisted to the left) (QM GH5208); c, sexually immature zooid (QM GH9725); d, thorax showing large bilobed atrial lip (QM GH5208); e, larva (QM GH5208). Scales: a, 1cm; b–d, 0.5mm; e, 0.2mm.

teriorly from opposite the base of the dorsal and ventral adhesive organs, respectively. These dorsal and ventral bands of vesicles are not continuous at the anterior end of the trunk. Neither vesicles nor ampullae are present in the median line between the adhesive organs. One larva found in the holotype had 5 adhesive organs instead of the usual 3.

REMARKS

The present species, based on a significant number of specimens, has a striking appearance with apparently stable characters showing little or no variability. It is distinguished by its double rows of zooids opening into depressions surrounding cushion-like elevations on its naked upper surface, the capacity to sort sand particles and arrange them around the margin of the zooid-free surface elevations, its red-orange colour, narrow thoraces, and the interruption of the band of lateral larval vesicles.

The same sort of cloacal systems, and the capacity to sort embedded sand particles and arrange them in the colony are properties of other *Aplidium* spp. (e.g. *A. caelestis*, *A. lenticulum* n.sp.). *Aplidium lobatum* Savigny, 1816 from Suez and *A. cellis* Monniot, 1987 from New Caledonia also have similar cloacal systems. *Aplidium caelestis* and *A. lenticulum* differ in having an atrial lip separate from the opening but the *Aplidium cellis* and *A. lobatum* have similar colonies, zooids and larvae to those of the present species, differing only in their embedded (and sometimes encrusting sand), smaller larval trunk (0.56mm long), and colour (white rather than red). Despite the description of *A. cellis*, the reported incrustation of sand on the upper surface (slightly less densely distributed over the cloacal canals) is not apparent in the published photograph (Monniot, 1987, Pl. 2B). Further, it is not clear whether the white colour recorded for the 2 New Caledonian specimens is their living colour, or their colour in preservative, or merely the colour of the sand encrusting them. Thus, in addition to the possibility that the New Caledonian species is a junior synonym of *A. lobatum*, *A. tabascum* could be as well.

Aplidium triggsense Kott, 1963
(Fig. 104)

Aplidium triggsensis Kott, 1963, p.104; 1976 (*A. triggiensis*) p. 61. Monniot, 1987, p.531.

DISTRIBUTION:

NEW RECORDS: Western Australia (Cockburn Sound WAM 23.84). South Australia (Pearson I., SAM E2574). Queensland (Heron I., QM GH5305).

PREVIOUSLY RECORDED: Western Australia (Triggs I. — AM U3923 holotype, Y1408 Kott 1963; Rottnest I. — AM Y1421 Y1428 Kott 1963; Nornalup — AM Y1405 Kott 1963). Victoria (Balnarring Beach — AM Y1427 Kott 1963; Westernport — Kott 1976). New Caledonia (Monniot 1987).

The Western Australian records are all from coastal habitats subjected to surf and turbulence, and the Westernport location is one where strong tidal currents prevail. A continuous temperate to tropical range is suggested by the record from Heron I.

DESCRIPTION

EXTERNAL APPEARANCE: One colony from Heron I. (QM GH5305) is an upright lobe, but usually the colonies are firm, gelatinous, investing sheets 0.5 to 0.6cm thick and 4 to 5cm in maximum extent. Varying quantities of sand are present in the basal half of the test but not in the transparent upper half. This strengthens the colony. The margins are irregular and reduced in thickness. Root-like projections from the base of the colony extend into and around particles of the substrate helping to anchor the colonies, which are found in rigorous, turbulent habitats. Zooids are crowded, conferring a reddish-pink colour on the preserved colonies. The living colony from Heron I. is reported to have been orange buff, with translucent test.

Circular cloacal apertures are randomly distributed over the surface. It is probable that the zooids are in double-row systems but this could not be confirmed in these crowded colonies. The posterior parts of the zooids criss-cross one another in the basal half of the colony.

INTERNAL STRUCTURE: Zooids are small, the contracted abdomen and thorax together being less than 3mm, although the thin posterior abdomen is up to twice that length. The branchial aperture is small, with a short siphon. The atrial aperture is a small, rounded, sessile opening with a small pointed or tridentate tongue from the upper border of the opening. The thorax has 12 wide longitudinal muscles and these extend the length of the abdomen. Stigmata are in 8 to 10 rows of up to 15. The stomach is short with 15 longitudinal folds. Testis follicles are in 2 longitudinal series, each of about 6 follicles.

One or 2 embryos are in the atrial cavity of specimens collected from Cockburn Sound in

January, Pearson I. in November, Heron I. in November, and Westernport (Kott 1976) and Western Australia in December. The larval trunk is 0.6mm long, and the tail is wound almost halfway around it. From each location larvae have from 7 to 14 small adhesive organs. These are on fine stalks expanding into cones at their base, and are in the mid-line around the anterior half of the trunk. Scattered epidermal vesicles arise in an arc from the lateral line on each side of the adhesive organs.

REMARKS

The species is distinguished by its firm colonies with sand in the basal half, its small zooids, 15

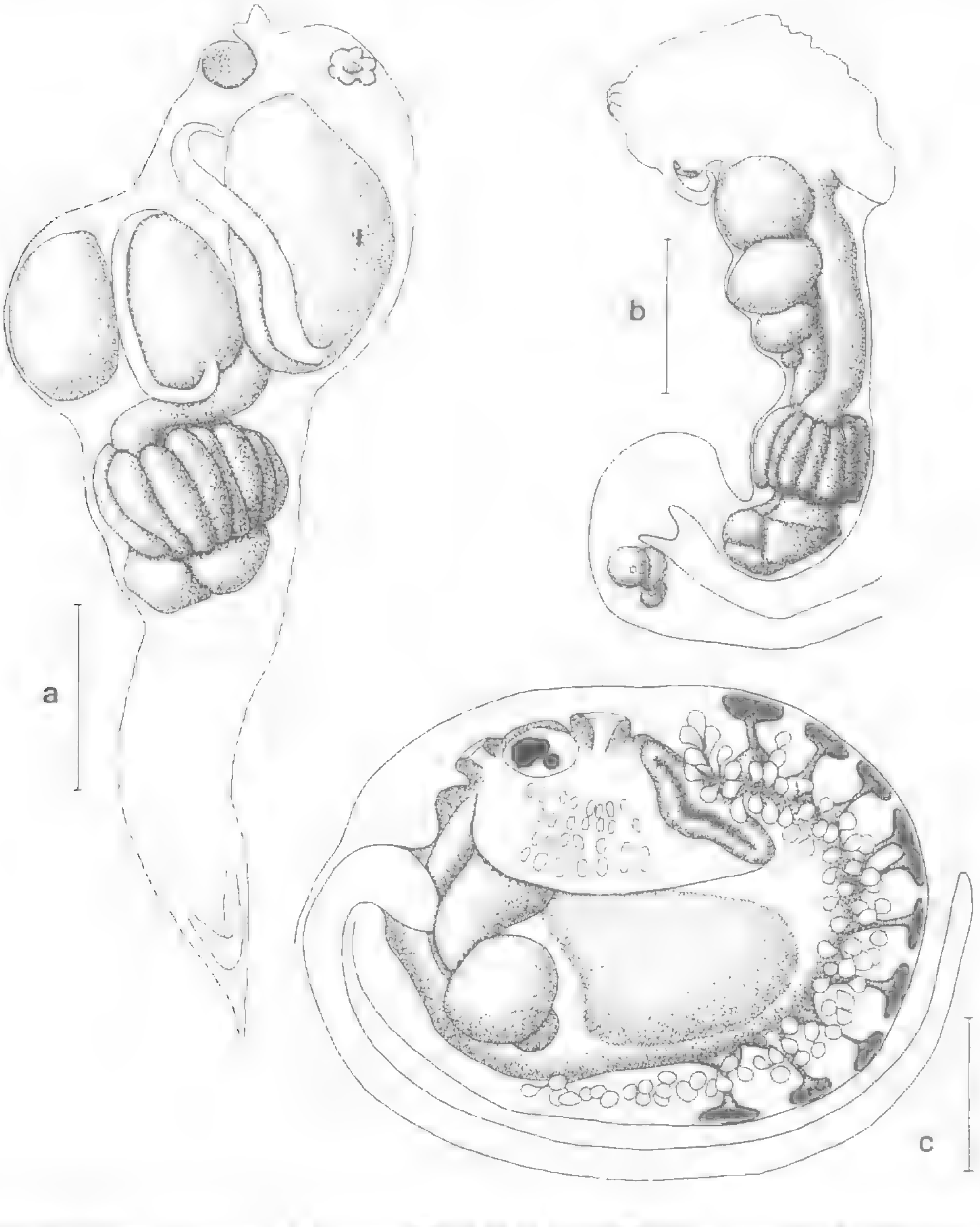


FIG. 104: *Aplidium triggsense* — a, b, zooids (WAM 23.84, QM GH5305); c, larva (AM Y1428). Scales: a, b, 0.5mm; c, 0.2mm.

stomach folds and remarkable larvae which, with 12 adhesive organs, seem adapted to make a firm adherence to the substrate in the stringent habitats from which it has been taken.

The colonies from 8cm in the lagoon, New Caledonia (Monniot 1987) are flattened lobes, joined basally, similar to the newly recorded upright lobe from Heron I.

This was previously regarded as a temperate species, but tropical records demonstrate a wider geographic range. The alternate possibility that different species are represented is not supported by the morphology of either colonies, zooids or larvae, which are all similar, with only small intrapopulation variations in size, number of stigmata, stomach folds, and adhesive organs.

Variation from the usual number (3) of adhesive organs occurs in *A. multipapillatum* Millar, 1975, from the China Sea, which has 7. It is probable that the large number in this apparently unrelated species is a convergent character, selected for in response to environmental pressures.

Aplidium uteute Monnniot and Monniot, 1987
(Fig. 105)

Aplidium uteute Monniot and Monniot, 1987, p.79.
Aplidium phortax: Kott, 1963, p. 109.
Aplidium latusexitus Monniot, 1987, p. 523.

DISTRIBUTION

NEW RECORDS: Queensland (Capricorn Group, QM GH1342 GH5132–48 GH5220–3 GH5313 GH5510 GH5524–5 GH5598–601 GH5610 GH5621–6).

FURTHER RECORDS: Queensland (Sarina — Kott 1963). Western Pacific (Solomon Is — Kott 1963; New Caledonia — Monniot 1987; French Polynesia — Monniot and Monniot (1987).

DESCRIPTION

EXTERNAL APPEARANCE: The colonies form flat-topped cushions, to sheets fixed by a large part of the under surface, or they reduce in diameter toward the base to form flat-topped mushroom-like colonies about 1cm in maximum diameter and 0.5cm high, fixed by a small part of the under surface. The test is firm, clear and transparent in life, honey-coloured, 'rufous' (Ridgeway 1886), or colourless. It is only rarely cloudy, although it usually does become so in preservative. The living zooids, seen through the clear, transparent test, are red, 'chrome scarlet', 'buff-yellow', 'orpiment orange', 'salmon-coloured', cream with orange stomachs, or with 'orange chrome' thoraces and flesh-coloured branchial apertures, with 'geranium-coloured' or 'dragons-blood red' abdomina, and often a 'dragons-blood red' patch each side of the base of the atrial lip or between the apertures (Ridgeway 1886). Sometimes 4 lines of dark orange pigment radiate out from the branchial aperture, including one along each side of the endostyle. Embryos when these are present, are 'saturn red', 'burnt carmine' (Ridgeway loc. cit.) or maroon. In preservative the test is yellowish and translucent and the zooids white or cream. The zooids are arranged in conspicuous circular systems of 7 to 10 zooids. Sand is often present around the outer margin of the colony, but is never embedded internally.

INTERNAL STRUCTURE: Zooids are up to 8mm long in semicontracted condition. They have large, rounded, sometimes subdivided branchial lobes and a large, fleshy, sometimes 2-lobed atrial lip from the upper border of the atrial aperture, which also has lobes around its posterior margin. Longitudinal muscles on the thorax are fine, and numerous (about 20), extending the whole length of the zooid in a wide ventral band. There are 9 to 11 rows of up to 25 stigmata in the wide thorax. The thorax is large probably exceeding the length of the posterior abdomen when it is not contracted. In preserved specimens there often is a crescent-shaped patch of greenish coagulated blood near the top of the abdomen, probably an artefact associated with the removal of the colony from the substrate.

The stomach is large and cylindrical with from 25 to 35 fine parallel longitudinal folds. The duodenal area and mid-intestine are continuous, and open into the oval posterior stomach at the base of the descending limb. A rectal valve is at the junction of the distal part of the mid-intestine and rectum at the end of the abdomen.

An ovary with up to 5 oocytes is about one-third of the distance down the posterior abdomen. The pear-shaped male follicles are posterior to the ovary, sometimes bunched but in other specimens spread out in an irregular longitudinal series. The posterior abdomen in this species is relatively short, often stumpy and only occasionally more than twice the length of the rest of the zooid.

Usually one or 2, but occasionally up to 5, embryos are in a brood pouch that projects out from, and is constricted off from, the posterodorsal corner of the thorax in zooids collected at Heron I. in May to August. The tailed larvae have a 0.65 to 0.8mm long trunk, and are deep sometimes almost spherical. The tail is wound two-thirds of the way around the trunk. Three or 4 fine,

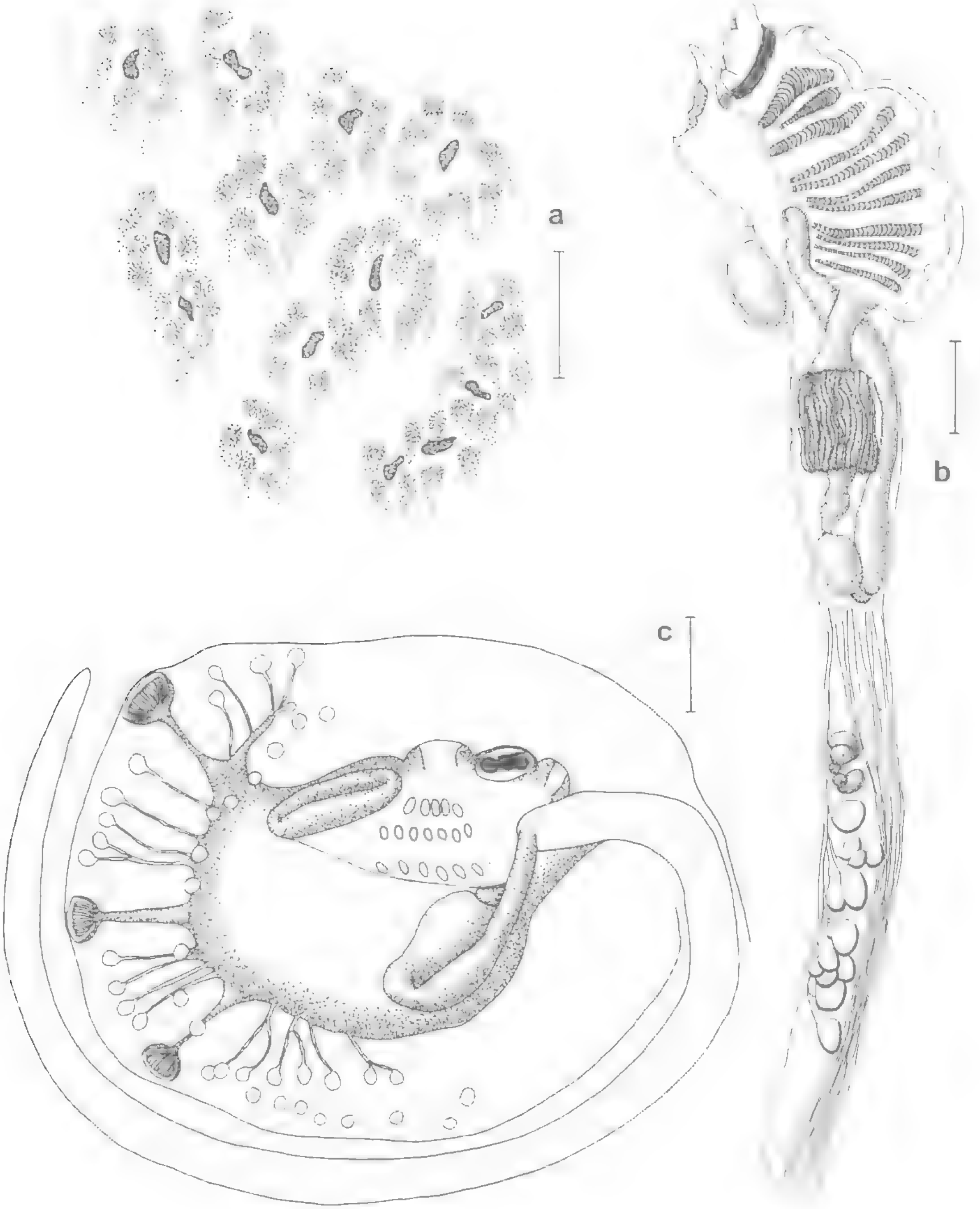


FIG. 105: *Aplidium uteute* — **a**, surface view of colony indicating systems (QM GH5134); **b**, zooid with embryos in brood pouch (QM GH5145); **c**, larva (QM GH5623). Scales: **a**, 5mm; **b**, 0.5mm; **c**, 0.1mm.

sometimes branched, stalks with terminal ectodermal vesicles extend out from the anterior mid-line in each interspace between the adhesive organs; and 20 vesicles develop in the same way from each lateral line around the anterior end of the larva. There are 3 rows of stigmata and a large ocellus and otolith in the cerebral vesicle.

REMARKS

The characteristics of this species are its transparent test, conspicuous circular systems, wide thorax, relatively long cylindrical stomach with numerous folds, postero-dorsal thoracic brood pouch, deep larval trunk with median epidermal vesicles alternating with the adhesive organs, and arc of about 20 vesicles along each lateral line. Stomachs are orange, some red pigment in the zooids, embryos and larvae are maroon-coloured.

The Australian material appears to be conspecific with *Aplidium uteute* Monniot and Monniot, 1987 from French Polynesia which has a similar stomach, large atrial aperture with the upper rim produced into a large lip, embryos incubated in a brood pouch constricted off from the thorax, red pigment each side of the neural complex, and apparently circular systems. The number of rows of stigmata are the same but unfortunately the number per row is not recorded for the Polynesian material. The number of stomach folds of the Polynesian type is said to be 50, but the number shown in Fig. 28 (Monniot and Monniot 1987) appears to be no more than 35. Monniot and Monniot (1987, Planche V-H) compared the species with a range of probably unrelated specimens assigned by various authors (Tokioka 1953, 1967a; Kott 1972, 1975; Nishikawa 1984a) to *A. pliciferum* Redikorzev, 1927 from the north-western Pacific. *Aplidium uteute* is readily distinguished from these by many characters. However, there are others that appear to have closer affinities with which it was not compared.

Aplidium latusexitus Monniot, 1987 has circular systems, and, like *A. uteute*, red pigment patches each side of the neural gland, a large atrial aperture with a large lip, 10 rows of stigmata with up to 28 per row and lateral as well as median epidermal vesicles in the larva. Monniot (1987) has discussed its relationship with *A. multiplicatum* (*A. californicum*: Monniot 1987), but not with *A. uteute* with which it appears to be synonymous. *Aplidium uteute* is readily separated also from *A. multiplicatum* by its larvae, the form of the systems, the number of stigmata per row (i.e. the width of the thorax), and the consistency of the test.

Kott (1963) assigned specimens of the present species to *Aplidium phortax* (Michaelsen, 1924) from New Zealand. However, despite similarities in the colonies and brood pouches, *A. uteute* has a wider thorax than the New Zealand species which has only 9 or 10 stigmata per row. The larva of *A. phortax* is not known.

Aplidium flavolineatum (Sluiter, 1898) from South Africa (see also Millar 1962) has zooids arranged in conspicuous round to oval systems, and embryos incubated in a brood pouch slightly constricted off from the thorax. Michaelsen (1934) thought it was synonymous with *A. phortax*, however *A. flavolineatum* differs from both *A. phortax* and the present species by having embedded and encrusting sand, generally more stomach folds (although the numbers overlap, and the stomachs are a similar shape) and by usually being a red colour in life. Also, *A. flavolineatum* incubates up to 4 embryos in the brood pouch and has a larval trunk of 1mm with median ampullae and some large lateral vesicles or ampullae (Millar 1962); while *A. uteute* has a larval trunk less than 0.8mm long with more numerous epidermal vesicles.

Aplidium flavolineatum: Monniot, 1987, has circular systems, brood pouch, and stomach resembling those of the present species. However the larvae, found in the single colony that Monniot described, have fewer epidermal vesicles than *A. uteute*. These vesicles, like those of *A. altarium* remain attached to the trunk epidermis. *Aplidium altarium* also has a large number of stomach folds, but is distinguished by its converging double row systems.

Aplidium ornatum is another species with large numbers of stomach folds, but its larvae lack the long arcs of evenly spaced epidermal vesicles that characterise the larvae of the present species.

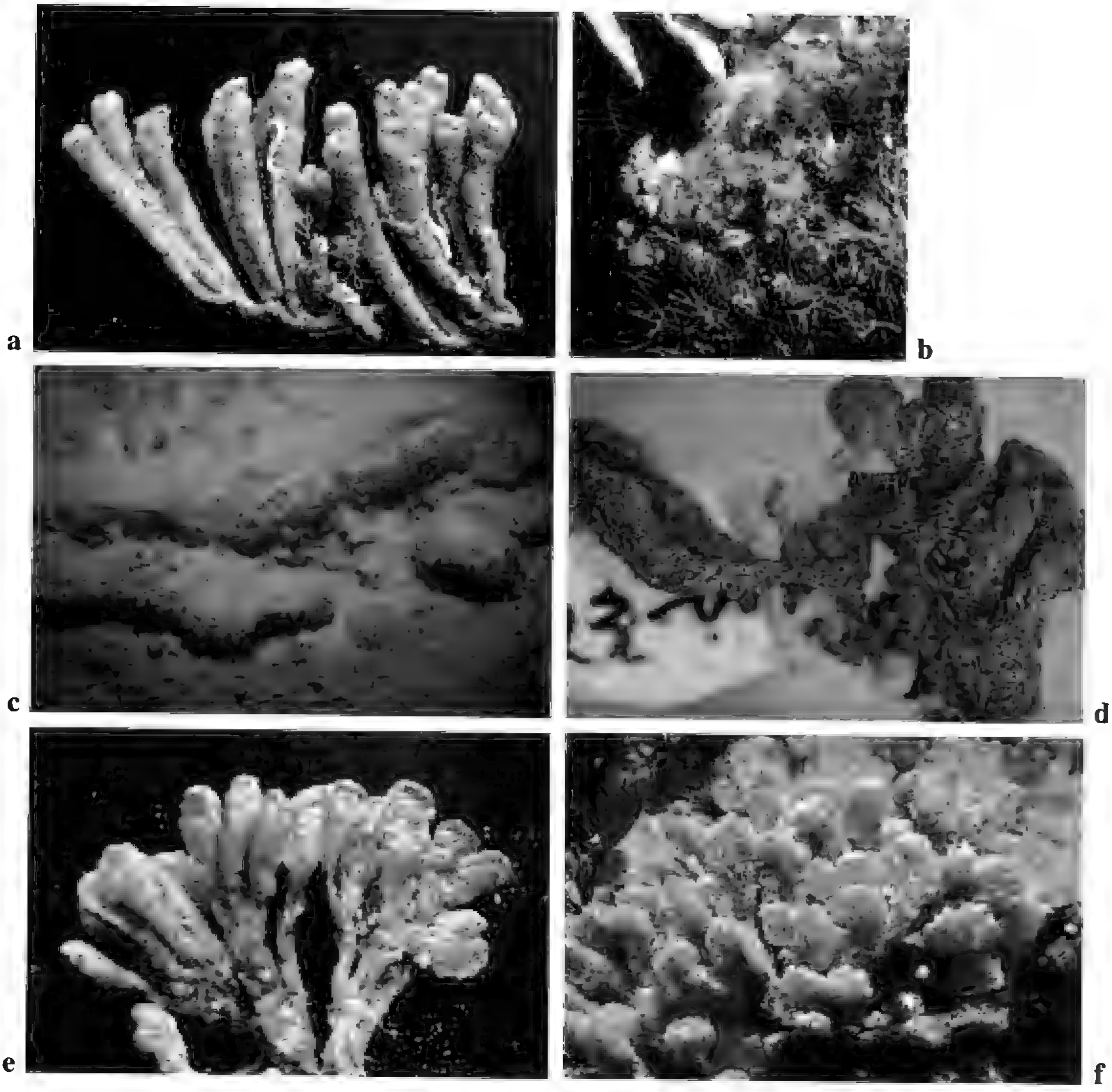


PLATE 1: **a**, *Monniotus australis* (QM GH4147 Price I., SA). **b–d**, *Condominium areolatum* n.gen. n.sp. (**b**, QM GH4161 Taylor I. SA; **c**, **d**, QM GH5418 central Great Barrier Reef Qd 20m). **e**, **f**, *Ritterella asymmetrica* (**e**, QM GH4195 Hopkins I. SA; **f**, QM GH5445 Cape Jaffa SA). Photos: **a**, **e**, S.A. Shepherd; **b**, W.H. Sasse; **c**, **d**, **f**, AIMS Bioactivity Gp, Q66-C1723 -C2457.

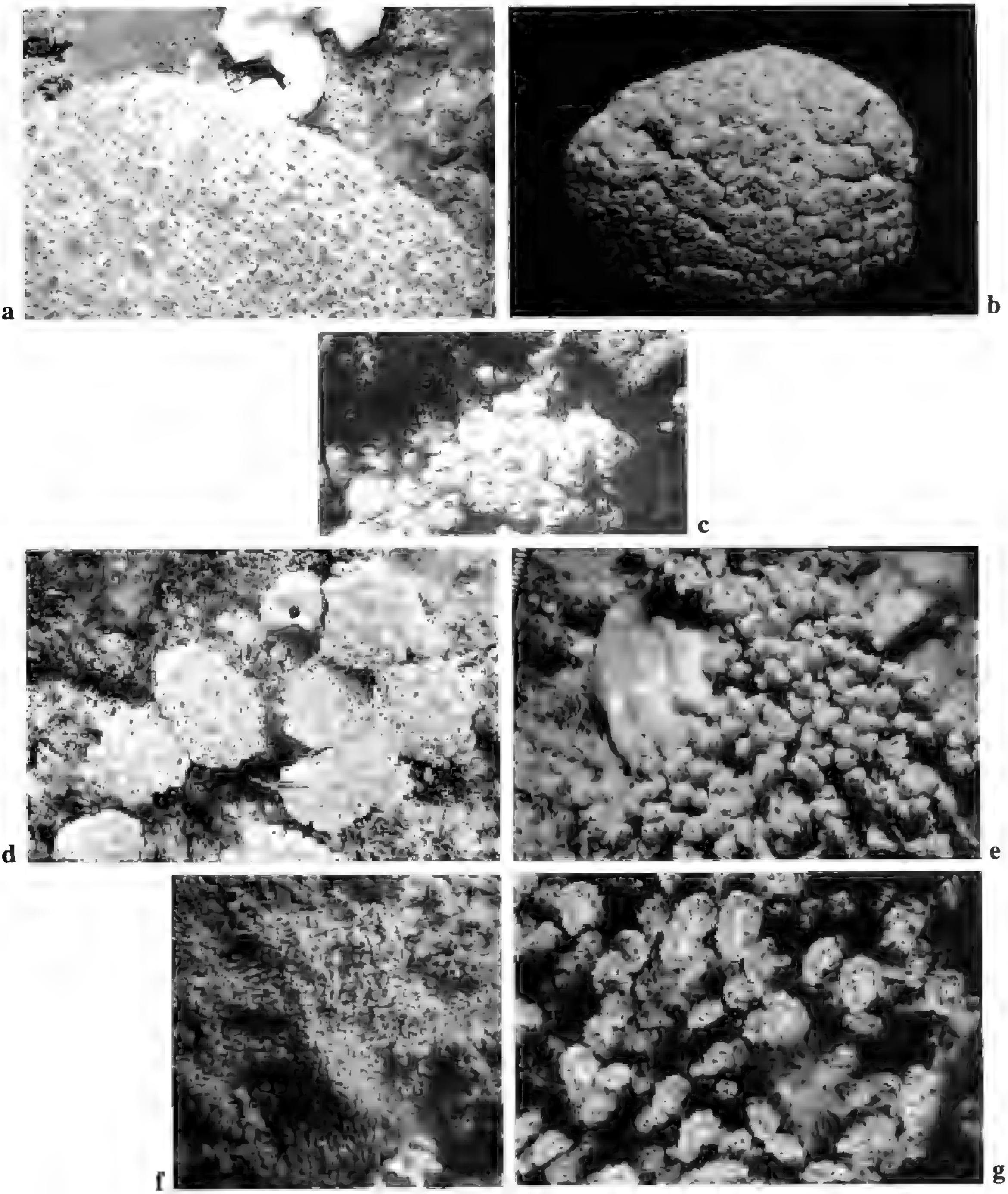


PLATE 2: **a**, **b**, *Ritterella compacta* n.sp. (**a**, QM GH2399 holotype Flinders I. SA; **b**, QM GH4177 The Gap SA). **c**, *Ritterella cornuta* n.sp. (QM GH4176 holotype Price I. SA). **d**, *Ritterella dispar* (QM G12001 Lord Howe I.). **e**, *Ritterella multistigmata* n.sp. (QM GH5463 holotype Rockingham WA). **f**, **g**, *Ritterella pedunculata* (**f**, QM G10156 George's Bay Tas. 5m; **g**, QM G10160 Phillip Bay Vict. 10m). Photos: **a**, N. Holmes FL975-PE0030; **b**, **c**, W.H. Sasse 9.4.87 7.4.87; **d**, **f**, **g**, N. Coleman AMPI 250 211 170; **e**, AIMS Bioactivity Gp Q66-C2822.

PLATE 3: **a**, *Euherdmania translucida* n.sp. (QM GH2310 Flinders I. SA). **b**, *Pseudodistoma acuatum* n.sp. (QM GH2323 holotype Ward I. SA). **c**, **d**, *Pseudodistoma australe* (QM G92 Exmouth Gulf WA). **e**, **f**, *Pseudodistoma candens* n.sp. (QM GH5462 Rockingham WA). Photos: **a**, **b**, N. Holmes FL985-PE0064; **c**, **d**, N. Coleman AMPI 76 77; **e**, **f**, AIMS Bioactivity Group Q66-C2798.

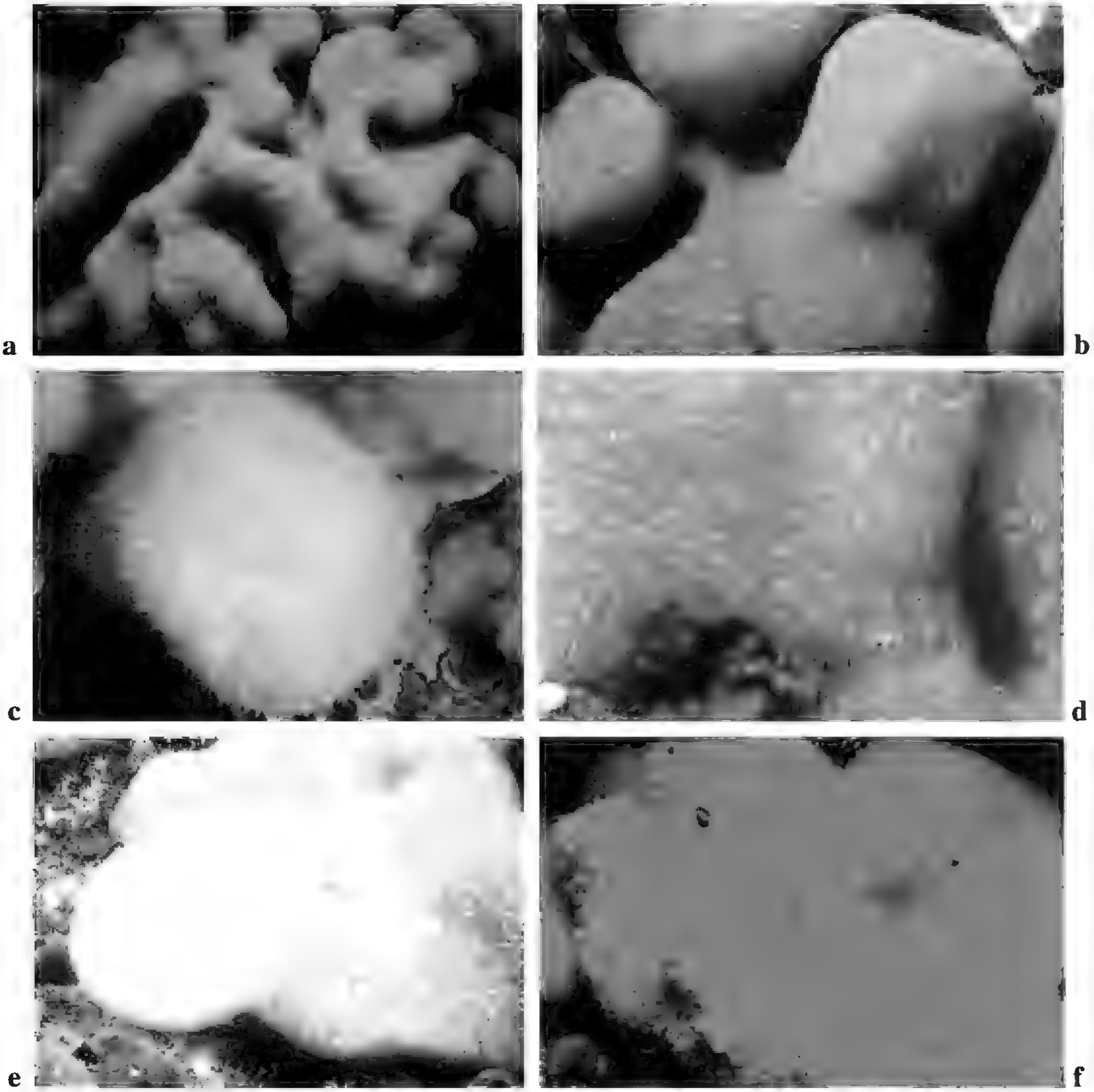


PLATE 4: **a–e**, *Pseudodistoma gracilum* n.sp. (**a**, QM G11989 Kangaroo I. SA; **b**, QM GH4158 Cathedral Rock SA; **c**, Kangaroo I. SA; **d**, QM GH4167 paratype Grindal I. SA; **e**, ? SA). **f**, *Pseudodistoma inflatum* n.sp. (QM G9472 paratype Byron Bay NSW). Photos: **a**, **c**, **f**, N. Coleman AMPI 227 223 158; **b**, **d**, W. H. Sasse 23 19; **e**, R. Kuiter 47SS.

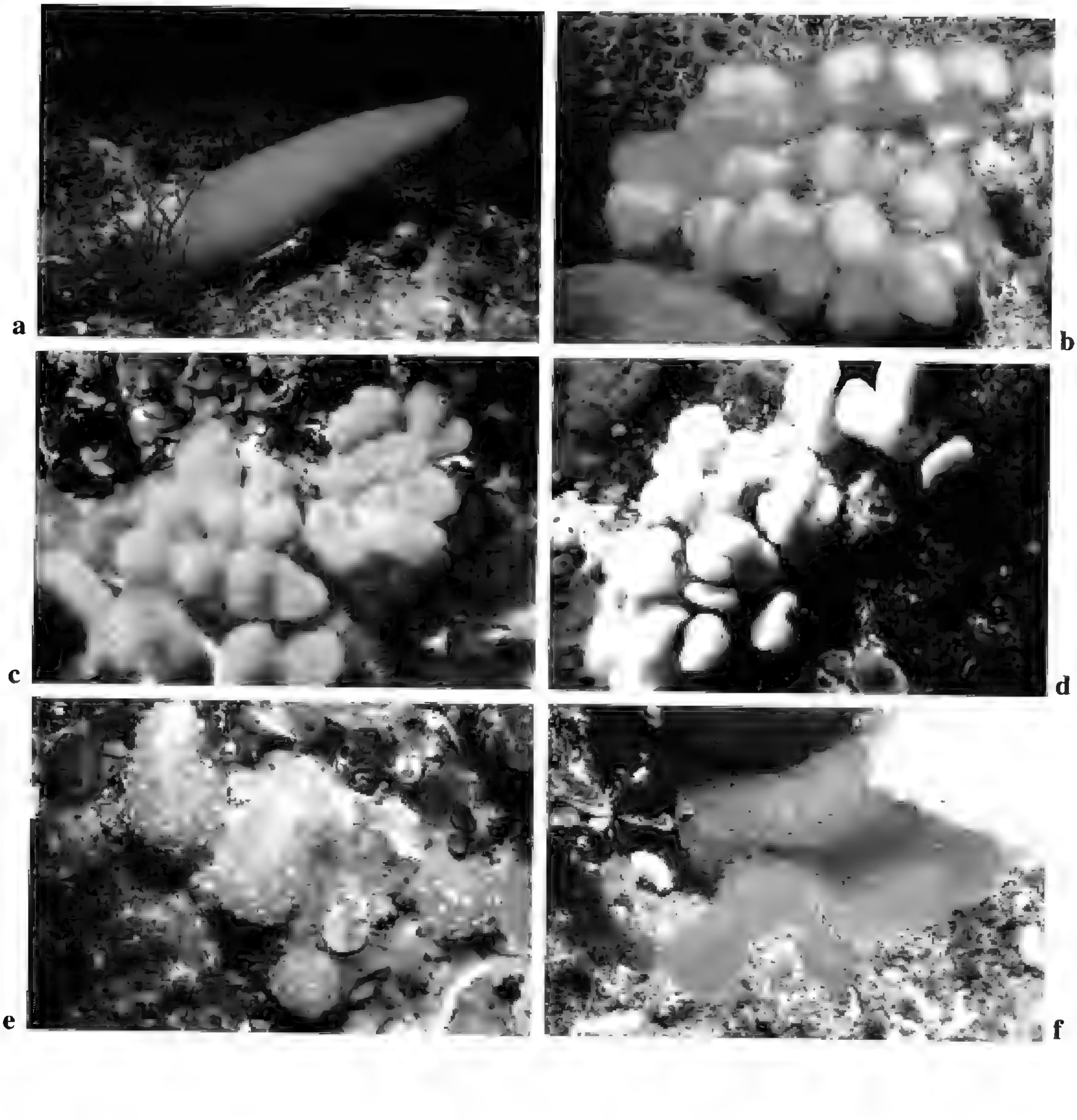


PLATE 5: **a**, *Pseudodistoma oriens* n.sp. (Port Phillip Heads Vict.); **b–d** *Pseudodistoma pilatum* n.sp., showing colour variants (**b**?; **c**, SAM E2409 paratype Cathedral Rock SA; **d**, QM GH4140 paratype Golden I. SA). **e**, **f**, *Pseudodistoma pulvinum* (**e**, QM GH2396 holotype Ward I SA, in caves; **f**, QM GH2300 Flinders I. SA).Photos: **a**, J. Watson April 1977; **b**, R. Kuiter 54SS; **c**, **d**, W.H. Sasse 20 10; **e**, **f**, N. Holmes FL979-PE0012 FL964-PE0060.

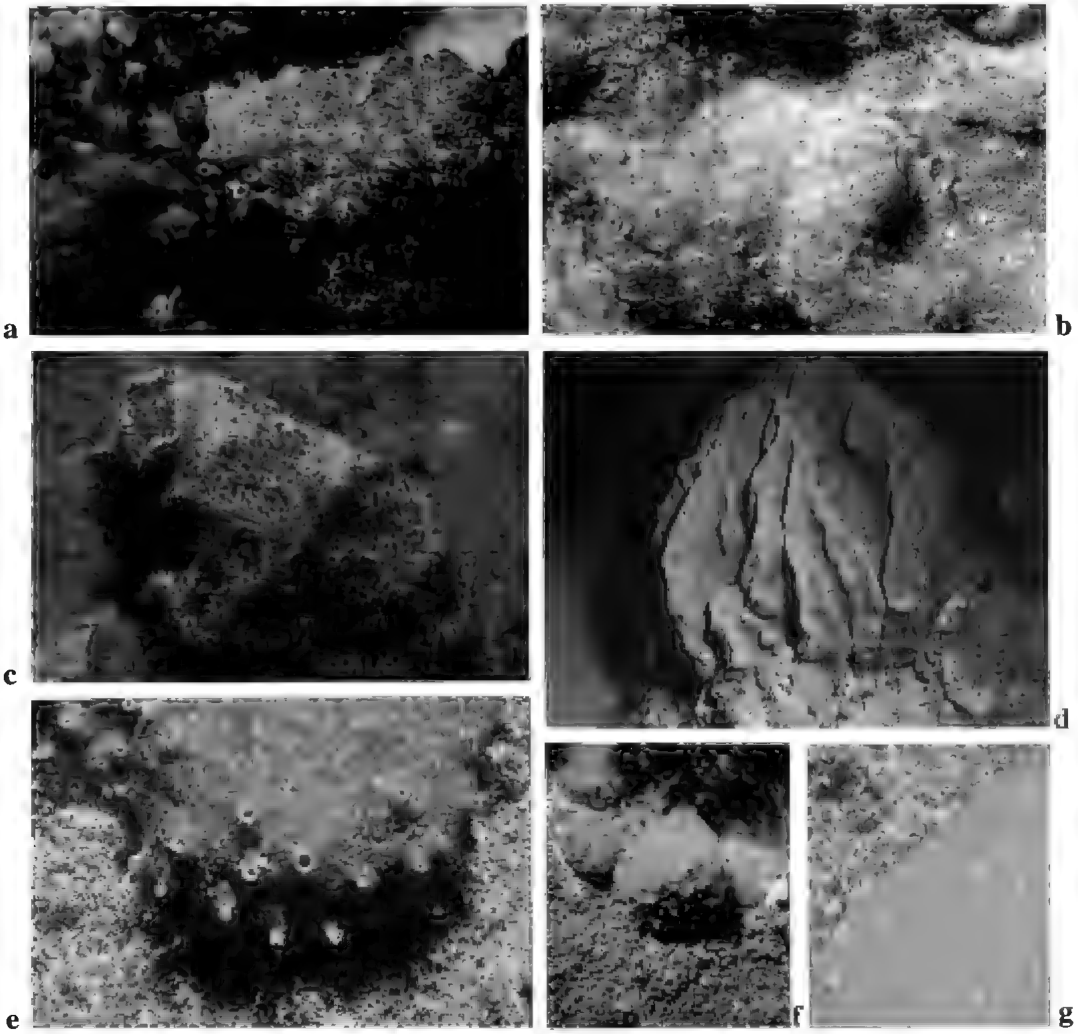


PLATE 6: **a**, **b**, *Polyclinum incrustatum* (**a**, QM GH4141 Perforated I SA; **b**, The Gap, QM GH4163). **c**, **d**, *Polyclinum marsupiale* (**c**, QM G10138 Kingston Jetty SA; **d**, QM G10175 Deal I. Bass Strait)). **e–g**, *Polyclinum nudum* n.sp. Coffs Harbour NSW, showing colour variants (**e**, QM GH5387; **f**, QM GH5388; **g**, QM GH5390). Photos: **a**, **b**, W.H. Sasse 34 3; **c**, J.E. Watson September 1977; **d**, N. Coleman AMPI 114 6.5.74; **e–g**, AIMS Bioactivity Gp Q66-C1108 -C1129 -C1131.

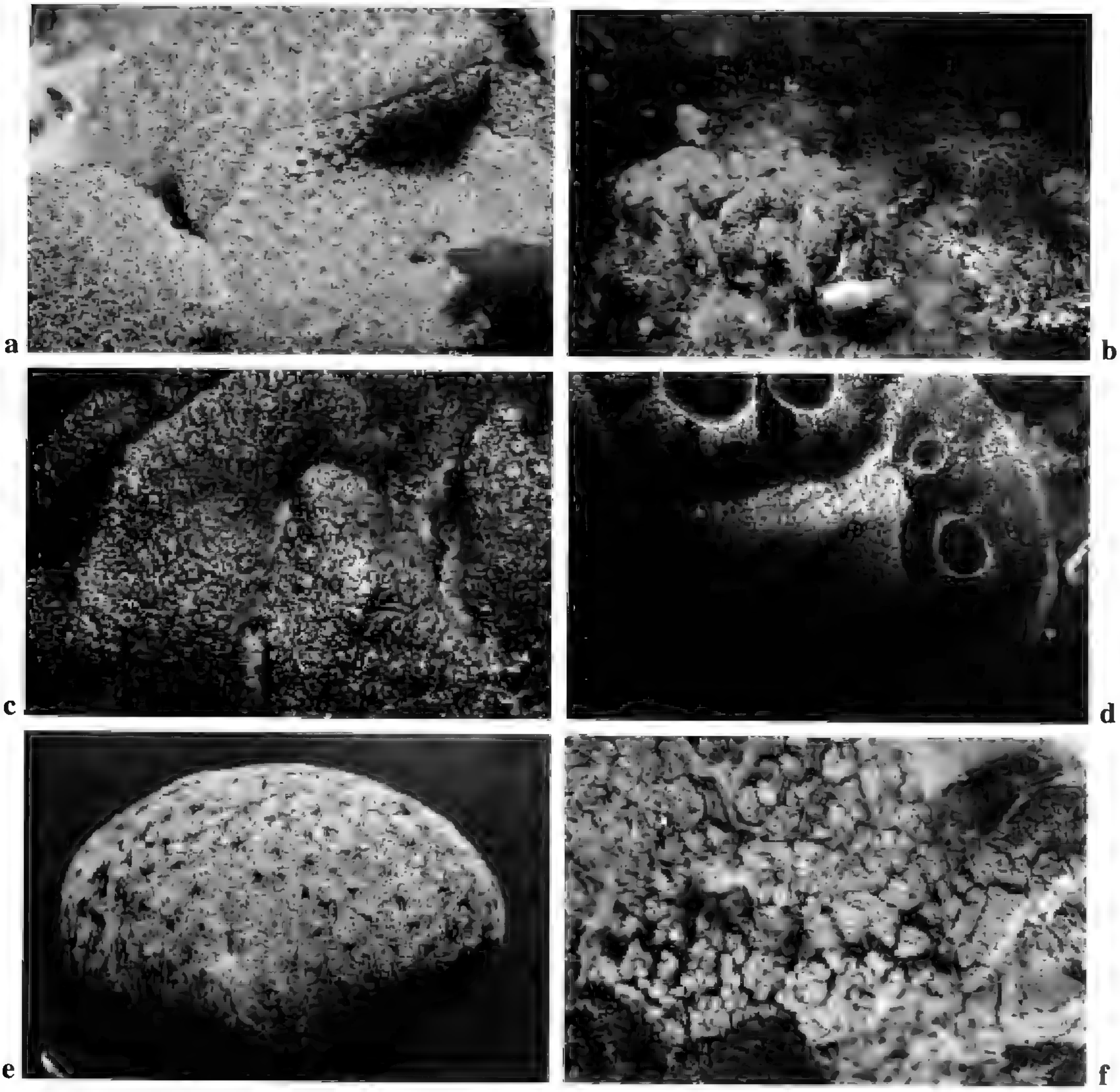


PLATE 7: **a**, *Polyclinum tenuatum* n.sp. (QM GH5444 Cape Jaffa SA). **b**, **c**, *Polyclinum terranum* n.sp. QM 5460 holotype Rockingham WA (**b**, distant view showing top of colony exposed on surface of substrate; **c**, close up). **d**, *Aplidiopsis mammillata* n.sp. QM GH1468 holotype Cathedral Rock SA). **e**, *Aplidiopsis sabulosa* n.sp. (QM GH4153 holotype Avoid Bay SA). **f**, *Sidneioides tamaramae* (QM G11859 South Ulladulla NSW). Photos: **a**, **b**, **c**, AIMS Bioactivity Gp Q66-C2455 -C2794; **d**, **e**, W.H. Sasse; **f**, I. Bennett 27.1.87.

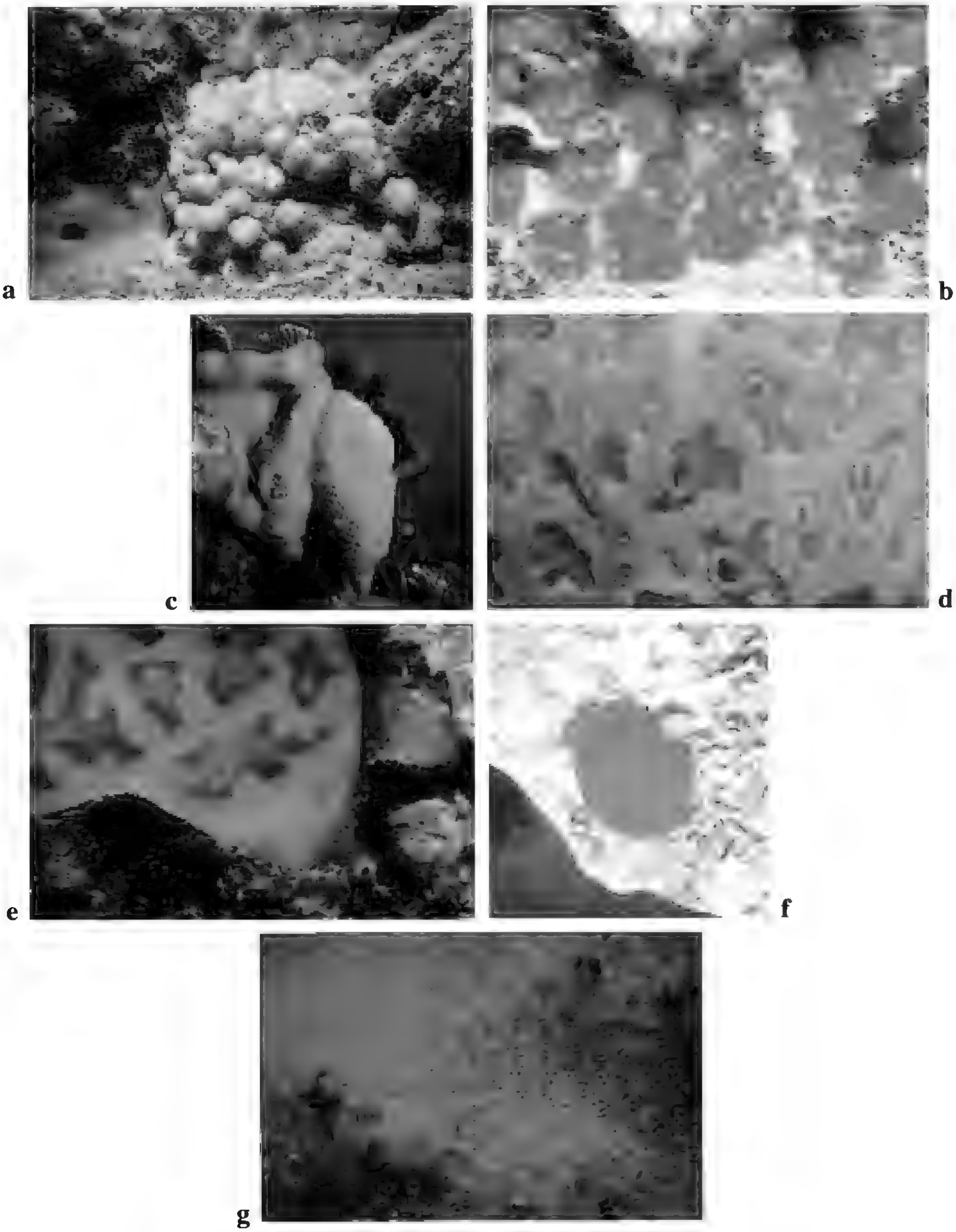


PLATE 8: **a**, *Synoicum bowerbanki* (Blacknose Point Portland Vict.). **b**, *Synoicum buccinum* n.sp. (QM GH5045 holotype Marion Reef, Coral Sea). **c–e**, *Synoicum castellatum* n.sp. (**c**, QM GH5401 Exmouth Gulf WA; **d**, Great Keppel I. Qd 10m; **e**, QM GH5322 Lizard I. Qd). **f**, *Synoicum citrum* n.sp. (QM GH2294 Port MacDonnell SA). **g**, *Synoicum concavitum* n.sp. (QM GH5465 holotype King George Sound WA). Photos: **a**, J.E. Watson June 1979; **b**, **d**, N. Coleman AMPI 209 243; **c**, **e**, **g**, AIMS Bioactivity Gp Q66-C1362 -B2069 -C2889; **f**, N. Holmes PM1193-PE0073.

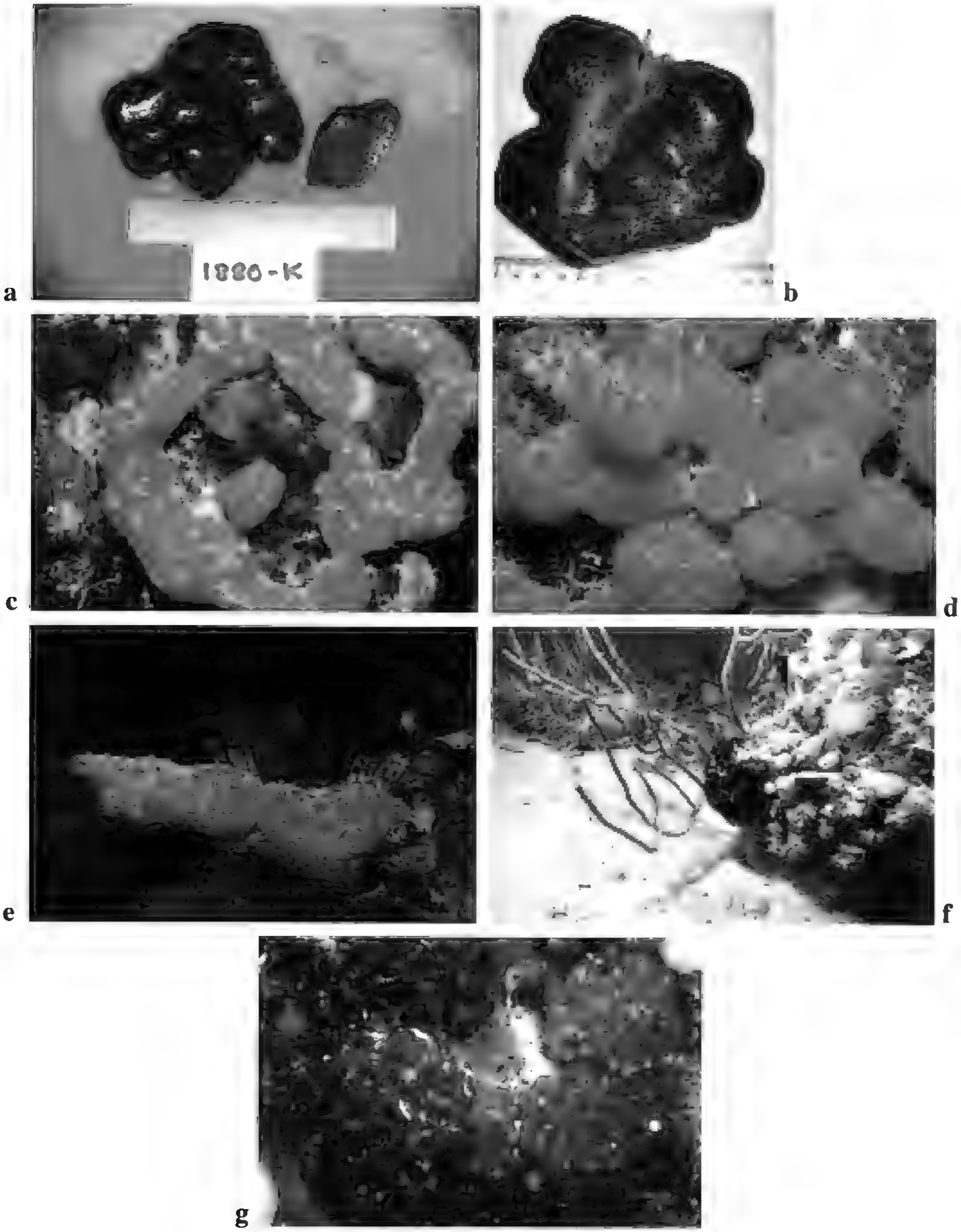


PLATE 9: **a**, *Synoicum macroglossum* (QM GH5421 Mackay Qd). **b**, *Synoicum prunum* (QM GH5394 Arrawarra NSW). **c–e**, *Synoicum sacculum* n.sp. (**c**, **d**, QM G10163 holotype Flinders Vict. 5m; **e**, Tipara Reef SA). **f**, **g**, *Synoicum suarenum* n.sp. (QM GH5377 Hardy Reef Qd). Photos: **a**, **b**, **f**, **g**, AIMS Bioactivity Gp Q66-C1880 -C1175 -C0872; **c**, **d**, N. Coleman AMPI 201; **e**, S. Shepherd 13.5.82.

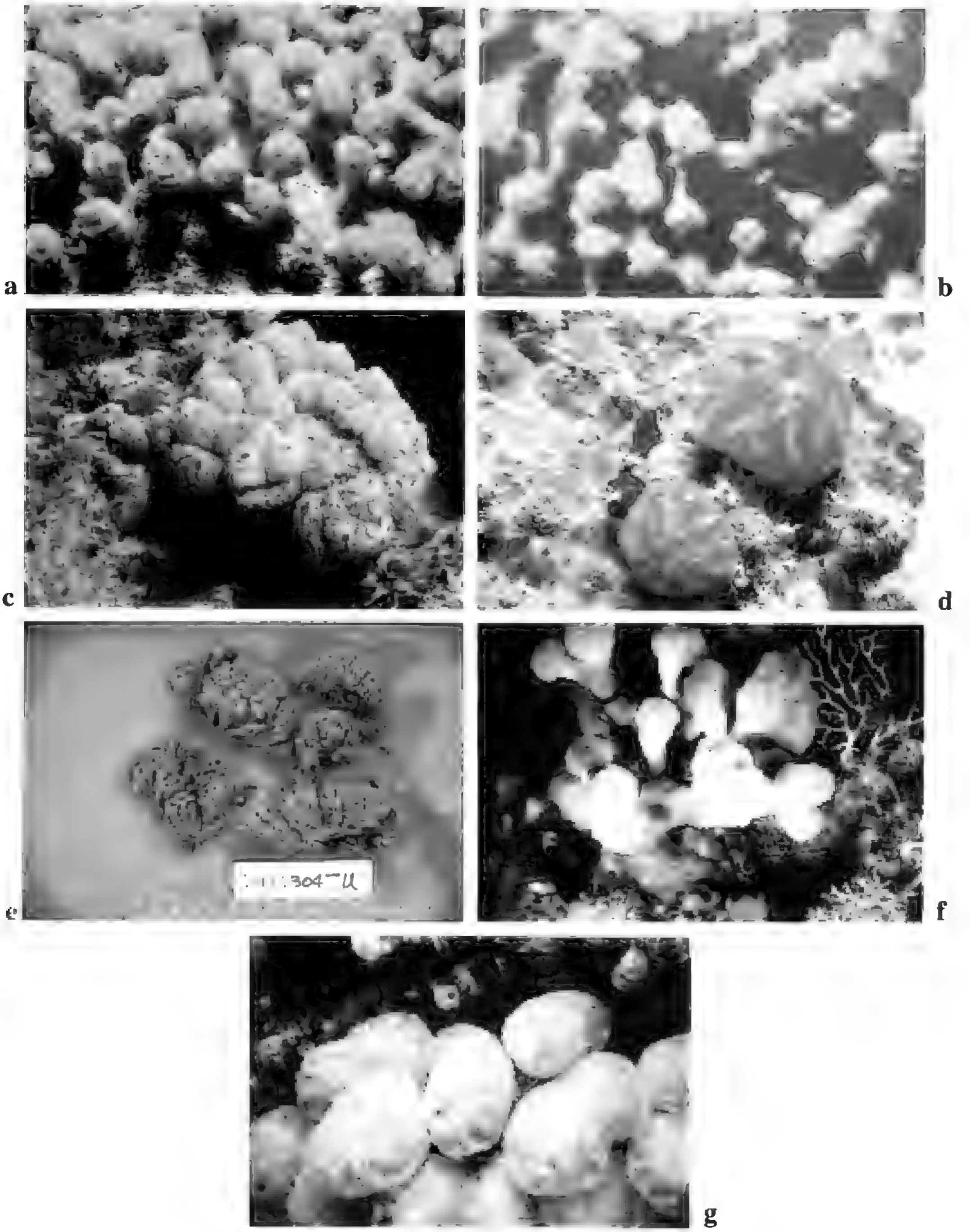


PLATE 10: **a**, **b**, *Aplidium acroporum* n.sp. (**a**, QM GH5443 paratype Kangaroo I. SA; **b**, SAM E2554 holotype The Gap SA). **c**, **d**, *Aplidium altarium* (**c**, QM GH5557 Houtman's Abrolhos WA; **d**, QM GH5522 Heron I. Qd). **e**, *Aplidium bacculum* n.sp. (QM GH5434 holotype York Peninsula SA). **f**, **g**, *Aplidium brevilarvacium* (**f**, ? SA; **g**, QM GH2412 Ward I. SA). Photos: **a**, **e**, AIMS Bioactivity Gp Q66-C2445 -C2304; **b**, W.H. Sasse 14; **c**, **d**, N. Coleman AMPI 60 150; **f**, R. Kuiter 43SS; **g**, N. Holmes WD894-PE0020.

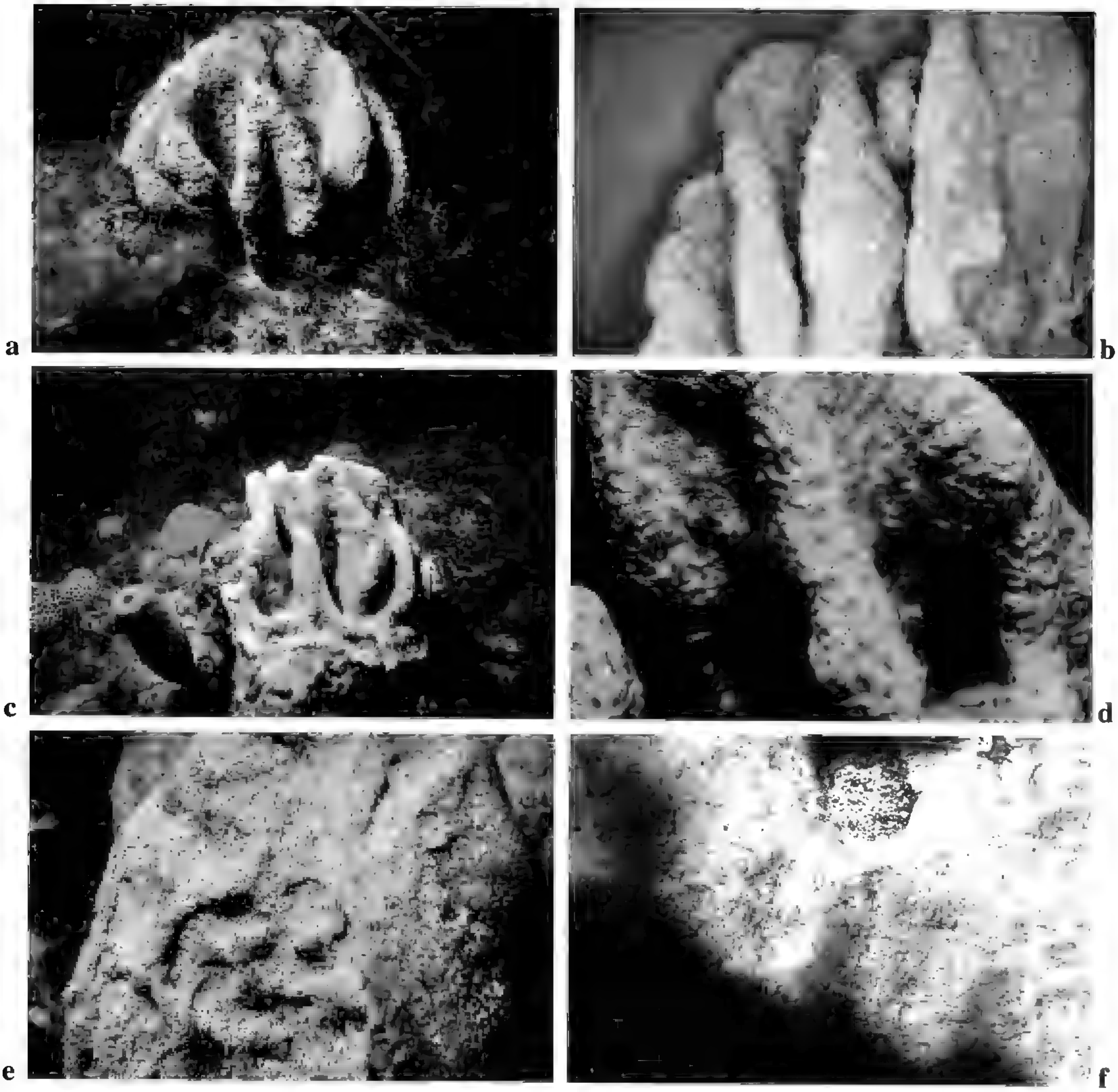


PLATE 11: **a–f** *Aplidium caelestis* (**a**, **b**, whole and part of colony respectively QM GH5430 Kangaroo I SA; **c**, **d**, whole and part of colony respectively QM GH5437 Edithburgh SA; **e**, QM GH5428 Kangaroo I. SA; **f**, Grindal I. SA). Photos: **a–e**, AIMS Bioactivity Gp Q66-C2186 -C2317 -C2184; **f**, W.H. Sasse 6.

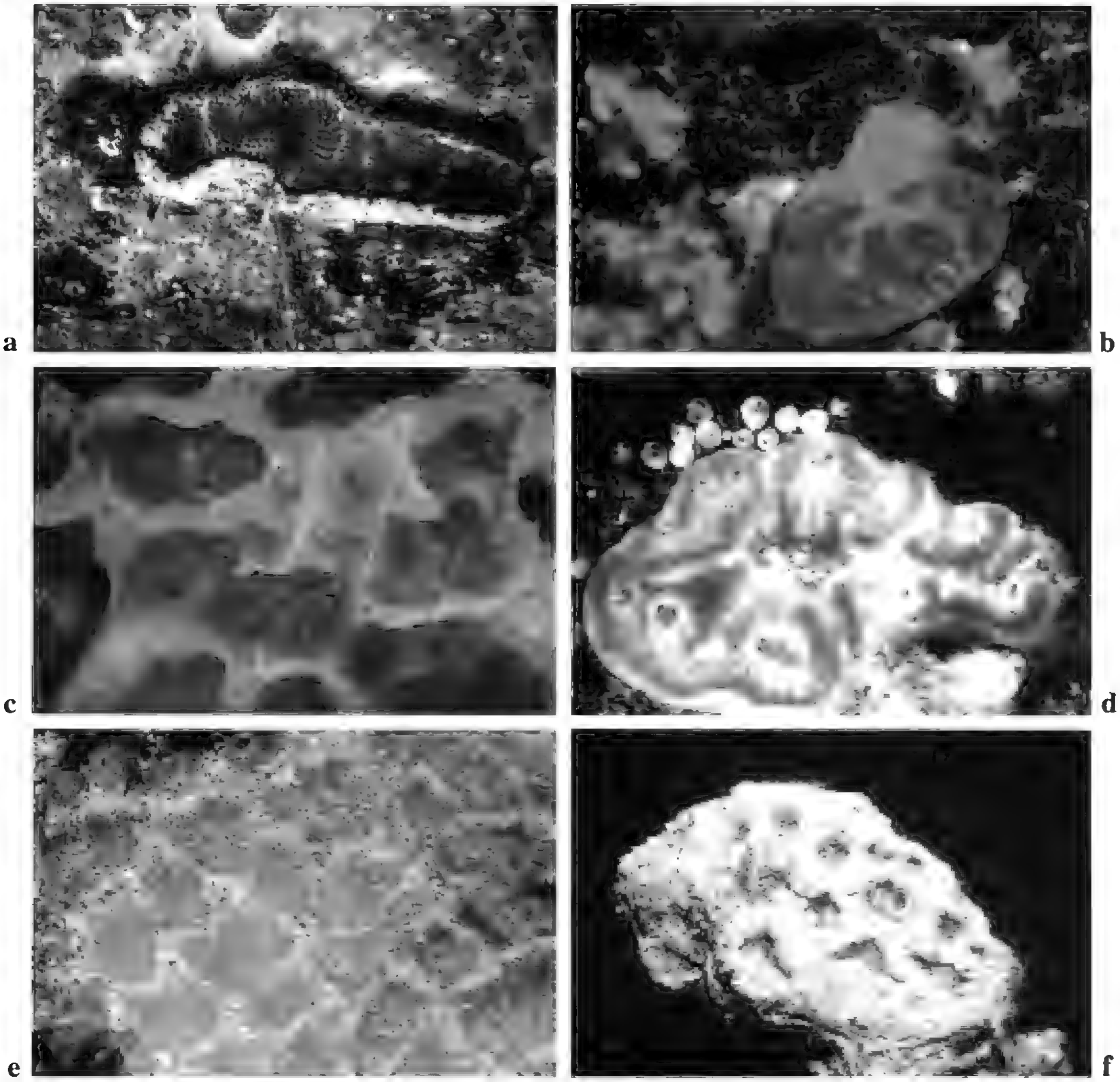


PLATE 12: **a–f**, *Aplidium clivosum* n.sp. (**a**, QM GH2417 Hotspot SA; **b**, QM GH5469 Geographe Bay WA; **c**, QM GH5447 Beachport SA; **d**, ? South Australia; **e**, QM GH5628 Jervis Bay NSW; **f**, QM GH5305 Flinders I. SA).Photos: **a**, **f**, N. Holmes HS1035-PE0008 FL792-PE0050; **b**, **c**, AIMS Bioactivity Gp Q66-C2928 -C2493; **d**, R. Kuiter SS51; **e**, N. Coleman AMPI 78.

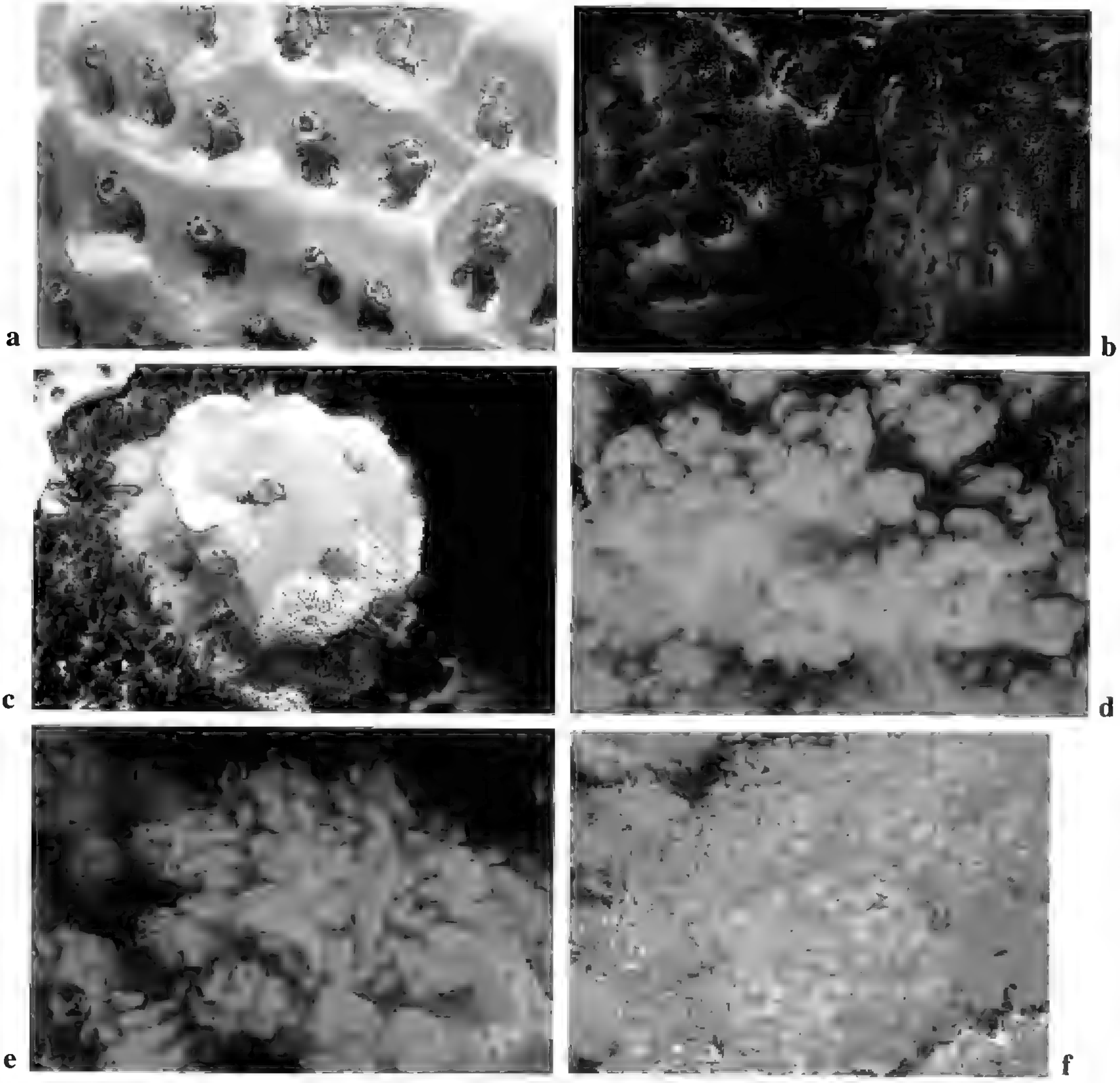


PLATE 13: **a–c**, *Aplidium crateriferum* (**a**, Heron I. Qd; **b**, QM GH5406 Montebello I. WA; **c**, Heron I. Qd). **d–f**, *Aplidium lenticulum* n.sp. (**d**, QM GH5457 Rockingham WA; **e**, QM G9475 Carnac I. WA; **f**, Denmark WA). Photos: **a**, **c**, **e**, **f**, N. Coleman AMPI 146 197 46 119; **b**, **d**, AIMS Bioactivity Gp Q66-C1548 -C2780.

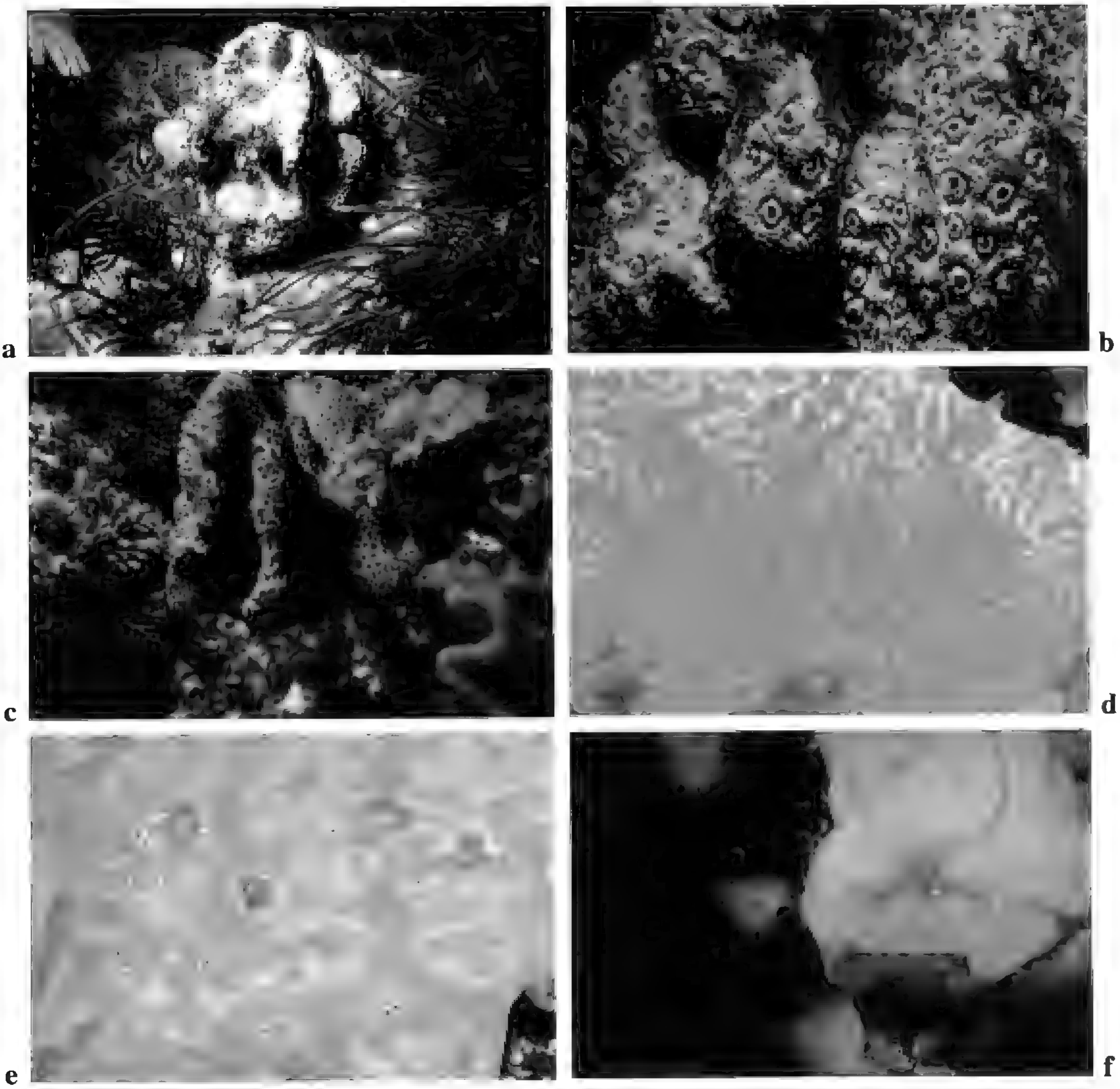


PLATE 14: **a–c**, *Aplidium lunacratum* nom. nov. (**a**, QM GH5429 Kangaroo I. SA; **b**, **c**, QM GH5446 Cape Jaffa SA). **d–f**, *Aplidium multiplicatum* (**d**, QM G10151 Wistari Reef Qd, with *Prochloron* on surface and in cloacal canals; **e**, Heron I. Qd; **f**, QM GH5361 Darwin Harbour NT). Photos: **a**, **b**, **c**, **f**, AIMS Bioactivity Gp Q66-C2185 -C2458 -C0635; **d**, **e**, N. Coleman AMPI 160, Nov. 1987.

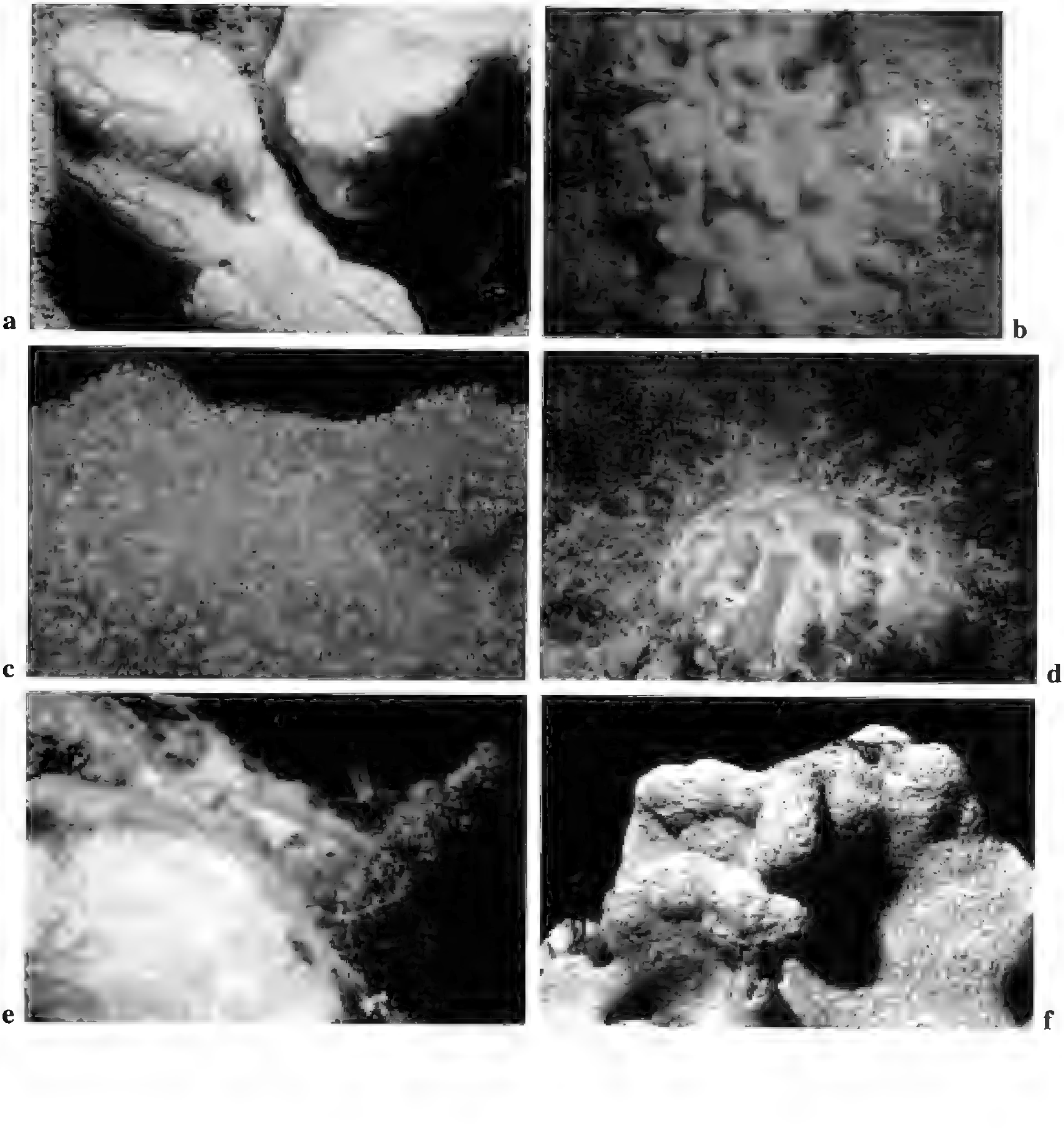


PLATE 15: **a–c**, *Aplidium opacum* (**a**, QM GH5440 Edithburgh SA; **b**, **c**, Port Hacking NSW 3m, 5m). **d–f**, *Aplidium petrosum* n.sp. (**d**, **e**, QM GH5454 Cape Jaffa SA; **f**, QM GH4165 The Gap SA). Photos: **a**, **d**, **e**, AIMS Bioactivity Gp Q66-C2376 -C2728; **b**, **c**, N. Coleman AMPI 255; **f**, W.H. Sasse 32.

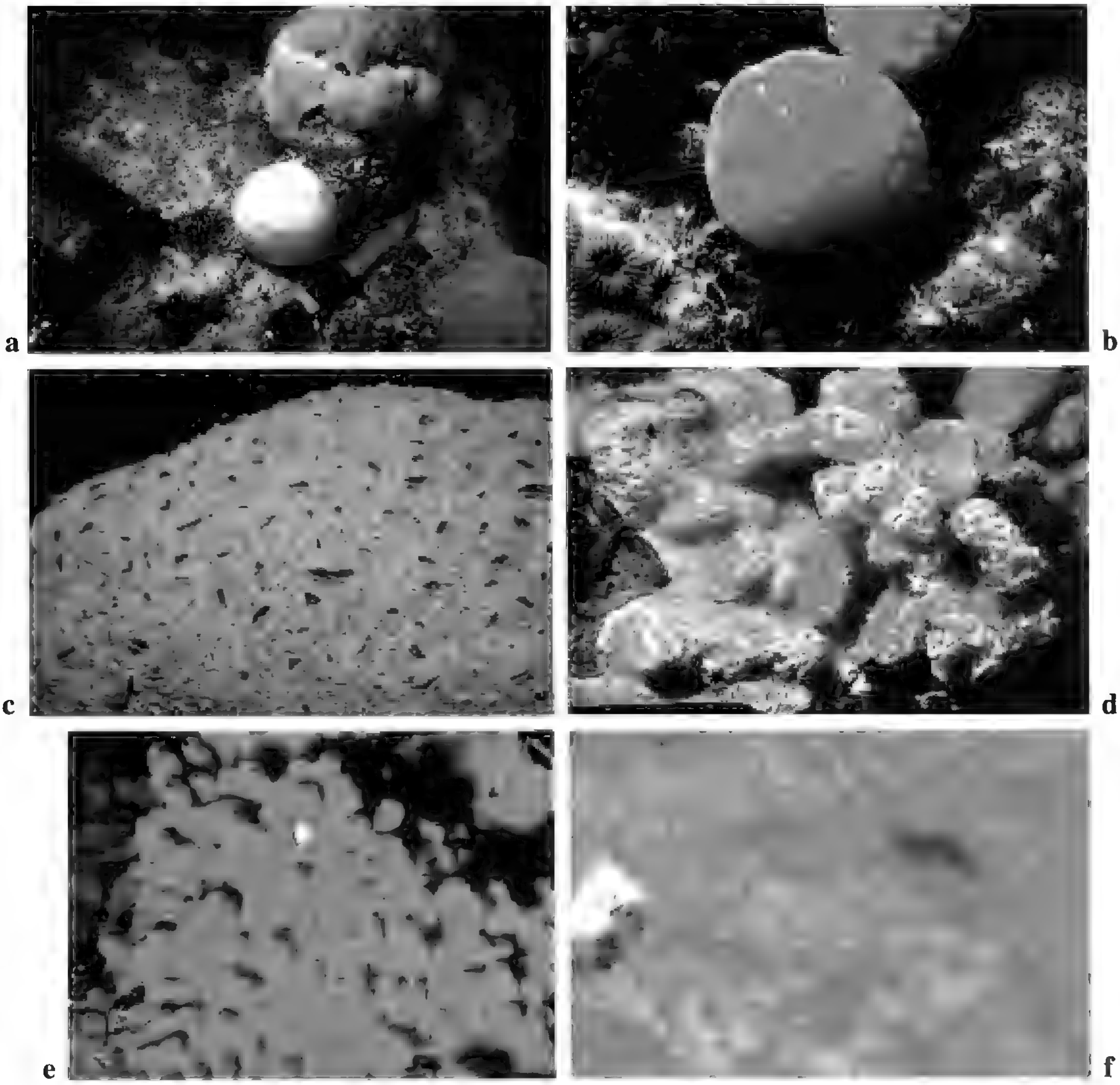


PLATE 16: **a**, **b**, *Aplidium protectans* (**a**, QM GH5378 central Great Barrier Reef; **b**, QM GH5336 far northern Great Barrier Reef). **c**, *Aplidium robustum* n.sp. (QM GH5467 holotype King George Sound WA). **d**, *Aplidium rubricollum* (QM GH4191 Golden I. SA). **e**, **f**, *Aplidium tabascum* n.sp. (**e**, QM GH5208 holotype Heron I. Qd; **f**, QM G9726 Heron I. Qd). Photos: **a–c**, AIMS Bioactivity Gp Q66-C0897 -B2177 -C2914; **d**, W.H. Sasse 14; **e**, **f**, N. Coleman AMPI 207 85.

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INDEX TO TAXA

(Taxon descriptions and figures in **bold**)

THE AUSTRALIAN ASCIDIACEA, SUPPLEMENT 2

PATRICIA KOTT

Kott, P. 1992 10 01: The Australian Ascidiacea, Supplement 2. *Memoirs of the Queensland Museum* 32(2): 621–655. Brisbane. ISSN 0079–8835.

Information from newly examined material and recently published reports supplements that in the continuing review of the Australian Ascidiacea (Kott 1985, 1990a, 1990b, 1992). Recorded ranges of *Sigillina fantasiana, Hypsistozoa distomoides, Polycitor obeliscus, Polycitorella coronaria, Exostoma ianthinum, Botryllus stewartensis*, and *Pyura rapaformis* are extended; the known depth range of *Pseudodiazona claviformis* increased; *Pycnoclavella aurantia, P. elongata, Distaplia prolifera* and *Eudistoma aureum* are now recorded from outside their type localities; new colour patterns and morphological variations are recorded for *Clavelina pseudobaudinensis, Pycnoclavella diminuta* and *P. elongata*; and larvae of *Pycnoclavella aurantia* and *Polycitor calamus*, described for the first time, are characteristic of their respective genera. A new species of the deep water genus *Protoholozoa* is from 7 to 15m off the southern Australian coast. A new species of *Cystodytes* has unusual spicules in a layer beneath the surface test, and one in *Polyandrocarpa*, indigenous to the central eastern Australian coast, forms colonies to a metre in maximum extent. A new *Cnemidocarpa* species has a large number of gonads, and another has only 3 branchial folds on each side.
Western Pacific species of *Ascidia* (1), *Ecteinascidia* (2), and *Pyura* (1), in the Australian fauna are found to have representatives in the component of the New Caledonian fauna previously supposed to be indigenous. The relationships and geographic range are discussed of a further 13 stolidobranch and phlebobranch species, including 4 believed to be pantropical, and abyssal *Asajirus indicus* and *Oligotrema psammites* of the Hexacrobylidae.

☐ *Ascidiacea, Aplousobranchia, Phlebobranchia, Stolidobranchia, Protoholozoa, Hexacrobylidae, Western Pacific.*

Patricia Kott, Queensland Museum, PO Box 3300, South Brisbane, Queensland, 4101, Australia; 13 May, 1992.

Australian ascidians in the suborders Phlebobranchia, Stolidobranchia and Aplousobranchia (excepting the family Didemnidae) have been reviewed by Kott (1985, 1990a and 1992). Morphological, taxonomic, phylogenetic and geographic information additional to that in the first part (Kott 1985) is presented in an initial supplement (Kott 1990b). This, the second supplement, complements parts 1 and 2 (1985 and 1990a). This information is presented only when it expands known geographical range, the known morphological parameters of the taxon, or where new phylogenetic insights are available from newly examined material or recently published accounts of the western Pacific fauna, as in Nishikawa (1984, 1986), Monniot and Monniot (1987, 1990, 1991), and Monniot, C. (1987a,b, 1988, 1989, 1991a,b).

A number of Australia's tropical species are discussed here, specifically in relation to their affinities with New Caledonian populations. The ascidian fauna of the western Pacific has been relatively well studied as evidenced by the works – cited below and in Kott (1985, 1990a, 1990b) – of Sluiter, Van Name, Tokioka, Nishikawa, Kott, Vasseur, Millar, and C. and F. Monniot. From these works it is clear that Fiji, the Tokhara Is in southern Japan, Indonesia, other western Pacific locations and tropical Australia share a common fauna which sometimes extends into the Indian Ocean (see Kott 1985, 1990a, 1992). In particular, the north eastern Australian coast and the Great Barrier Reef can be said to be part of the western Pacific region.

The reports of C. and F. Monniot (1987–91) on the ascidians taken in the French 'vaste programme d'exploration' (Monniot, C. 1987a, p. 3) around New Caledonia propose new species suggesting a larger indigenous fauna than has been found previously in this or any other western Pacific location. Comparison of a number of these species, however, with related ones in tropical Australia and other western Pacific locations has shown them not to be distinct. Differences reported between New Caledonian and other populations lie within the range of intraspecific variability that is a property of all biological material. This variability is associated with age differences, intraspecific population differences, differences between genotypes, ecological differences in growth form or pigmentation, and differences due to artefacts associated with the collection and preservation of the material. The status of morphological differences has sometimes been difficult to determine where neither intraspecific variation nor the number of specimens examined is indicated. Thus, in some, but not all, cases intraspecific differences can be confused with the genetic differences indicating isolation and speciation.

A further problem in resolving some of these problems is the relationship between apparently conspecific populations in the tropical eastern Atlantic and western Pacific — where distance and other geographic barriers would appear to preclude gene flow (see *Ascidia archaia*, *Perophora multiclathrata*, *Polycarpa aurita*, and *Cnemidocarpa areolata*, below).

Museum registration numbers are given for all examined material. Abbreviations used are AM (Australian Museum), SAM (South Australian Museum), QM (Queensland Museum), MV (Museum of Victoria). For detailed data on distribution of each taxon the registers of relevant Australian Museums must be referred to.

The following taxa are discussed below:

DIAZONIDAE
- *Rhopalaea crassa* (Herdman, 1880)
- *Pseudodiazona claviformis* (Kott, 1963)

CLAVELINIDAE
- *Clavelina pseudobaudinensis* (Kott, 1976)

PYCNOCLAVELLIDAE
- *Pycnoclavella aurantia* Kott, 1990a
- *Pycnoclavella diminuta* (Kott, 1957)
- *Pycnoclavella elongata* Kott, 1990a

HOLOZOIDAE
- *Sigillina fantasiana* (Kott, 1957)
- *Sigillina grandissima* Kott, 1990a
- *Distaplia prolifera* Kott, 1990a
- *Hypsistozoa distomoides* (Herdman, 1899)
- *Protoholozoa* Kott, 1969
- *Protoholozoa australiensis* n.sp.

POLYCITORIDAE
- *Cystodytes ramosus* n.sp.
- *Polycitorella coronaria* F. Monniot, 1988
- *Polycitor calamus* Kott, 1990a
- *Polycitor obeliscus* Kott, 1957
- *Eudistoma aureum* Kott, 1990a
- *Exostoma ianthinum* (Sluiter, 1909)

ASCIDIIDAE
- *Ascidia archaia* Sluiter, 1890
- *Ascidia liberata* Sluiter, 1887

PEROPHORIDAE
- *Perophora multiclathrata* (Sluiter, 1904)
- *Ecteinascidia diaphanis* Sluiter, 1885
- *Ecteinscidia nexa* Sluiter, 1904

STYELIDAE
- *Cnemidocarpa amphora* n.sp.
- *Cnemidocarpa areolata* (Heller, 1878)
- *Cnemidocarpa intestinata* Kott, 1990
- *Cnemidocarpa tribranchiata*, n.sp.
- *Asterocarpa humilis* (Heller, 1878)
- *Polycarpa contecta* (Sluiter, 1904)
- *Polycarpa aurita* (Sluiter, 1890)
- *Polyandrocarpa colemani* n.sp.
- *Botryllus stewartensis* Brewin, 1958

PYURIDAE
- *Pyura albanyensis* Michaelsen, 1927
- *Pyura curvigona* Tokioka, 1950
- *Pyura rapaformis* Kott, 1990b
- *Herdmania momus* (Savigny, 1816)
- *Microcosmus tuberculatus* Kott, 1985

HEXACROBYLIDAE
- *Asajirus* Kott, 1989a
- *Asajirus indicus* (Oka, 1913)
- *Oligotrema* Bourne, 1903
- *Oliogtrema psammites* Bourne, 1903

Suborder APLOUSOBRANCHIA Lahille, 1887

Family DIAZONIDAE Seeliger, 1906

The family is distinguished from Cionidae by its relatively small thorax, long, straight, vertical gut loop, and epicardial sacs isolated from the pharynx. Further, although only 2 species of *Rhopalaea* are known to form colonies of not more than 2 zooids, other genera of the Diazonidae are colonial, replicating as do some other aplousobranchs by horizontal strobilation of the abdomen across the epicardium.

Lahille (1887) proposed a common ancestor for taxa with complete internal longitudinal branchial vessels, and accordingly included Diazonidae and Cionidae in the suborder Phlebobranchia. Most authors accepted this phylogeny until Kott (1969, 1985, 1990a) drew attention to the relationships between Cionidae, Diazonidae and other aplousobranch families, based on the presence of entire epicardial sacs and their regenerative role in the process of replication. In Phlebobranchia (but not in Diazonidae or Cionidae) the epicardial sacs are divided into minute vesicles that serve an excretory rather than regenerative function. Further, in phlebobranch ascidians (including Diazonidae and Cionidae) the gut loop is folded up alongside the pharynx while the aplousobranch gut loop, although sometimes horizontal and twisted, is always behind the pharynx. As pointed out by Kott (1985), the loss of internal longitudinal vessels occurs in parallel in all sub-orders of the Ascidiacea as zooids reduce in size with the evolution of replication and a colonial habit (see Perophoridae and Polyzoinae). The morphological relationships between Diazonidae, Cionidae and other aplousobranch (rather than phlebobranch) families is confirmed by their chemistry (see Hawkins *et al.* 1983).

Genus **Rhopalaea** Philippi, 1843

C. Monniot (1991a) believes that *Diazona* and *Rhopalaea* are indistinguishable. However, these genera are readily separated by the relatively primitive characters of *Rhopalaea* including its particularly large branchial sac, and relatively short oesophagus. Although the epicardium is used to regenerate parts of zooids, apparently the process is not one of spontaneous replication, for only 2 species of *Rhopalaea* are known to form colonies (see Kott 1990a). On the other hand, *Diazona* species have smaller thoraces, a generally longer oesophagus, and a prolific replicative capacity resulting in large colonies of numerous zooids.

Rhopalaea crassa (Herdman, 1880)

Ecteinascidia crassa Herdman, 1880, p.723.
Rhopalaea crassa Kott, 1990a, p.26 and synonymy. Nishikawa, 1991, p.25.
Rhopalaea respiciens Monniot, C. 1991a, p.494.

REMARKS

Monniot (1991a) has suggested that species of *Rhopalaea* can be separated by the colour of the living test, the musculature and relative size of the thorax and abdomen. The significance of the colour differences that occur in living specimens of this species is not resolved. However Kott and Goodbody (1982), Kott (1990a) and Nishikawa (1991) have reported on a wide range of specimens of *R. crassa* and its synonyms from a wide range of locations, including type locations and have demonstrated similar variations in the musculature associated with contraction, and variations in the relative size of thorax and abdomen, apparently the result of growth, and regeneration of the thorax which appears to occur from time to time.

Colour differences appear partly regional, blue being the usual colour recorded for living specimens in the Philippines, while specimens with colourless, transparent thoraces with yellow, white and black markings, becoming yellow and opaque when the test is thicker, are recorded from eastern Australia (Kott 1990), Hong Kong (Kott and Goodbody 1982), New Caledonia (Monniot 1991a) and Japan (Nishikawa (1991). The colour of all specimens is lost in preservative.

Rhopalaea respiciens Monniot, 1991a falls well within the range of variation recorded for even single populations of *R. crassa*, e.g. from Heron I. (see Kott 1990a).

Genus **Pseudodiazona** Millar, 1963

Pseudodiazona claviformis (Kott, 1963)
(Fig. 1)

Protopolyclinum claviforme Kott, 1963, p.72.
Pseudodiazona claviformis: Kott, 1990a, p.31 and synonymy.

DISTRIBUTION

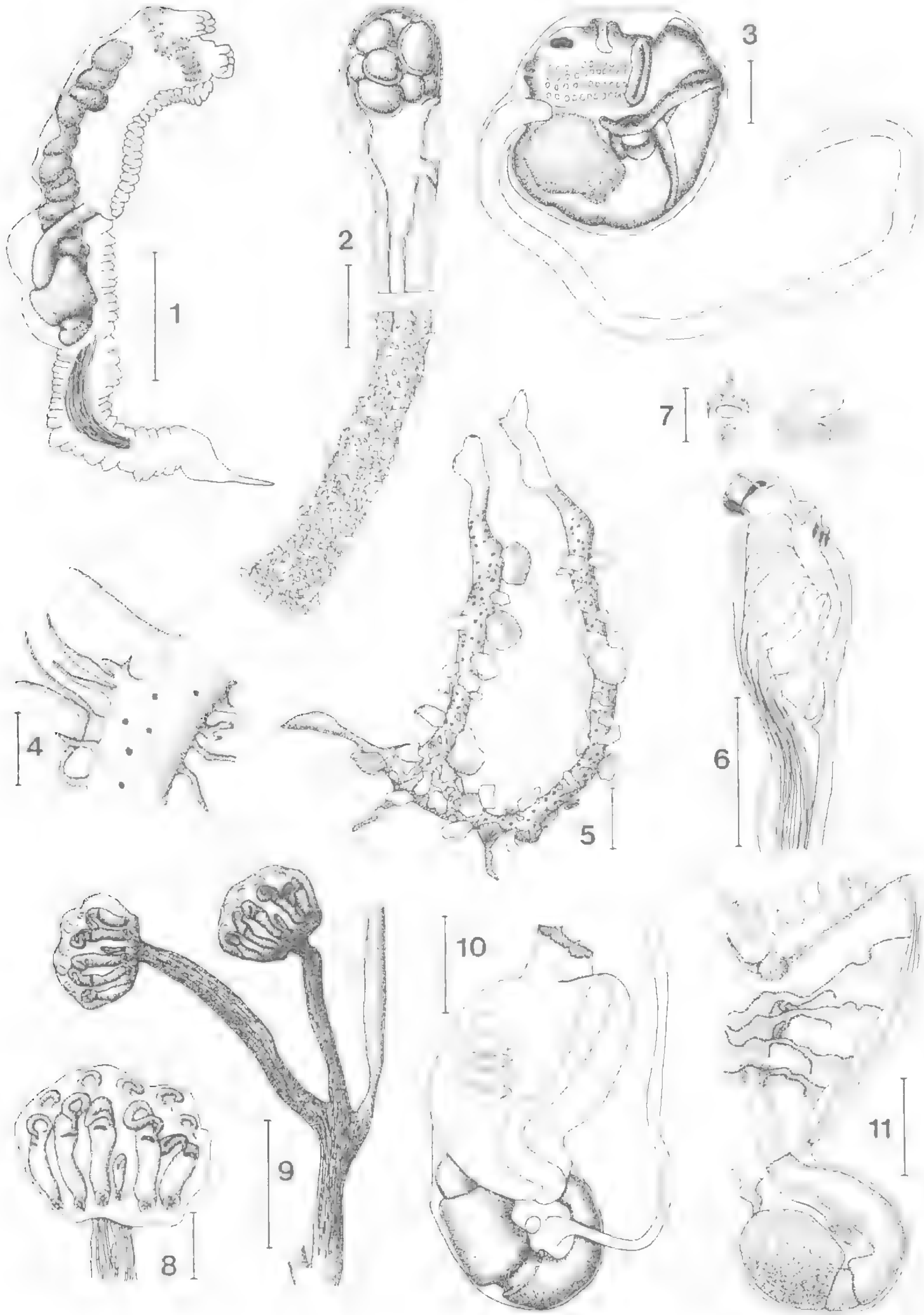
NEW RECORDS: Victoria (off Cape Everard, SAM E2460). South Australia (Spencer Gulf, SAM E2547).
RECORDED RANGE: The species is known from New South Wales and the eastern end of Bass Strait to the northern Great Australian Bight. The newly recorded specimen from Cape Everard increases the known depth range from 100 to 446m.

DESCRIPTION

The newly recorded specimens confirm the morphology of this seldom recorded species.

The specimen from Spencer Gulf retains a pattern of pale grey pigment in vertical petal shaped patches forming a ring around the base of each of the siphons.

In one specimen (SAM E2460) collected in October, the numerous male follicles are bunched in the posterior end of the zooid and eggs are lined up in a single series in the oviduct. In the other specimen gonads are not mature.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Family CLAVELINIDAE Forbes and Hanley, 1848

Genus **Clavelina** Savigny, 1816

Clavelina pseudobaudinensis (Kott, 1976)

Oxycorynia pseudobaudinensis Kott, 1976, p.54.
Clavelina pseudobaudinensis: Kott, 1990a, p.58, and synonymy.

DISTRIBUTION

NEW RECORDS: South Australia (Nuyts Archipelago, SAM E2434 E2471).

RECORDED RANGE: The known range is around the southern half of the Australian continent, from Houtman's Abrolhos to Jervis Bay (NSW).

DESCRIPTION

One of the newly recorded specimens from South Australia (SAM E2434) has a long (3cm) narrow (1.3cm diameter) stalk similar to that of *C. baudinensis* (see Kott 1990a). Otherwise the zooids are characteristic of *C. pseudobaudinensis*, with median pigment patches — one between the siphons and one at the anterior end of the endostyle. Larvae are large, with the trunk 0.9mm long (0.9cm *sic*, Kott 1990a).

Family PYCNOCLAVELLIDAE Kott, 1990

Genus **Pycnoclavella** Garstang, 1891

Pycnoclavella aurantia Kott, 1990

(Figs. 2,3)

Pycnoclavella aurantia Kott, 1990a, p.71.

DISTRIBUTION

NEW RECORD: South Australia (Thorny Passage, SW Hopkins I., SAM E2422).

RECORDED RANGE: The holotype from Franklin I. Nuyts Archipelago was the only previously recorded specimen (Kott 1990a).

DESCRIPTION

Unlike the type specimen, the vertical stalks of the newly recorded one form a sandy aggregated basal mass similar to that observed previously in *Pycnoclavella tabella* Kott, 1990a. Zooids are a gold colour in preservative.

The thoraces are turned at right angles to the long axis of the abdomen, and have a terminal atrial aperture and the branchial aperture on the side of the transparent head. Stigmata are in 6 instead of the 8 rows in the type specimens.

The newly recorded specimens, collected in October, have up to 12 embryos in the atrial cavity at the terminal end of the zooid. The larvae are large, with an almost spherical trunk about 0.9mm long with the tail wound almost once around it. There is an ocellus but no otolith, 4 rows of stigmata, and 3 characteristic deeply invaginated adhesive organs.

REMARKS

Pycnoclavella arenosa (Kott, 1972b) also has 6 rows of stigmata, but its thoraces are not turned at right angles to the long axis of the zooid, the abdomina are not free of the central common test, and the thorax is narrow (with only 20 rather than 50 stigmata per row). The tropical *Pycnoclavella detorta* (see Kott 1990a) resembles the present species in the orientation of the thorax, and in having 6 rows of stigmata. There is a difference in the number of stigmata, however, *P. detorta* having only about 24 per row.

The larva is also similar to that of *P. detorta*, having the characteristic 3 inverted tubular adhesive organs and lacking an otolith. No more than 4 embryos at a time have been found in the atrial cavity of *P. detorta*, while the newly recorded zooids have up to 12. Also the larvae of *P. detorta* have 1.7mm long trunks, longer than those of the present species (1.1mm).

The newly recorded specimens confirm the separate status of the related species *P. aurantia* and *P. detorta*.

Pycnoclavella diminuta (Kott, 1957)

(Figs. 4–7)

Clavelina diminuta, Kott, 1957, p.89.
Pycnoclavella diminuta: Kott, 1990a, p.73 and synonymy.

FIGS. 1–11. *Pseudodiazona claviformis* (SAM E2547) — 1, contracted zooid. *Pycnoclavella aurantia* (SAM E2422) — 2, zooid in test showing embryos in atrial cavity (1cm excised from oesophageal neck); 3, larva. *Pycnoclavella diminuta* — 4, section of colony stalk showing vesicles and hair-like test processes (SAM E2473); 5, part of colony (SAM E2473); 6, thorax showing pigment patches around apertures (SAM E2492); 7, detail of pigment patches around atrial (left) and branchial apertures. *Protoholozoa australiensis* n.sp. (holotype SAM E2423) — 8, head of colony showing zooid arrangement; 9, part of colony; 10, zooid from ventral surface; 11, zooid, dissected down endostyle showing transverse vessels in thorax. (Scales: 1,4,10,11 — 0.5mm; 2,5,8 — 2mm; 3 — 0.25mm; 6 — 1mm; 7 — 0.2mm; 9 — 5mm).

DISTRIBUTION

NEW RECORDS: South Australia (Nuyts Archipelago, SAM E2473; Lincoln National Park, SAM E2492).

RECORDED RANGE: The species is often encountered in benthic collections from all around the Australian coast and in the Western Pacific.

DESCRIPTION

The newly recorded colonies (SAM E2473), have their stalks aggregated together into a loose sandy mass that readily distintegrates. This mass is formed by hair-like test processes from along the stalks of adjacent zooids adhering to sand particles. The usual oily-looking spheres characteristic of this species are in the test of the stalks. It is probable that the basal sandy mass was buried in the substrate, and that only the thoraces projected above the surface.

The specimen lot SAM E2492 has unusual comma-shaped pigment patches around each smooth-rimmed aperture. In preservative these patches are a brown-orange colour. Around the atrial aperture 3 of these patches are arranged symmetrically in front of the aperture (between the siphons) and one is behind the aperture. Five patches, each with its point directed posteriorly, are in a row around the ventral border of the branchial aperture. These 5 separate patches sometimes are confluent.

Despite this unique pigment pattern, the zooids are characteristic of *P. diminuta*. Similar (but not identical) pigment patches are around the branchial apertures of specimens from Exmouth Gulf (QM GH4083: Kott 1990a, Plate 6d).

Pycnoclavella elongata Kott, 1990

Pycnoclavella elongata Kott, 1990a, p.76.

DISTRIBUTION

NEW RECORD: South Australia (St. Vincent Gulf; SAM E2418).

RECORDED RANGE: The species was previously known only from type localities amongst rocky outcrops around the Nuyts Archipelago. The newly recorded specimen is from a boat ramp at 3 to 5m.

DESCRIPTION

Thoraces are dark coloured in preservative, and naked. The stalks are aggregated together to form a basal mass of parallel, vertical sandy stalks. Zooids have 11 rows of stigmata, while the type material has 14 rows. Specimens otherwise conform with the previous descriptions of this species (Kott 1990a).

Family HOLOZOIDAE Berrill, 1950
Genus **Sigillina** Savigny, 1816

Sigillina fantasiana (Kott, 1957)

Eudistoma fantasiana Kott, 1957, p.76.
Sigillina fantasiana: Kott, 1990a, p.92.

DISTRIBUTION

NEW RECORDS: Tasmania (Break Sea I. Port Davey, QM GH5504). South Australia (Spencer Gulf, SAM E2505 E2518–9; Yorke Peninsular, SAM E2485 E2488; St. Vincent Gulf, SAM E2483 E2494; Pearson I., SAM E2537).

RECORDED RANGE: The species is known from Cockburn Sound (WA) and across the southern coast of the continent to Gabo I. off the south eastern coast. The newly recorded specimen from Port Davey, southwestern Tasmania, suggests a range around that island.

DESCRIPTION

Colonies from Tasmania are small cushions with evenly distributed blue zooids and a cloudy test. Larger sheet-like colonies from South Australia, growing along *Zostera* stalks, have almost glassy test and blue pigment around the apertures.

Zooids have a characteristically short abdomen up to 3 times the length of the thorax. A relatively long vascular stolon projects from the posterior end of the abdomen. Three embryos are lined up from the top of the abdomen to the postero-dorsal part of the thorax, where the most advanced projects from the body wall. Tailed larvae are present in February (SAM E2519), July (SAM E2494), September (SAM E2483), and November (SAM E2488 E2518)

Sigillina grandissima Kott, 1990

Sigillina grandissima Kott, 1990a, p.93.

DISTRIBUTION

NEW RECORDS: South Australia (W. Great Australian Bight, SAM E2452 E2457 E2479–81 E2545).

RECORDED RANGE: The species is known from Dampier Archipelago to the Great Australian Bight, although, so far there is a gap in the records between Cockburn Sound and Eucla (SA).

DESCRIPTION

The specimens are fleshy lobes with thick fleshy stalks about the same length as the oval head. They are a very soft, pale lemon in preservative with patches of dark pigment over the neural complex and at the anterior end of the endostyle.

be incorrect, although the type location of the Australian species is off the most southerly part of the Australian continent.

The family Holozoidae is represented in Australian waters by all its known genera, including 2 indigenous ones (*Polydistoma* Kott, 1990a and *Neodistoma* Kott, 1990a). *Sigillina* Savigny, 1816, *Hypodistoma* Tokioka, 1967, *Hypsistozoa* Brewin, 1956, *Sycozoa* Lesson, 1830 and the present genus (with the exception of *P. pigra*) are known mainly from the southern hemisphere (see Kott 1990a). Only *Distaplia* is a cosmopolitan genus.

Protoholozoa australiensis n.sp.
(Figs. 8–11)

DISTRIBUTION

TYPE LOCALITY: South Australia (approximately 1km NE Margaret Brock Reef off Cape Jaffa, 7 to 15m dropoff, overhangs, caverns, coll. W. Zeidler, K. Gowlett Holmes 17.2.89, holotype SAM E2423, paratype SAM E2422).

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: The colony consists of almost spherical heads up to 5mm diameter, each at the end of the terminal branch of a branching stalk up to 1cm long. The combined length of primary, secondary and terminal branches of the stalk are about 2cm. However the available specimens are only part of a colony and the total length of the colonies could be greater. Stalks are narrow, cylindrical, about 1mm diameter, firm and translucent, with a stiff outer cuticle on the lower part.

Zooids are in a single circle, parallel with one another, around the perimeter of the head of the colony. The abdomina of the zooids are uppermost around the top of the head. The atrial apertures are at the posterior end of the thoraces opening to the exterior in a circle around the outer margin of the head just behind its terminal free end. The antero-dorsal branchial apertures are in a circle at the other end of the head, around the top of the stalk. Posterior abdominal vascular stolons extend parallel to one another along the length of the stalk, running back past the endostyle from the centre of the gut loop to enter the top of the stalk.

Vegetative zooids are in the stalk and sometimes in the head in a circle around the top of the stalk near the anterior ends of the adult zooids. However, there is no sign of more than a single circle of zooids in each head, and the vegetative zooids formed in the stalk may move up to increase the diameter of a head, and/or to form systems in developing terminal branches of the stalk.

INTERNAL STRUCTURE: Zooids are delicate and transparent, 2 to 3mm long with the gut bend slightly to the left against the posterior end of the thorax. The ventral border of the thorax is longer than the dorsum so that the short branchial siphon turns dorsally. It has fine crenellations around the rim but no lobes. Circular muscles are around the branchial and atrial apertures and short bands extend laterally from each end of the atrial aperture which is a transverse slit at the posterior end of the thorax. Twelve, short, stumpy branchial tentacles are in a circle at the base of the branchial siphon. The branchial wall consists of 4 transverse vessels attached to about the ventral one third of the parietal body wall, and free for the dorsal two-thirds of their length. They are attached to the dorsum where they cross the dorsal sinus as wide transverse membranes, but there are no dorsal languets. A few longitudinal connectives run between the transverse vessels each side of the mid-dorsal line.

The oesophagus is short, and turns to the right to open into an almost horizontal smooth walled, oval stomach. The post-pyloric part of the gut forms a smooth curve from the distal part of the stomach to the anus near the atrial aperture. As in other genera of the Holozoidae (see *Sycozoa*: Kott 1990a) a spherical gastric reservoir is in the gut loop, together with 4 or 5 immature ova. However, the gonads are not mature in the type material.

REMARKS

The type species of this genus, *P. pedunculata* Kott, 1969 (from the Scotia Sea, the South Pacific Basin and the Antarctic Peninsula at from 3000 to nearly 5000m) differs from the present species in having 2 rather than 4 transverse vessels, an internally ridged stomach, a larger head with a thick fleshy stalk and zooids in rows of about 3 down the length of the head.

Protoholozoa anthos Monniot and Monniot, 1991, and *P. lilium*: Monniot and Monniot, 1991 also have a smooth stomach, but 3 rather than 4 transverse vessels, and, in the former species, a long anterior atrial lip (an unusual feature in this genus). *Protoholozoa cantrella* Monniot and Monniot, 1985 differs in its internally ridged stomach and 3 transverse vessels.

Family POLYCITORIDAE Michaelsen, 1904
Genus **Cystodytes** Drasche, 1884

Cystodytes ramosus n.sp.
(Figs. 12–16)

DISTRIBUTION

TYPE LOCALITY: Queensland (Central section Great Barrier Reef, Haslewood I., in bay, 20m, coll. AIMS Bioactivity Group 17.10.87, holotype QM GH5374).

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a knobbly mass, basically cylindrical with side branches. Each cylindrical branch is about one to 2cm diameter, to 2cm long. The colony is about 5cm in maximum extent overall.

Zooid systems open into furrows and depressions on the outer surface and circular to oval or irregular raised zooid-free elevations are scattered between the surface openings of the systems. Each system consists of a circle of up to 20 zooids, surrounding a depression (rudimentary common cloacal cavity) in the surface. This depression contains the circle of atrial apertures. The circle of branchial apertures is slightly less than 1cm in diameter.

In life, photographs show the specimens to have a smooth, translucent colourless surface layer covering brownish-pink test. The surface 2mm of test is a translucent, firm and gelatinous layer of bladder cells. It covers a layer of calcareous plate-like spicules, lying parallel to the surface of the colony. The layer is only 1 spicule thick, but the spicules overlap one another slightly around their thickened, scalloped edges. These spicules are relatively pliable, consisting of deposits of granular calcareous material, rather than the hard rigid spicules of *Cystodytes dellachiajei*. Minute brown pigment cells are scattered through the test, especially in the surface layer. In the holotype the zooids are withdrawn from the surface into the central layer of test through the layer of spicules.

INTERNAL STRUCTURE:Contracted zooids are one to 2mm long. Both the branchial and atrial apertures are 6-lobed, on cylindrical siphons, the atrial siphon larger than the branchial siphon. Strong longitudinal muscles are in the body wall. Stigmata are long, arranged in 4 rows of about 12. The gut loop is vertical, with a large, smooth-walled stomach. About 5 pear-shaped male follicles are in the gut loop

REMARKS

The species is distinguished from *Cystodytes dellachiajei* by the layer of spicules beneath the surface bladder cells, and the absence of a capsule of spicules enclosing the abdomen of each zooid.

Genus **Polycitorella** Michaelsen, 1924

Polycitorella coronaria F. Monniot, 1988
(Figs. 17–22, 43)

Polycitorella coronaria F. Monniot, 1988, p.228. Kott, 1990a, p.184 and synonymy.

DISTRIBUTION

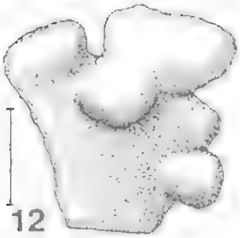
NEW RECORD: Queensland (Heron I. QM GH5616).

RECORDED RANGE: The species is recorded from 3 to 190m from Northwest Cape to Port Phillip Bay. The new record extends this range to the southern tip of the Great Barrier Reef.

DESCRIPTION

EXTERNAL APPEARANCE: The colony is a small thick cushion, about 1.5cm diameter and 1cm deep. Zooids are arranged in 7 circular systems of about 6 per system. Spicules are crowded in the lower half of the colony, at abdominal level. In the upper half, at thoracic level, they are present only in the centre of each circle of zooids, forming a pillar of spicules that reaches to the upper surface. The branchial apertures open around the outside of the upper margin of this white pillar, and the atrial apertures project through the upper edge and open just inside its upper margin. The external surface of the colony, both around the sides and on the flat upper surface is covered with a thick layer of bladder cells, free of spicules and pigment cells.

Pigment cells are black in the living specimen, but brown in preservative. They are crowded in the test lining the zooid compartments, and are evenly distributed elsewhere except where they are excluded by either colourless bladder cells or white spicules. Spicules are 0.025 to 0.07mm. The smaller ones are most plentiful at abdominal level around the zooids. Moderately sized ones are most frequently encountered, and the largest ones are rare. They have about 30 short pointed rays in optical section, although the smaller ones often have rounded rays. The living colony was black and white, the white circular upper surface of the pillars of spicules in the centre of each system contrasting with the rest of the upper surface where spicules are not present to dilute the black pigment cells.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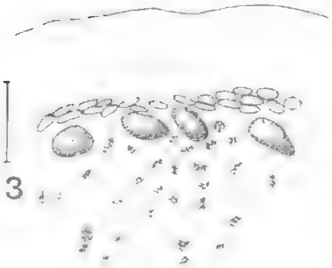
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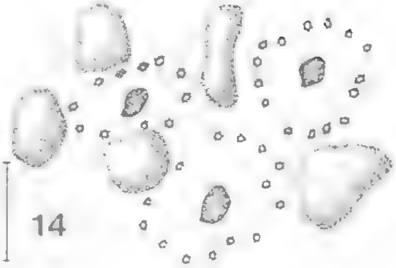
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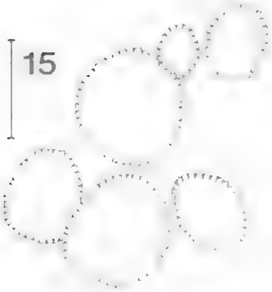
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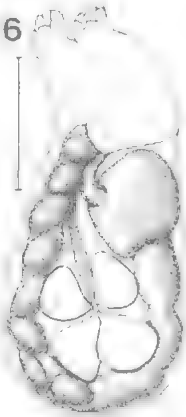
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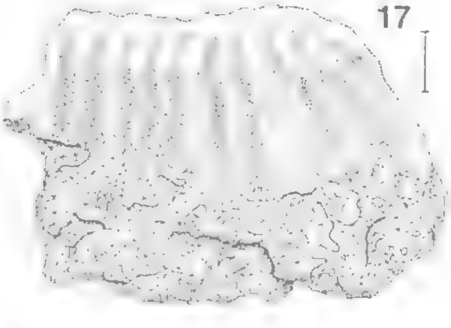
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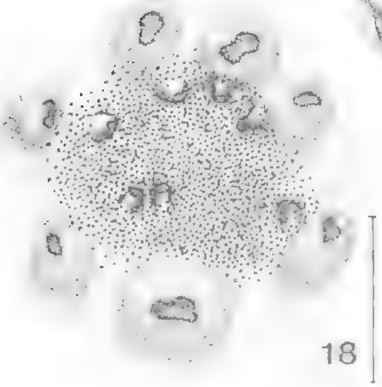
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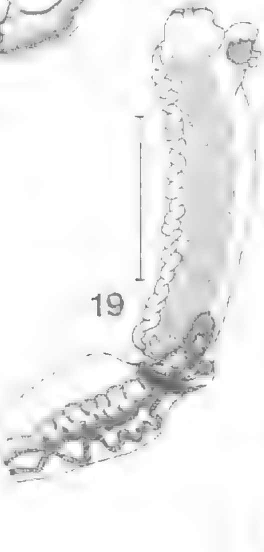
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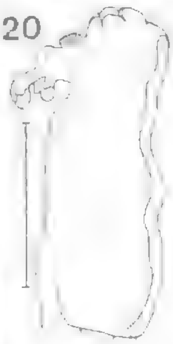
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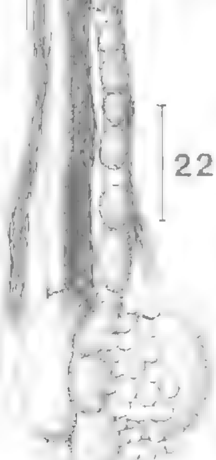
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INTERNAL STRUCTURE: Zooids are contained narrow vertical canals in the test, and in the present colony seem always severed somewhere along the long, narrow oesophageal neck. The rounded, slightly expanded posterior ends of the abdomina appear to have remained in place in their test compartment in the base of the colony and are not very much contracted. The anterior part of the zooids also has remained in place at the surface.

However, both the thorax and the most of the oesophageal neck is very much contracted, and it is this that appears to have caused the zooids to break apart, the abdomina remaining in the base of the colony and the apertures at the surface. The rim of the branchial aperture is divided into 6 small lobes. The atrial aperture is on a moderately long siphon. The upper rim of the opening is produced into a tongue-like lip, its tip divided into 3 round lobes. The posterior rim of the aperture also is divided into 3 lobes.

The thoracic musculature consists of about 16 narrow longitudinal bands, with very fine transverse muscles overlying them to form square meshes. Around the anterior part of the abdomen the longitudinal muscles reorganise themselves into about 8 wider bands on each side. Further posteriorly 4 wide longitudinal muscle bands encase the abdomen, but break up into separate fibres anterior to the gonads and stomach. Fine circular muscles are in one or 2 bands around the anterior part of the abdomen. These appear to be a continuation of the layer of transverse thoracic muscles onto the abdomen. Their arrangement in several bands may be due to the contraction of the longitudinal muscles. These transverse bands do not appear to have become embedded in the test, and there is not a constriction of the test between the thoracic and abdominal compartments, as there is in the large colonies of this species from southern and western Australia (see Kott 1990a).

The branchial sac is long with 13 rows of about 16 stigmata. The stomach is smooth, and located in the posterior end of the abdomen. It is obscured by the large testis consisting of numerous crowded pyriform follicles covering the dorsal side of the pole of the gut loop, and partly covered by a single large ovum.

REMARKS

Although it has been taken from Northwest Cape (Western Australia) this species has not previously been recorded from the eastern tropical coast of Australia or from any other location in the Western Pacific. The species appears to flourish in temperate Australian waters, where large colonies often are taken. This small specimen from the southern tip of the Great Barrier Reef may represent a population at the northern limits of its range. The single specimen does not appear juvenile, despite its small size, having large, mature male follicles and a large ovum. The gonads, branchial sac, circular systems, spicules, pigment cells and other features of the zooid and colony are characteristic of the species. The only significant difference appears to be the absence of a test constriction with a bundle of transverse muscle bands embedded in it between the thoracic and abdominal zooid compartments. However the transverse muscles are present outside the longitudinal ones, behind the thorax, and the fact that they have not become embedded in the test may be associated with the small size of the colony.

Genus **Polycitor** Renier, 1804

Polycitor calamus Kott, 1990
(Figs. 23–25)

Polycitor calamus Kott, 1990a, p.167.

DISTRIBUTION

NEW RECORD: South Australia (Spencer Gulf, SAM E2530).

RECORDED RANGE: The species is recorded from the Great Australian Bight and Spencer Gulf, South Australia, and from the Kurnell Peninsula (Botany Bay) New South Wales.

DESCRIPTION

The newly recorded colony is characteristic, with its long cylindrical stalk, divided into basal holdfasts that are spread out over sea grass leaves (*Posidonia*). A few epibionts are on the stalk. The expanded head has scattered spots in the surface of the preserved specimen.

FIGS. 12–22: *Cystodytes ramosus* n.sp. (holotype QM GH5374) — 12, colony; 13, section through upper part of colony showing contracted zooids beneath a layer of disc shaped spicules; 14, systems; 15, disc shaped spicules; 16, zooid. *Polycitorella coronaria* (QM GH5616) — 17, colony; 18, system from above; 19, thorax and anterior part of abdomen; 20, thorax showing atrial lip; 21, zooid showing muscle bands on abdomen; 22, gut loop and gonads. (Scales: 12 — 2cm; 13, 17 — 2mm; 14 — 5mm; 15, 16, 20–22 — 0.5mm; 18, 19 — 1mm)

The zooids have the usual long thorax and abdomen. In this colony (collected at the end of September). There are up to 9 embryos in a developmental series in the top of the abdomen. In some zooids the 2 best developed have moved up into the posterior end of the atrial cavity.

The larval trunk is up to 0.9mm long, with the tail wound about three-quarters of the distance around it. Half of the length of the trunk is taken up with a large frontal lobe which, at its anterior end, supports 3 triradially arranged, large adhesive organs. Each consists of a small everting cone in a depression at the end of a thick cylindrical stalk. The cerebral vesicle contains a large ocellus and otolith. There are 3 rows of stigmata in the larval pharynx.

REMARKS

Larvae of this species previously were unknown. Kott (1990a) suggested that since larvae were not present in the known specimens (collected in January and April) the breeding season could be restricted. The newly recorded specimens contain large numbers of relatively large embryos which appear to have been fertilised at the base of the long abdomen, and to have been developing as they move up the long stalk of the colony. This could be a lengthy process, and it suggests that sexual reproduction in this species could be an event that occurs once only during the year. The larvae, with their triradial adhesive organs and long frontal lobe, resemble the larvae of *Polycitor giganteus*, the tropical *P. annulus*, and *P. circes* (see Kott 1990a).

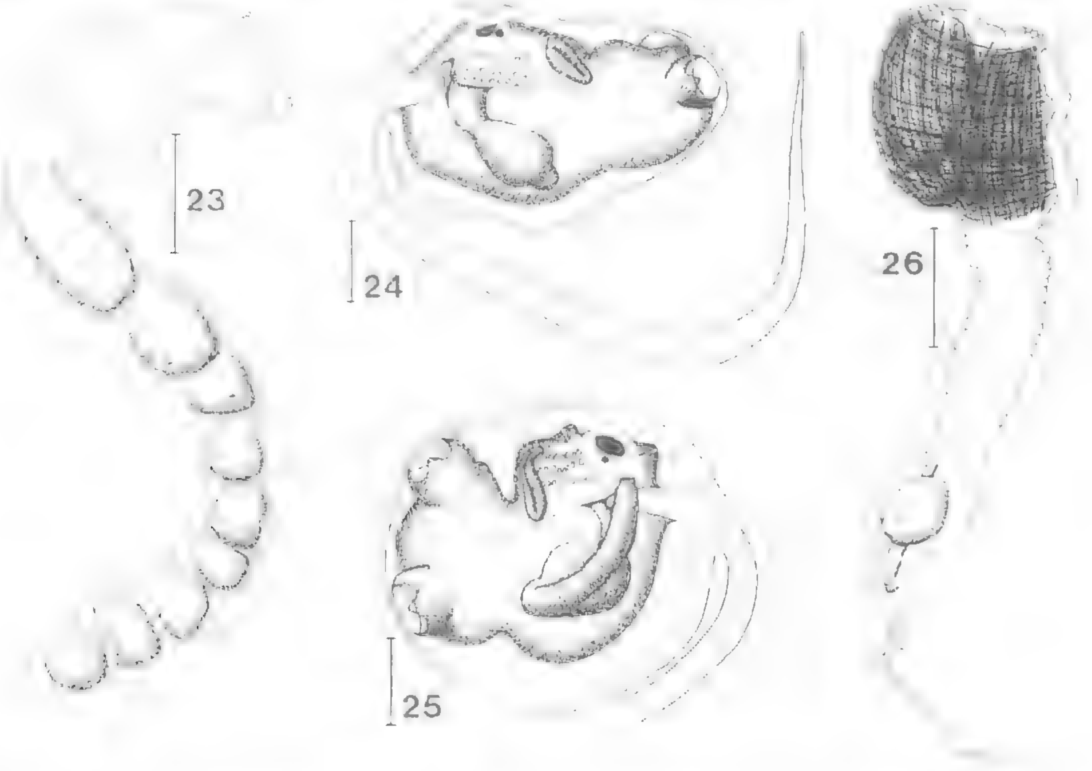
Polycitor obeliscus Kott, 1972

Polycitor obeliscus Kott, 1972b, p.171; 1990a, p.175.

DISTRIBUTION

NEW RECORDS: South Australia (Nuyts Archipelago, SAM E2543–4). Victoria (Bass Strait, MV H454).

RECORDED RANGE: The species previously was known only from its holotype from Investigator Strait. Its range is apparently restricted to the southern coast of



FIGS. 23–26: *Polycitor calamus* (SAM E2530) — 23, zooid showing embryos in abdomen; 24, 25, larvae. *Eudistoma aureum* (SAM E2538) — 26, zooid with two embryos in atrial cavity. (Scales: 23, 26 — 1mm; 24, 25 — 0.2mm).

Australia from the Great Australian Bight to Bass Strait.

Description

External Appearance: The newly recorded colonies are of various shapes. The specimen from Bass Strait (at 70m) is upright, egg-shaped and fixed by its narrow base. The other colonies are fixed by a broad base (to 3cm diameter). One is a wide cone on the upper surface, but the other has a vertical margin and is flat-topped. Sand is present internally. It is absent from the surface of much of the upper part of the colony although occasionally, especially around the margins, or toward the base, some sand is present on the surface around the zooid openings. Atrial and branchial apertures open separately to the surface.

In one colony the zooids seem arranged in pairs, but there are no systems. The test is white and the zooids are reddish-orange to flesh-coloured in preservative.

Internal Structure: Zooids are large and robust, with almost continuous coat of external longitudinal and internal circular muscles. The longitudinal muscles continue in 2 bands along each side of the abdomen. Stigmata are in 6 or 7 rows of about 20. The stomach, in the expanded posterior end of the abdomen, is smooth-walled. The testis follicles are clustered in a large mass on the dorsal side of the gut loop.

Remarks

The present species is distinguished mainly by the number of rows of stigmata and the smooth-walled stomach.

Genus **Eudistoma** Caullery, 1909

Eudistoma aureum Kott, 1990
(Fig. 26)

Eudistoma aureum Kott, 1990a, p.199 and synonymy.

Distribution

New Record: South Australia (off Eucla, 170 to 190m, SAM E2538–9).

Recorded Range: The species was known only from its type locality in *Posidonia* beds in St. Vincent Gulf.

Description

External Appearance: The largest colony (SAM E2538) consists of upright lobes, possibly spherical in life, but slightly laterally flattened in preservative, about 4cm diameter. It is fixed to the substrate by a narrow basal part. Internally the colony contains grey sand throughout. Sand also is present in the surface test on the lower half, which may be buried in the substrate. In preserved colonies, the surface test on the upper part of the colony, which is free of sand, is translucent and greenish black with black zooids showing through it. The arrangement of the zooids is obscure in these colonies.

Internal Structure: The zooids are robust, with conspicuous muscles, about 50 internal transverse bands and 30 external longitudinal ones. Apertures are both 6-lobed. Stigmata are in 3 rows of 25 (middle row) to 30 (anterior) in each row. The dorsal end of the anterior row extends forwards along each side of the neural complex.

In the large colony taken from off Eucla, up to 2 large embryos (trunk 1.25m long) are being incubated in the atrial cavity. They have 4 lateral ampullae along each side of the median adhesive organs. However, these are crowded, the larvae are opaque and other details could not be determined. The tail is wound two-thirds of the way around the larval trunk.

Remarks

The pigmentation in the large colony is more intense than in previously recorded specimens, which were said to have red-brown zooids in grey colonies (Kott 1990a). Possibly the colour fades in long-term preservation, for other features of both zooids and colony such as the muscular zooids, and the large number of stigmata per row, with the anterior row inclined along the mid-dorsal line, are identical.

Previously recorded colonies were said to have been yellow in life. Unfortunately the colour of the newly recorded ones is not known.

Genus **Exostoma** Kott, 1990

Exostoma ianthinum (Sluiter, 1909)

Polycitor ianthinus Sluiter, 1909, p.20.
Exostoma ianthinum: Kott, 1990a, p.234 and synonymy.

Distribution

New Record: Queensland (Far northern Great Barrier Reef — Great Detached Reef, QM GH5726).

Recorded Range: The southern limit of the recorded range of this species was previously thought to be Motupore I. New Guinea. It is known also from Palau Is, Philippines, and Bunda (Indonesia).

Suborder PHLEBOBRANCHIA Lahille, 1887

Family ASCIDIIDAE Adams & Adams, 1858

Genus **Ascidia** Linnaeus, 1767

Ascidia archaia Sluiter, 1890

Ascidia archaia Sluiter, 1890, p.346. Kott, 1985, p.26 and synonymy. Monniot and Monniot, 1987, p.92 and synonymy. Monniot, C. 1987a, p.18.

DISTRIBUTION

RECORDED RANGE: The species is known from Norfolk Is, from north of Moreton Bay and northwards up the Great Barrier Reef to New Caledonia, the Philippines, Indonesia, French Polynesia, Fiji, the Marshall Is, and the southern islands of Japan; and from the northwest coast of Australia and south to Shark Bay. The tropical Atlantic species *Ascidia corelloides* (Van Name, 1924) appears to be inseparable from it (see Van Name 1945, Tokioka 1953). Nevertheless, the Western Pacific and Atlantic populations apparently are isolated from one another, neither having a range into temperate waters.

REMARKS

Monniot and Monniot (1987) do not accept the view (Kott 1985) that *A. aperta* Sluiter, 1904 is a synonym of the present species on the grounds that it is large, up to 5cm long, with an open gut loop and with muscles on the right better developed than in the smaller specimens they have assigned to *A. archaia*. None of the characters invoked by Monniot and Monniot are outside the range of variation observed in *A. archaia*, which is one of the most common species on the Heron I. reef flat, under rubble. It is known to reach a size of 5cm in less than 6 months (see Kott 1985).

Ascidia liberata Sluiter, 1887

Ascidia liberata Sluiter, 1887, p.251. Kott, 1985, p.43 and synonymy.

Ascidia solomonensis Nishikawa, 1986, p.61.

Ascidia dorsalis C. Monniot, 1987a, p.9.

Not *Ascidia liberata*: Sluiter, 1904, p.32. C. Monniot, 1987a, p.8.

DISTRIBUTION

RECORDED RANGE: The species is recorded from Norfolk I. and the Great Barrier Reef, Indonesia (Sluiter 1887; Bay of Batavia, ZMA TU244), New Caledonia and Solomon Is.

DESCRIPTION

The species is characterised by the naked, transparent test, pointed papillae on the siphons, the fringe of minute tentacular projections along the edge of the lobes surrounding the apertures, and tranverse muscles across the dorsal surface of the generally laterally flattened, short, often triangular body, extending about half to two-thirds of the way across the right side but only about one-third of the way down the left. Short longitudinal muscles extend from along each siphon, those from the branchial siphon crossing the transverse muscles.

The red colour at the anterior end of the body in the living specimens has been referred to by Kott (1985), Nishikawa (1986) and Sluiter (1887).

REMARKS

Monniot (1987a) refers to the poor condition of the type specimen (ZMA TU244). Nevertheless it was this type specimen that Kott (1985) examined before assigning this common species to it. At the time she examined it, the characteristic papillae on the siphons, the tentacular fringe around the apertures, and the transverse muscles on the dorsal part of the right side of the body were all clearly visible. The general shape of this individual, which was figured by Sluiter (1887), closely resembles many of the more recently examined specimens.

Monniot, C. (1987a) examined and figured a specimen from the Siboga collection assigned to *A. liberata* by Sluiter (1904). Although Kott (1985) did not include it in the synonymy of *A. liberata*, Monniot believed the *Siboga* specimen to be identical with the type of *A. liberata*, and since it has characters inconsistent with *A. liberata*: Kott, 1985 he assigned the latter to a new species, *A. dorsalis* Monniot, 1987a. However, the Siboga specimen Monniot examined is not conspecific with *A. liberata* Sluiter, 1887. Its muscles, both on the right and left sides, as well as the swollen gut, the remnants of a fringe around the apertures and the foreign particles attached to the test, suggest that the Siboga specimen Monniot examined is *A. sydneiensis*.

Kott's specimens, for which *A. dorsalis* was erected, being conspecific with *A. liberata* Sluiter, 1887, *A. dorsalis* becomes a junior synonym of *A. liberata*. Similarly *Ascidia solomonensis* Nishikawa, 1986 has the characteristic features of *A. liberata* Sluiter, 1887.

Family PEROPHORIDAE Giard, 1872

Genus **Perophora** Wiegman, 1835

Perophora multiclathrata (Sluiter, 1904)

Ecteinascidia multiclathrata Sluiter, 1904, p.12.
Perophora multiclathrata: Kott, 1985, p.106 and synonymy (part, **not** *P. bermudiensis*: *pers. comm.* I. Goodbody). Nishikawa, 1986, p.30 and synonymy; 1991, p.38. C. Monniot, 1987a, p.88.

DISTRIBUTION

RECORDED RANGE: The species has a wide range in the Western Pacific from the Japan Sea (Sado), in both Micronesia and Melanesia as well as the northeastern coast of Australia, the Great Barrier Reef and Norfolk Island. *Perophora multiclathrata* also occurs on the western coast of Africa (> *Perophora africana* Millar, 1953; *fide* Nishikawa, 1986) and in the West Indies (although it is not a synonym of *P. bermudiensis*). The record from the Japan Sea is the only one outside tropical locations.

REMARKS

It is of interest that a possible junior synonym of *P. bermudiensis* (*P. fascia* C. Monniot, 1991a) occurs in New Caledonia. Although Monniot has discussed the differences of *P. fascia* from the temperate *P. hutchisoni* and tropical *P. namei*, both with jointed stolons (see Kott 1985), he has not compared the morphology of his new species with either *P. multiclathrata* or *P. bermudiensis*, species with which it has more in common. If *P. fascia* is a synonym of *P. bermudiensis*, both *P. multiclathrata* and *P. bermudiensis* are sympatric in the Western Pacific and the Atlantic.

Genus **Ecteinascidia** Herdman, 1880

Ecteinascidia diaphanis Sluiter, 1885

Ecteinascidia diaphanis Sluiter, 1885, p.168. Kott, 1985, p.90.
Ecteinascidia koumaci C. Monniot, 1987a, p.3.
Ecteinascidia ndouae C. Monniot, 1991a, p.505.

DISTRIBUTION

RECORDED RANGE: The species is known from northern New South Wales, Great Barrier Reef, Northern Australia, Palau Is, Indonesia, and New Caledonia.

REMARKS

Monniot has compared the New Caledonian material with *E. hedwigiae* Michaelsen, 1918 from the coast of Natal, and with the Western Pacific *E. diaphanis*. The latter, on geographical grounds is a more likely taxon to occur in New Caledonia. Differences between *E. diaphanis* and the 2 species from New Caledonia, viz. *E. koumaci* and *E. ndouae*, appear to be either the result of intraspecific variation, or artefacts such as muscle contraction. They include variations in the red or pink-orange pigmentation at the anterior end of the zooids, which forms rings around the siphons, and sometimes spots as well (see Kott 1985). In *E. ndouae* C. Monniot, 1991a, the colour is described as yellow-gold.

Ecteinascidia koumaci Monniot, 1987a is distinguished from *E. diaphanis* by the interval between the band of transverse muscles behind the atrial siphon and the siphonal muscles. This is affected by contraction of the longitudinal muscles along the length of the siphon. The membrane between the dorsal languets, also said to distinguish the species, is not always present (Monniot, C. 1987a). There seems no valid justification for the assignation of *E. koumaci* and *E. ndouae* to species distinct from *E. diaphanis*.

Ecteinascidia nexa Sluiter, 1904

Exteinascidia nexa Sluiter, 1904, p.11. Kott 1985, p.94 and synonymy. Nishikawa, 1986, p.42.
Ecteinascidia aequale C. Monniot, 1987a. p.5.
Ecteinascidia imperfecta: Nishikawa 1984, p.42.

DISTRIBUTION

RECORDED RANGE: The species is recorded from Lord Howe I., the northeastern Australian coast and the Great Barrier Reef, Solomon Is, Indonesia, Philipines, Fiji, Tokhara Is, the Indian Ocean (Sri Lanka), and now from New Caledonia.

REMARKS

C. Monniot (1987a), comparing *E. aequale* with *E. nexa*, was unable to reconcile the descriptions of Kott (1985) and Nishikawa (1986). However, there are not significant differences in these accounts. The species is readily characterised by its muscles, cloudy body wall in preservative, smooth stomach, duodenal and posterior stomach enlargements in the gut loop, hemispherical mass of male follicles and usually yellow colour in life. All of these characters are referred to by both Nishikawa (1986) and Kott (1985).

Ecteinascidia nexa has a range of orientations of the sessile to stalked zooids and a variety of primary and accessory stolons attaching them to the basal stolons or to one another. Apertures are, respectively, terminal and halfway along the body, sometimes sessile, but usually on conical siphons when living. Kott (1985) describes the preserved zooids as flaccid and distorted, cloudy in preservative, with numerous blood cells. Nishikawa (1986) refers to the 'lustreless' free surface with pale yellowish spherules densely distributed in the body wall. Similar body muscles are described (in some detail) by Kott (1985) and Nishikawa (1986). Stigmata are in 19 (Kott 1985) or 20 (Nishikawa 1986) rows, and there are from 14 to 24 longitudinal vessels on one side of the body.

Both authors, independently, examined the types of *P. hornelli* Herdman, 1906, and proposed its synonymy. Nishikawa (1986) also examined the type of *E. nexa*.

The branchial processes on the prepharyngeal band figured by Kott (1985, fig. 39b) only occur in the most robust zooids and are not characteristic of the species, nor was it suggested that they are.

Ecteinascidia aequale C. Monniot 1987a from New Caledonia appears to fall within the range of variation reported for *E. nexa*.

Suborder STOLIDOBRANCHIA Lahille, 1887

Family STYELIDAE Sluiter, 1895
Subfamily STYELINAE Herdman, 1881
Genus **Cnemidocarpa** Huntsman, 1912

Cnemidocarpa amphora n.sp.
(Figs. 27–31)

DISTRIBUTION

TYPE LOCALITY: South Australia (Sir Joseph Banks Group, North Point, Marum I., 200m offshore in sand, rubble, *Posidonia*, 7m, coll. W. Zeidler 13.1.84, holotype SAM E2531; Sir Joseph Banks Group, W. Partney I., Partney Shoal Reef, rubble, sand, *Posidonia*, 5–15m, coll. W. Zeidler and K. Gowlett Holmes 21.8.86, paratypes SAM E2536.

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: Individuals are club-shaped, with an expanded body, rounded anteriorly and posteriorly continuous with a thick, cylindrical stalk about the same length as the body. The branchial and atrial apertures are directed away from one another in opposite sides of the anterior end of the body, the branchial siphon almost terminal, and the atrial one on the dorsal side.

The available specimens are contracted, and behind the large, naked lobes of each aperture is a collar or band of wrinkled test. When the animal is relaxed it is probable that these disappear, and that the siphons are long, projecting out like horns from the anterior end of the body.

Sand adheres to the anterior part of the body around the base of the siphons, and to the fine hairs around the base of the stalk. The hairs aggregate together to form a sandy holdfast. The test is transversely wrinkled over most of the surface. It is particularly thin on the base of the stalk where it is surrounded by the sandy holdfast.

INTERNAL STRUCTURE: The body wall is red, shiny and muscular. Posteriorly it is extended into an inflated stolon which projects down into the stalk. Anteriorly the two siphons are relatively long, the branchial siphon directed obliquely away from the substrate, the atrial one curved over to the side toward the substrate. Attenuated body muscles are confined to the anterior part of the stolon, which is thin-walled and hollow in its distal part. The hollow may be part of the haemocoele, as it does not appear continuous with the atrial cavity, being separated from it by a thin membrane.

Longitudinal stripes line the siphons, and numerous fine branchial tentacles surround the base of the branchial siphon. The dorsal tubercle is a particularly large cushion with a double spiral slit, both horns rolled in, and directed either to the left or anteriorly. A large dorsal ganglion occupies the space between the base of the 2 siphons in these contracted specimens.

The branchial sac has 4 low folds on each side of the body, with crowded internal longitudinal vessels arranged according to the formula DL0(18)2(10)3(12)3(10)2E. About 4 stigmata are in meshes in the interspaces, and more are between the endostyle and the first longitudinal vessel on each side.

The gut loop is simple, and vertical, its pole compressed into the V of the posterior end of the body where, in these contracted specimens, it projects slightly into the top of the stalk. The oesophageal opening is halfway down the dorsal side of the pharynx. The oesophagus is short, the stomach long with parallel internal longitudinal folds. The stomach and post pyloric part of the intestine (proximal to the pole of the gut loop) are of about equal length. The rim of the anal opening (at the base of the atrial aperture) is deeply divided into 16 rounded lobes. On each side, up to 10, crowded, parallel gonads lie horizontally (at right angles to the long axis of the body). They consist of a double rows, each row of about 10 large testis follicles, beneath a long ovarian sac.

A very short oviduct is at the dorsal end of each ovary. The short vas deferens opens on top of the female duct. Irregular, upright endocarps are crowded along the dorsal one third of each side of the atrial cavity (between the dorsal ends of the gonads, and dorsal to them).

REMARKS

Both *Cnemidocarpa floccosa* (Sluiter, 1904) and *C. completa* Kott, 1985 have a similar number of cnemidocarp gonads on each side of the body as the present species. The former tropical species is rounded posteriorly, while the present one narrows to its stalk; the gonads lie vertically, parallel to the long axis of the body in *C. floccosa*, rather than at right angles to it as in *C. amphora*; and the gut loop in the present species lies vertically, extending back from the oesophageal opening, while that of *C. floccosa* curves anteriorly around the ventral margin of the body. *Cnemidocarpa completa* Kott, 1985 is known from temperate waters, although not from South Australia. It also is distinguished from the present species by the curve of the gut loop around its posterior ventral border, the absence of a dorsal band of endocarps, the long stomach, and the loose attachment of gonads to the body wall.

Cnemidocarpa areolata (Heller, 1878)

Styela areolata Heller, 1878, p.26.

Cnemidocarpa areolata: Kott, 1985, p.122 and synonymy. **Not** Monniot, 1983, p.451 (< *C. legali* Gravier, 1955).

Cnemidocarpa valborg Monniot, 1988, p.193; 1991b, p.27 (part, ? not specimen from Dumbéa). **Not** Monniot and Monniot, 1984a, p.577 (< *C. legali* Gravier, 1955); ? 1991, p.400.

Cnemidocarpa irene: Nishikawa, 1991, p.96 and synonymy.

DISTRIBUTION

RECORDED RANGE: The species is known from all around the Australian coast, from Sri Lanka, and the western Pacific to the Marianas, Fiji, Japan and Hong Kong (see Kott 1985). The newly recorded specimens from New Caledonia (Monniot 1991b) are consistent with other records from the western Pacific.

REMARKS

Monniot and Monniot (1984a, p.577), having examined the type specimen of *C. areolata* (from Sri Lanka) found that its vas deferens was divided and that it opened by 'unbouquet de papilles'. Comparing its gut loop with Herdman's figure of *C. areolata*: Herdman, 1906 (Pl. 4, Fig. 24), Monniot and Monniot assume that Herdman's specimens, also from Sri Lanka, are conspecific with the holotype of *C. areolata*, and separate from the (principally western Pacific) specimens assigned to *C. areolata* Heller, 1878 by various authors (see Nishikawa 1991). Monniot and Monniot (1984a, p.577) contend that 'La synonymie certaine de cette espèce est restreinte au type de l'espèce et à l'échantillon de Herdman'. The specimen recorded by Nishikawa (1991) as 'C. Monniot's collected from India' apparently is part of the type of *C. areolata* Heller, 1878 'mounted on a glass slide' (see Nishikawa 1991, p.97). Neither Monniot and Monniot (1984a) nor Monniot (1988, 1991b) refer to the examination of Herdman's specimens, and there is no record that these have the remarkable, and possibly abnormal, replicated openings of the male ducts which they found in the type. Apparently the synonymy of Herdman's specimens with the type is based entirely on the curvature of the gut loop reported by Herdman (1906, pl.4, fig. 24). The curve of the gut loop is variable in the large sample of examined specimens from Australia (Kott 1985), Japan (Nishikawa 1991) and New Caledonia (Monniot 1988). Further, its curvature varies according to the curvature of the body, influenced party by its state of contractions, and by the size and shape of the adhering surface. The curvature of the gut loop is not on its own a reliable enough character to determine the relationships of the Sri Lankan specimens to one another and to others from the Indo-West Pacific. These relationships will be resolved only when the status of the unusual opening of the vas deferens (known in the one, albeit type, specimen) is established.

Cnemidocarpa valborg: Monniot and Monniot 1991 from 300 to 500m off New Caledonia has different gut loop, branchial sac and endocarps from the present species, and does not appear conspecific. Similarly, the specimen from Dumbéa (Monniot 1991b) with ducts turned ventrally does not appear to belong to this species.

The specimens from the Atlantic (Monniot 1983; Monniot and Monniot 1984a) lack the characteristic yellow and red stripes lining the siphons of living specimens, which turn to black in preservative; the gut loop is narrow, the limbs parallel to one another with endocarps in an irregular row (rather than being bunched together in the open pole of the loop (as they are in *C. areolata*);

the stomach lacks the numerous, regular parallel folds of *C. areolata*; and the posterior gonad on the left is much more branched, or it does not curve over the anterior pole of the gut loop, as in *C. areolata*. Although there are certain similarities in the morphology of these two species, they do not seem sufficiently close to justify their synonymy, especially where there is no reasonable geographic basis for gene flow between them.

Cnemidocarpa intestinata Kott, 1985

Cnemidocarpa intestinata Kott, 1985, p.128.
Not *Cnemidocarpa* aff. *intestinata*: Monniot and Monniot, 1991, p.401.

REMARKS

This species, recorded from northern and northeastern Australia, is well characterised by its hollow conical overlapping spines (Kott 1985 Fig. 50d), large numbers of stigmata (15) in the meshes between the folds, a narrow gut loop, a gonad directed posteriorly in the second gut loop, and clumps of male follicles constricting the ovarian tubes at regular intervals along each side. Endocarps are not present.

The specimen from 700m depth off New Caledonia (Monniot and Monniot 1991), believed to have affinities with *C. intestinata*, shares only one of these characters — viz. the lack of endocarps. It does not appear to be related in any way.

Cnemidocarpa tribranchiata n.sp.
(Fig. 32–35)

DISTRIBUTION

EXTERNAL APPEARANCE: South Australia (Encounter Bay, Seal Rocks, with bryozoan *Hornera foliacea*, 15m coll. N. Holmes 24.8.88, holotype SAM E2533; Willunga Reef, low tide, coll. I.C. Kowanka 23.11.76, paratype SAM E2534.

FURTHER RECORDS: None.

DESCRIPTION

EXTERNAL APPEARANCE: Individuals are upright and oval, about 2cm long, with fleshy, 4-lobed, sessile apertures, the branchial terminal and the atrial about halfway down the dorsal surface. Irregular extensions of the basal test fix the animal to the substrate. The test is white, translucent and moderately thick and firm. The surface is slightly rough, and has patches of epibionts and shell and sand particles attached here and there.

INTERNAL STRUCTURE: The body wall has strong longitudinal muscle bands radiating from each siphon and crossing one another over the sides of the body. About 15 are from the atrial siphon and 12 from the branchial siphon. They branch into fine bands forming a delicate inconspicuous network on the postero-ventral part of the body. Circular muscles are around each siphon. A long neural ganglion is between the siphons.

The simple branchial tentacles (about 40) are of various sizes and alternate with rudimentary ones. The dorsal lamina is wide and plain-edged. A long neural ganglion is between the siphons. The dorsal tubercle is a circular slit with a large C-shaped opening, the open interval directed anteriorly.

Three broad, but not overlapping folds are present on each side of the pharynx. Internal longitudinal vessels are thick and project into the pharynx. They are arranged according to the formula E3(13)3(12)2(13)ODL. They are not crowded, either on the folds or in the interspaces, there being 8 stigmata per mesh between the folds and 6 per mesh on the folds.

The gut loop is long and narrow, curving at least halfway around the postero-ventral curve of the body. It is open at the pole where it encloses a flat-topped endocarp which is lobed around its margin. The stomach occupies about three-quarters of the ascending limb of the gut loop. It has 11 parallel, slightly oblique folds. These flatten out at its pyloric end, which tapers gradually to the intestine. The oesophagus is short and narrow. The anus is visible through the open atrial aperture. Its margin is divided into 5 shallow lobes.

Two gonads are on each side of the body, converging toward the atrial aperture. The ovarian tubes are sinuous, the curves giving an impression of irregular lobes along each side, an impression that is emphasised by the presence of an endocarp on each outer curve. Crowded testis follicles are in 2 rows beneath each ovary. On the left side of the body the posterior gonad is curved into the secondary gut loop, and the anterior one

FIGS. 27–35. *Cnemidocarpa amphora* n.sp. (27, paratype SAM E2536; 28–31, holotype SAM E2531) — 27, 28, external appearance; 29, body removed from test showing extension into stalk; 30, internal organs; 31, lateral view of gonad. *Cnemidocarpa tribranchiata* n.sp. (holotype SAM E2533) — 32, external appearance; 33, body removed from test; 34, dorsal tubercle and anterior part of dorsal lamina; 35, internal organs on left side. (Scales: 27–29, 31, 32 — 5mm; 30, 34, 35 — 1mm; 33 — 2mm).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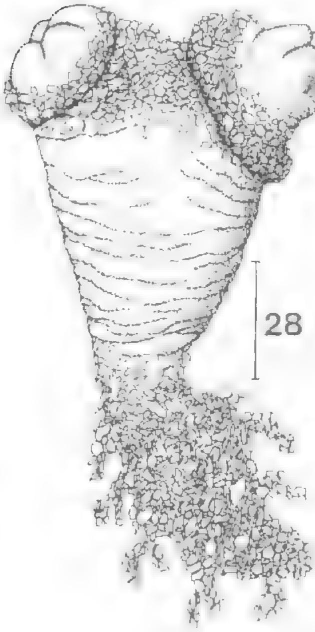
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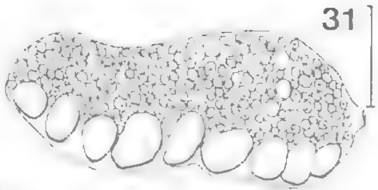
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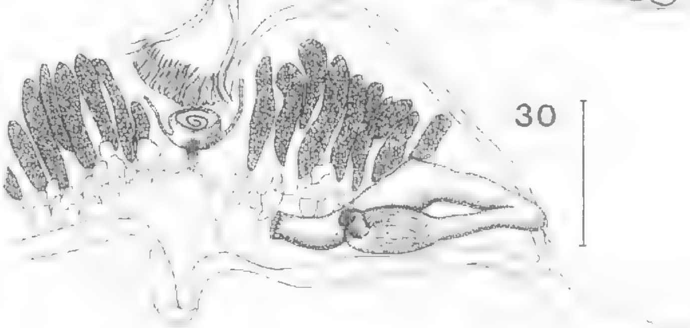
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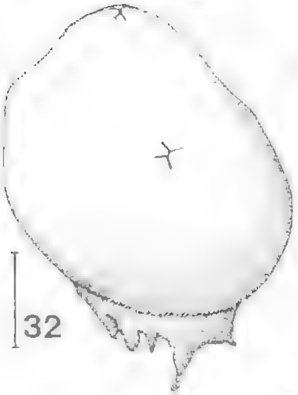
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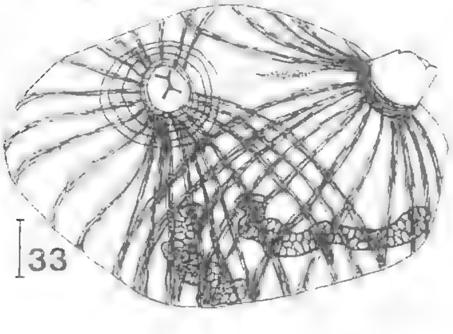
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extends across the body wall anterior to the pole of the gut loop. Endocarps are scattered on the body wall between the gonads.

REMARKS

Cnemidocarpa tripartita Kott, 1985 from Bass Strait has, like the present species, a rounded body, white (but thin) translucent test, 3 branchial folds on each side of the body, a long stomach with longitudinal folds, an endocarp enclosed in the pole of the gut loop, and 2 gonads on the left and 3 on the right. Its significant differences from the present species are its low branchial folds with only 2 or 3 internal longitudinal vessels (while those of the present species are broad and flat with 12 or 13 longitudinal vessels), its light attachment of the gonads to the body wall by fine ligaments (while in the present species gonads are embedded) and the absence of endocarps on the body wall between the gonads.

Genus **Asterocarpa** Brewin, 1946

Asterocarpa humilis (Heller, 1878)

Styela humilis Heller, 1878, p.26.
Asterocarpa humilis: Kott, 1985, p.141 and synonymy.
Not *Cnemidocarpa* aff. *humilis*: Monniot, 1991b, p.25.

DISTRIBUTION

RECORDED RANGE: This species is known from temperate waters from Albany, across the southern coast of Australia to Tasmania and Victoria, New Zealand, and from South Africa and the eastern Pacific (see Kott 1985).

REMARKS

The specimen from tropical New Caledonian waters which Monniot (1991b) believed to have affinities with this species has 2 long, branched gonads across each side of the body, between the ventral and dorsal mid-line, converging to the atrial aperture. The short, cnemidocarp-type gonoducts are at the dorsal (distal) end of each gonad. This contrasts with the genus *Asterocarpa* which has irregularly branched gonads, with ventrally directed gonoducal openings, around the ventral margin of the right side of the body, and one in a similar (ventral) position anterior to the gut loop on the left. The New Caledonian specimen also has more longitudinal branchial vessels than the temperate species *Asterocarpa humilis*.

Cnemidocarpa lobata Kott, 1985 has undulating branched gonads, like the New Caledonian specimen, but it has a particularly long gut loop and also is temperate. The New Caledonian specimen appears either a small (1cm diameter) specimen of *Cnemidocarpa stolonifera*, or the related *C. pedata* which has a short stomach like Monniot's specimen.

Genus **Polycarpa** Heller, 1877

Polycarpa aurita (Sluiter, 1890)

Styela aurita Sluiter, 1890, p.338.
Polycarpa aurita: Kott, 1985, p.152 and synonymy. Monniot, 1987b, p.294. Nishikawa, 1991, p.92.
Polycarpa insulsa: Monniot 1987b, p.294 and synonymy.

DISTRIBUTION

RECORDED RANGE: The species apparently is pantropical, being recorded from the Caribbean, as well as from the Japan Sea, Indonesia, New Caledonia and the Philippines, north-western and north-eastern Australia, and south to Cockburn Sound and Port Jackson respectively.

REMARKS

Van der Sloot (1969) believed there to be 2 species, a Caribbean one, consisting of *P. insulsa* (Sluiter, 1898) and its synonyms, and a western Pacific one, *P. circumarata* (Sluiter, 1904) which Kott (1985) and Monniot (1987b) believe to be a junior synonym of *P. aurita* (Sluiter, 1890). The distinctions between the Atlantic and Pacific species which were established by Van der Sloot are differences between the type specimen of *P. circumarata* (lacking gonads in the posterior end of the body) and the Caribbean populations. This distinction can be sustained only if specimens from the Western Pacific never have gonads on the posterior part of the body wall. In fact, specimens from Australian waters show a great range in the distribution of gonads. Other distinctions such as the tough lining of the atrial cavity, which is said to occur in *P. insulsa*, occur also in *P. aurita*.

A problem with the separation of the Pacific and Atlantic species, is that specimens of the former have a range in characters, such as the number of internal longitudinal vessels, the consistency of the test and surface projections from it, that transcends any of the currently recognised differences between the species. Thus, although it is always difficult to justify genetic continuity for pan-tropical species, the present evidence supports such a range for this species.

The occurrence of the specimen from New Caledonia assigned to *P. insulsa*: Monniot, 1987b, which is said to be identical with specimens from the Caribbean, adds support to the view that there is no distinction between these species.

Polycarpa contecta (Sluiter, 1904)

Styela contecta Sluiter, 1904, p.66. Kott, 1985, p.162. ?C. Monniot, 1987b, p.291.

DISTRIBUTION

RECORDED RANGE: The species is recorded from Indonesia, and Townsville, and possibly from New Caledonia.

REMARKS

Monniot (1987b) remarks that his (single) specimen from New Caledonia corresponds well with Kott's (1985) description (based on the Siboga type material and specimens from Townsville). However, it does differ in 3 important respects. The opening of the neural gland is not the deep S-shaped slit — which Kott (1985) believes to be characteristic of *P. contecta*, its gonads are embedded in thick endocarp while those Kott examined are attached by a membrane along the proximal half of each, and the stomach of *P. contecta* is characteristically long, occupying most of the proximal limb of the primary gut loop while that of the New Caledonian specimen is shorter. Thus, there is some doubt about the assignation of the New Caledonian specimen.

Genus **Polyandrocarpa** Michaelsen, 1904

Polyandrocarpa colemani n.sp.
(Figs. 36–41, 44)

DISTRIBUTION

TYPE LOCALITY: New South Wales, off Queensland border (Cook I., 9m, north side of I, rocky bottom, coll. N. Coleman January 1987, holotype QM GH5724; Arrawarra, 12m, south face of North Rock, coll. AIMS Bioactivity Group 19.2.88, paratype, QM GH5392).

FURTHER RECORDS: New South Wales (Coffs Harbour, photographed specimens; Cook I., QM GH5725).

The species grows along the top of of ridges where it is subjected to maximum current flow.

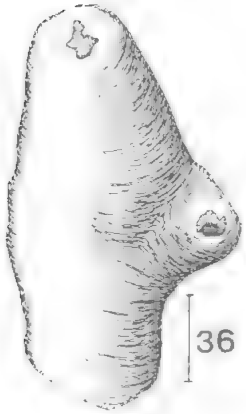
DESCRIPTION

EXTERNAL APPEARANCE: Colonies are firm, massive, to 1m long and about 0.3m wide, opaque and grey, with white rings around the apertures. The apertures protrude from the otherwise smooth surface of the colony on short cylindrical siphons. Branchial apertures are bent over to lie on the surface while the atrial apertures are directed upwards. The apertures appear to have smooth rims, the usual 4 lobes usually characteristic of styelid ascidians not being evident. In preservative the external test is dark grey, but internally the test is whitish, translucent and gelatinous, without embedded nor encrusting sand. The dark zooids are completely embedded in the tough test, and are evenly spaced. They protrude only slightly from the surface of the colony. They lie on their ventral surface with the dorsal surface uppermost, near the outer surface of the colony. Blood vessels anastomose through the thick gelatinous internal test.

INTERNAL STRUCTURE: Zooids are muscular, and much contracted in the available colonies. From the base of the branchial siphon to the posterior end of the contracted body is about 1cm. The siphons are sometimes long and thin, but in other specimens they are withdrawn and the apertures appear sessile. Externally circular muscles form an almost complete layer. The internal longitudinal muscles are less crowded. Branchial tentacles are long and pointed, and number about 50. The peritubercular area is a shallow V. The opening of the neural duct is a long, sessile slit, oriented transversely, longitudinally, or obliquely, and affected by the body's contraction — the transverse slit sometimes being bent into a U- or V shape. The slit often is obscured by the closely papillated and wrinkled lining of the prebranchial area, although this also may be caused by contraction of body wall muscles.

The branchial sac is robust, with conspicuous longitudinal vessels arranged according to the following formula: DL0(4)1(6)1(8)1(5)1E. Stigmata are 6 per mesh in the middle of the branchial sac, and 8 per mesh between the first fold and the plain-edged, long, dorsal lamina. The oesophagus is also long, curving up posteriorly toward the oesophageal opening.

The oesophagus is short. The long stomach, occupying about three-quarters of the ascending limb of the gut loop, is narrow at the cardiac end, gradually increasing in width to its junction with the wide intestine. There are 18 internal longitudinal stomach folds. A small, straight caecum is at the distal end of the stomach, in the inside curve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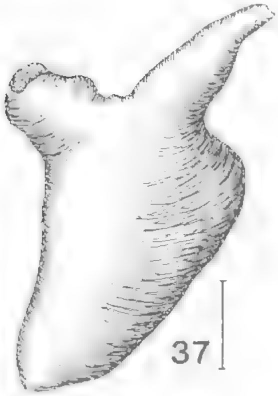
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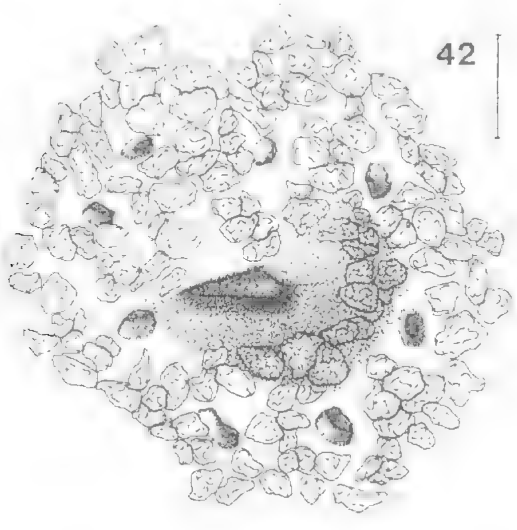
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There is no blue pigment in the epicardial sac as described for the type material.

Zooids and larvae are characteristically large, the larval trunk 3.8mm long with a short tail that reaches only part of the way along the ventral surface. A narrow waist is behind the 2 large adhesive organs. Three broad ampullae are on each side, at the base of the thick stalks of the adhesive organs. Larvae are present in January (SAM E2480).

Genus **Distaplia** Della Valle, 1881

Distaplia prolifera Kott, 1990

Distaplia prolifera Kott, 1990a, p.122.

DISTRIBUTION

NEW RECORDS: Western Australia, (Dampier Archipelago, QM GH5399 GH5409–10 GH5413).

RECORDED RANGE: Only the holotype colony from off Port Hedland was known previously.

DESCRIPTION

The colonies are all robust sheets with spongy test. Zooids are in circular systems, slightly depressed into the surface. They are pink in preservative. Parastigmatic vessels cross each row of moderately numerous stigmata. The vertical stomach has longitudinal striations internally but is smooth externally. The gonads are in a posterior abdominal sac.

Genus **Hypsistozoa** Brewin, 1956

Hypsistozoa distomoides (Herdman, 1899)

Amaroucium distomoides Herdman 1899, p.72.
Hypsistozoa distomoides: Kott, 1990a, p.134.

DISTRIBUTION

NEW RECORD: Tasmania (W. of Mutton Bird I., SAM E2451).

RECORDED RANGE: The species is known from the Great Australian Bight to Port Jackson New South Wales. The new record from Tasmania represents the southern limits of the known range.

Genus **Protoholozoa** Kott, 1969

Type species: *Protoholozoa pedunculata* Kott, 1969.

The genus has the long posterior abdominal stolon characteristic of the Holozoidae. Its short abdomen with the gonads and gastric vesicle in the gut loop, and its 2 to 4 transverse vessels suggest an affinity with *Sycozoa* and *Distaplia*. The arrangement of the zooids in the colony, opening separately rather than in double rows, is like another holozoid genus *Sigillina*. The colonies with long, soft, cylindrical stalks, also resemble those in other holozoid genera. The genus is separated from others in this family by its reduced branchial sac lacking stigmata.

As with all stalked, separately opening species, in this family (*Sigillina* spp.), as well as in other families (Pseudodistomidae and Clavelinidae: see Kott 1990a and 1992) the atrial apertures are directed toward the terminal free end of the colony while the branchial apertures face toward the base of the stalk. The advantages of this orientation of the apertures are discussed by Kott (1989b).

Six species are now described in the genus *Protoholozoa* (see Monniot and Monniot, 1991). *Protoholozoa pedunculata* Kott, 1969 from the Antarctic and *P. anthos* Monniot and Monniot, 1991 from off New Caledonia each have 2 transverse vessels, while *P. lilium* Monniot and Monniot, 1982 (see also Monniot and Monniot 1991) from the Antarctic and New Caledonia (sympatric with *P. pedunculata* and *P. anthos* respectively) has 3 transverse vessels as has *P. pigra* Monniot, 1974 from the Azores and *P. cantarella* Monniot and Monniot, 1985 off South Africa. Most of these species have internally ridged stomachs (except *P. anthos* and a specimen of *P. lilium*, both from New Caledonia). With the exception of *P. pigra*, the colonies are stalked, with translucent test and flat-topped heads. The long atrial lip of *P. anthos* also appears unique. However many of the other characters formerly used to distinguish species appear variable, and additional material (especially of sympatric species such as *P. lilium* and *P. pedunculata* from the Antarctic, and *P. anthos* and *P. lilium*: Monniot and Monniot, 1991 from New Caledonia) is needed to establish the range of intraspecific variation and the taxonomic significance of the number of transverse branchial vessels.

The absence of stigmata is a characteristic of most ascidian taxa from deep slope to abyssal waters from which previously recorded species of the present genus have been taken. The new species described below is the only one recorded from shallow waters.

The statement that *Protoholozoa* was the only genus of the family Holozoidae not known from Australian waters (Kott 1990a) is now known to of the loop, crowded between the stomach and the short, comma-shaped, flat-topped endocarp which is enclosed in the pole of the gut loop. The descending limb of the narrow primary gut loop is parallel to the ascending limb, although this could be an artefact resulting from contraction. The rectum is long. Although there is some variation in its length relative to the descending limb of the primary loop, this variation may also be the result of contraction. The anal border has 4 to 6, sometimes subdivided, deep lobes on its dorsal rim. The opposite side is undivided.

Gonads are present only in the holotype colony. They are long, narrow polycarps lying on, rather than embedded in, the body wall. Immature ova fill the ovarian tube, but male follicles are not developed in any of the zooids examined. On the left are up to 4 gonads in a row in the middle of the body wall, sometimes with an additional one dorsal to them in what may represent an incomplete second row. In one zooid a rather irregular clump of 3 polycarps is near the pole of the gut loop, just to the left of the endostyle. On the right, gonads are seldom present, being observed in only 2 of approximately 10 zooids examined. They are in one or 2 incomplete rows on the dorsal half of the body wall, and are directed toward the atrial aperture. The lining of the parietal wall of the atrial cavity is foamy with crowded vesicles about 0.05mm in diameter.

REMARKS

There are several known species of *Polyandrocarpa* with embedded zooids. Of these, *P. abjornseni* Hartmeyer and Michaelsen, 1928 and *P. simulans* Kott, 1972a (respectively from Western Australia and South Australia) have a simlar flat-topped endocarp in the gut loop, and similar numbers of branchial vessels to the present species. However, they both lack the great mass of zooid-free test that is characteristic of the present species. *Polyandrocarpa robusta* Sluiter, 1915 (which Kott, 1985, thought may be similar to *P. colligata* Sluiter, 1913) has one to 3 internal longitudinal vessels in the interspaces while the present species never has more than one; and it has a curved stomach caecum, only 14 stomach folds, a smooth anal border, and gonads in a row each side of the endostyle. *Polyandrocarpa maxima*: Van Name, 1918, 1945 from the Philippines and western (*sic*, eastern, Kott 1985) Atlantic has scattered gonads (which may be in a similar position to the gonads in the present species), and a vestigial gastric caecum. Zooids in Van Name's material, however, are crowded with only thin layers of test between them, longitudinal vessels are more numerous both on the folds and in the interspaces, and although the stomach has a similar number of folds to the present species, it is markedly shorter, and the gonads are only loosely attached to the body wall (possibly tending to be upright: see Kott 1985).

Polyandrocarpa colligata Sluiter, 1913 from the Aru Is has a bulky colony, with protuberant apertures, and it closely resembles that of the present species. Also the zooids are similar with similar slit-like openings of the neural duct, a small stomach caecum, a long stomach with apparently a similar number of folds (see Sluiter 1913, pl.VI, Fig. 14) and long, narrow polycarps. Sluiter's species is distinguished from the present one by the course of the gut, and its position across the posterior end of the zooid (features which Sluiter has emphasised do not necessarily constitute a distinction from *P. robusta* since they are readily affected by contraction). *Polyandrocarpa colligata* is also distinguished by its more numerous longitudinal branchial vessels, both in the interspaces and on the folds, its gonads in a row each side of the endostyle (as in *P. robusta*) and the endocarps on the body wall. Other characters conspicuous in the present species and not observed (but possibly overlooked) in *P. colligata* are the foamy layer of vesicles lining the parietal wall of the atrial cavity, and the lobed anal border.

Nevertheless, *P. colemani* has a limited distribution at the boundary of tropical and temperate zones of the eastern Australian coast. It is well isolated from the tropical *P. colligata*.

Subfamily BOTRYLLINAE Adams and Adams, 1858

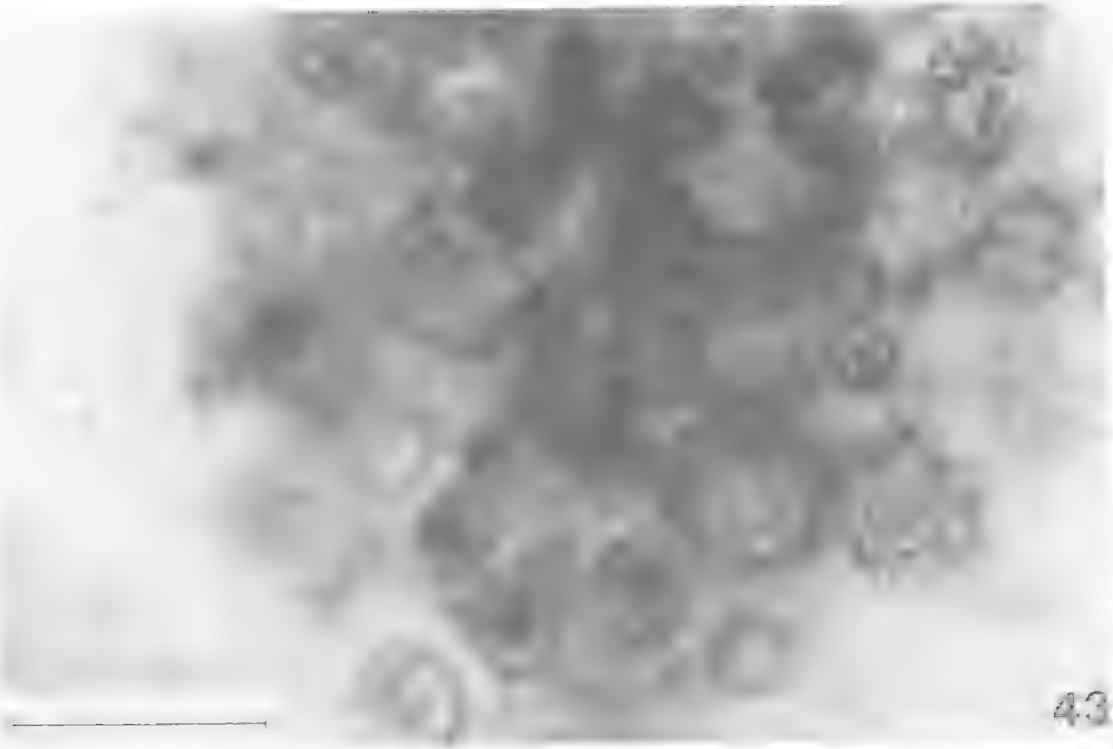
Genus **Botryllus** Gaertner, 1774

Botryllus stewartensis Brewin, 1958

(Fig. 42)

Botryllus stewartensis Brewin, 1958, p.444. Kott, 1985, p.269 and synonymy; 1990b, p.286.

FIGS. 36–42: *Polyandrocarpa colemani* n.sp. (holotype QM GH5724) — 36, 37, bodies removed from test; 38, section across colony showing blood vessels and position of zooids; 39–41, internal organs on left. *Botryllus stewartensis* (QM GH5294) — 42, system showing branchial and common cloacal apertures from above. (Scales: 36, 37, 39–41 — 2mm; 38 — 1cm; 42 — 0.5mm).



43

44

FIGS. 43, 44: *Polycitorella coronaria* (QM GH5616) — 43, spicules. 44, *Polyandrocarpa colemani* n.sp. — view of colony (photo, N. Coleman). (Scale: 43, 0.1mm).

DISTRIBUTION

NEW RECORD: Queensland (Point Lookout, QM GH5294).

RECORDED RANGE: The species is known from Albany (WA) across the southern coast of Australian to Port Kembla and Port Stephens (NSW) and Moreton Bay (Qld), as well as Stewart I. and South I. (New Zealand).

Previous records from Moreton Bay are from inside the Bay. The new records are from the ocean side of North Stradbroke I. indicating that Moreton Bay is part of the continuous range of this widespread species, rather than being a refuge at the northern limit of its range.

DESCRIPTION

The colonies are irregular sandy slabs to 5cm or more in maximum dimension, and 1cm thick. They are subdivided into lobes on the surface. About 5 zooids are in each circular system of about 2.0m diameter. Two or 3 systems are crowded into each lobe. Sand particles are embedded in the basal test, and adhere all over the surface. However there is little sand in the tough white internal test, around the zooids.

REMARKS

The present colonies do not have quite such long, narrow stalks as have been previously described. They are otherwise characteristic of this species.

Family PYURIDAE Hartmeyer, 1908
Genus **Pyura** Molina, 1782

Pyura albanyensis Michaelsen, 1927

Pyura albanysensis Michaelsen, 1927, p.193.
Pyura obesa: Kott, 1985, p.315 and synonymy.
Not *Pyura albanyensis*: Monniot, 1989, p.492. Monniot and Monniot, 1991, p.411.

DISTRIBUTION

RECORDED RANGE: The species is known from tropical and temperate waters around the Australian coast, the Arafura Sea, and the Palau Is.

REMARKS

Monniot (1989) distinguishes *Pyura albanyensis* from *P. curvigona* (> *P. vittata*: Monniot, 1989, 1991) only by the presence of the swollen rectum in the latter species. He remarks that 'tous les autres caractères sont peu importants et les différences observées entre les espèces pourraient correspondre à une variabilité'. However, there are significant differences in a number of conspicuous and stable characters between these two species. The principal difference is the form of the siphonal spines (Kott 1985). In *P. curvigona* these have a flat scale halfway along them, which is not present in *P. albanyensis*. In *P. albanyensis* the needle-like spines are of two sizes. Further differences are the short dorsal lamina, the long, deeply curved U-shaped gut loop and the distinct longitudinal stripes down the outside of the siphons in *P. albanyensis*. The species are similar only in the crowded endocarps on gut loop and gonads, in the almost pinnate form of the ovarian tube, each short branch with a cap of male follicles, and in the distribution of the siphonal spines, which continue over the outer surface from inside the siphon.

Monniot (1989) assigned 2 specimens from New Caledonia, one 5cm and one 1.2cm long, to *P. albanyensis*. In neither were the small spines between the larger ones reported, nor can they be detected in Monniot's scanning electron micrographs. It is possible that these have been obscured by the larger spines, although this does not seem to be the case. The smaller spines, like the larger ones, are on the surface of the test both inside and outside the siphons, and should be apparent if they are present.

Further, although the gut loop and gonads have crowded endocarps on them, and the long ovarian tubes have pinnate branches, each with a cap of terminal testis follicles, the New Caledonian specimens differ from *P. albanyensis* in having a long dorsal lamina and a narrow but gently curved gut loop.

The form of the siphonal armature needs to be established by light microscope examination of cleared preparations in order to accurately assign the New Caledonian specimens.

Monniot(1989) drew attention to the fact that the name Hartmeyer applied to the holotype of this species is preoccupied by the Antartic *Pyura obesa* Sluiter, 1912.

Pyura curvigona Tokioka, 1950

Pyura curvigona Tokioka, 1950, p.147. Kott 1985, p.296 and synonymy.
?*Pyura vittata*: Monniot, 1989, p.490.
?*Pyura uatio* Monniot, 1991b, p.33.

DISTRIBUTION

RECORDED RANGE: The species is known from Shark Bay (Western Australia), Heron and Lizard I. (Queensland), the Palau Is, Indonesia (see Kott 1985), and possibly from New Caledonia.

REMARKS

Monniot (1989) has synonymised this species with the Atlantic Ocean *Pyura vittata*. He appears to have overlooked the opalescent scale which is such a feature of the siphonal armature of the present species (see Kott 1985, Figs 5k, 145a,b). Since the New Caledonian specimens assigned to *P. vittata* have the enlarged rectum, pinnate gonads, and endocarps of the present species it is possible that they are conspecific. Examination of cleared preparations of siphonal armature by light, rather than by scanning electron, microscopy, would, if they are present, display the scales of the siphonal spines which are just under the surface of the test.

The green liver and pink body wall of this species is found also in *P. uatio* from New Caledonia which, however, lacks an expanded rectum, and may be a different species.

Pyura rapaformis Kott, 1990
(Figs 45, 46)

Pyura rapaformis Kott, 1990b, p.287.

DISTRIBUTION

NEW RECORD: South Australia (Beachport Jetty piles, SAM E2510).

RECORDED RANGE: The species, previously recorded from the upper surface of a reef at Cottesloe, probably has a continuous range between Cockburn Sound and St Vincent Gulf.

DESCRIPTION

The present specimens are as previously described, with both apertures on the upper, more or less flattened, surface of a turnip-shaped body. The surface test has irregular extensions and papillae to which sand adheres, and sand also is embedded in the test. The body has a posterior stolon projecting down into the test. The siphonal spines are about 0.08mm long, with a long narrow opening and 4 rounded knobs at the posterior end of the shaft. Branchial tentacles are feathery, with long primary branches. The branchial sac has 6 wide, overlapping folds on each side with 7 to 18 internal longitudinal vessels on the folds and up to 3 between. Leafy, irregular endocarps are on the gut and gonads.

REMARKS

Externally the species resembles individuals of *Pyura isobella* Kott, 1985 from Ulladulla (NSW) and internally it has similar endocarps and gut loop and gonads. The siphonal spines lack the posterior expansion, and the small opening of spines of *P. isobella*, and more closely resemble the spines of *P. tasmanensis* Kott, 1985 (as observed by Kott 1990b).

Genus **Herdmania** Lahille, 1888

Herdmania momus (Savigny, 1816)

Cynthia momus Savigny, 1816, p.143.
Herdmania momus: Kott, 1985, p.338.
Pyura momus: Monniot, 1989, p.498.

DISTRIBUTION

RECORDED RANGE: The species is pantropical, extending into temperate waters of southern Africa and southern Australia.

REMARKS

Monniot (1989) believes the genus *Herdmania* to be a junior synonym of *Pyura*. In addition to the characteristic long barbed spines, *Herdmania* has a continuous ovarian tube surrounded by male follicles, rather than being broken up into separate gonad blocks as in *Pyura*; and the liver lobules are embedded in the body wall, rather than lying free in the atrial cavity as in *Pyura* (see Kott 1985).

Genus **Microcosmus** Heller, 1877

Microcosmus tuberculatus Kott, 1985

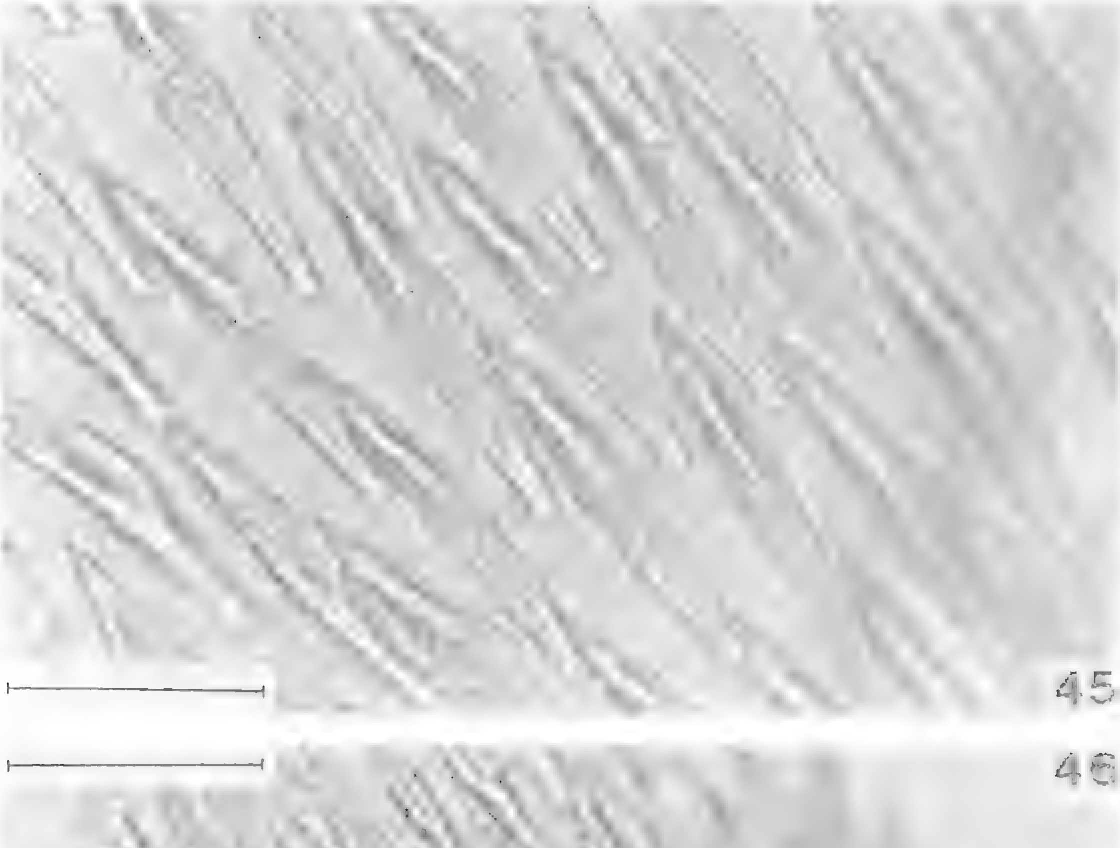
Microcosmus tuberculatus Kott, 1985, p.361. ? Monniot, 1991b, p.31.

DISTRIBUTION

RECORDED RANGE: The species is known for certain only from its type locality in the Swain Reefs.

REMARKS

The species is distinguished from *M. exasperatus* by its large conspicuous conical spines around and lining the apertures (see Kott 1985, Fig. 179b) and the deeply incised anal border. The specimen from New Caledonia (Monniot 1991) has neither of these features. The thick endocarp-like layer of the body wall Monniot observed over the gonads and gut occurs variably in most *Microcosmus* species, including *M. exasperatus*, to which the New Caledonian specimens very likely belong.



FIGS. 45, 46: *Pyura rapaformis* (SAM E2510) — siphonal spines (Scales: 45, 0.05mm; 46, 0.1mm).

Family HEXACROBYLIDAE Seeliger, 1906

The family was reviewed by Kott (1989a), and later, by Monniot and Monniot (1990).

The family is characterised by its large buccal cavity, surrounded by 6, usually large, branched branchial arms, a large kidney, and a reduced perforated pharynx, limited to a short band at the proximal end of the gut. Ciliated stigmata are small and rounded. The gut is well developed with a wide, and often long oesophagus, and there is evidence of adaptation for a carnivorous habit (see Kott 1989a). Although, successively, a new pleurogonid suborder, Aspiraculata Seeliger, 1906, and a new tunicate class Sorberacea Monniot, Monniot and Gaill, 1975 have been proposed for the family, there appears to be no justification for either of these higher taxa (see Kott 1989a).

The Hexacrobylidae have adaptations for deep water habitats, but their morphology is homologous with that of Molgulidae, with which they appear to have closer affinities than the latter family has with other extant ascidian taxa, even within the Pleurogona (see Kott 1989a).

The view (Monniot and Monniot 1990) that the family name Hexacrobylidae should be abandoned in favour of Oligotrematidae (sic. Oligotremidae Monniot and Monniot, 1990) is incorrect (ICZN Article 40). Further, the type genus is *Hexacrobylus* Sluiter, 1905a, a junior objective synonym of *Oligotrema* Bourne, 1903.

Although Kott (1985) thought the family was not represented in Australian waters, *Asajirus indicus* Oka, 1913 and *Oligotrema psammites* Bourne, 1903 have since been recorded (Kott 1989a).

Genus **Asajirus** Kott, 1989a

Type species: *Hexacrobylus indicus* Oka, 1913.

Kott (1989a) examined and redescribed the type specimen (ZMA TU564) of *Hexacrobylus psammatodes* Sluiter, 1905a, and found it to be a species of the genus *Oligotrema* Bourne 1903, possibly conspecific with its type species *O. psammites* Bourne, 1903 from New Britain. Thus was corrected a belief that *Hexacrobylus psammatodes* and *H. indicus* Oka, 1913 were congeneric, and *H. indicus* Oka was found to be a member of an undescribed genus. *Hexacrobylus indicus* Oka, 1913 was therefore designated type species of a new genus *Asajirus* Kott, 1989a (of which *Hexadactylus* Monniot and Monniot, 1990, with the same type species as *Asajirus*, is a junior synonym).

Monniot and Monniot (1990) recognise 12 species in the genus *Asajirus*, distinguished from one another primarily by differences in the length of the vas deferens and in the number and length of testis lobes. It may be difficult to sustain this number of species, in view of the probability that there is some intraspecific variation in taxa which, in many cases, have vast geographic ranges.

The differences are less compelling than the similarities between most of the species Monniot and Monniot (1990) have documented, and many are sympatric in at least part of their range, while some are over their whole range. For instance, *A. longitestis* (Monniot and Monniot, 1990), *A. ovirarus* (Monniot and Monniot, 1990), *A. hemisphericus* (Monniot and Monniot, 1990), *A. gulosus* (Monniot and Monniot, 1984b) and *A. indicus* (Oka, 1913) are all recorded from the vicinity of New Caledonia, *Asajirus millari* (Monniot and Monniot, 1991) also is from the West Pacific (the Bali Sea); *A. seeligeri* (Monniot and Monniot, 1990) and *A. gulosus* are from the Comoro Is in the Indian Ocean and some records of *A. indicus* are also from the Indian Ocean; *A. ledanoisi* and *A. eunuchus* are from wide ranges in the Atlantic, and *A. arcticus* is from the Norwegian Sea; while *A. antarcticus* is recorded from around the Southern Ocean and *A. dichotomus* is from the southeastern Atlantic (the Cape Basin).

It is not intended to review this genus in the present work, rather attention is drawn to some of the problems of species definition in this family. These will not be resolved if descriptions do not take account of the homologies of organs, of similarities in morphology as well as morphological differences, of probable artefacts resulting from contraction and distortion, and of differences that most likely arise from growth and maturity.

Asajirus indicus (Oka, 1913)

Hexacrobylus indicus Oka, 1913, p.6. Millar, 1959, p.203; 1969, p.97; 1970, p.146; 1975, p.332. Monniot and Monniot, 1968, p.32; 1970, p.334; 1979, p.564; 1984b, pp.198 (figs 1,2) 203; 1987, p.41. Monniot, F., 1971, p.458.

Asajirus indicus: Kott, 1989a, p.521.

Hexadactylus indicus: Monniot and Monniot, 1990, p.271.

Hexacrobylus arcticus Hartmeyer, 1923, p.133. Monniot and Monniot, 1984b, p.203 (specimens from *Norbi* cruise).
Hexadactylus arcticus: Monniot and Monniot, 1990, p.261
Hexacrobylus eunuchus Monniot and Monniot, 1976, p.658.
Hexadactylus eunuchus: Monniot and Monniot, 1990, p.265.
Hexacrobylus sp. Monniot and Monniot, 1982, p.128 (part, Eltanin cruise 5, station 258).
Oligotrema psammites: Kott, 1969, p.168.
Hexadactylus antarcticus Monniot and Monniot, 1990, p.259.
Hexadactylus longitestis Monniot and Monniot, 1990, p.275.
Hexadactylus millari Monniot and Moniot, 1991, p.277.
Hexadactylus seeligeri Monniot and Monniot, 1990, p.281

DISTRIBUTION

NEW RECORDS: Coral Sea (12° 05' S 146° 24'E, *Cidaris* 3 site 6.1, 16.2.92, 3319–3105m, QM G300891; 13° 29'S 147° 13'E *Cidaris* 2 Site 15.1, 5.9.88, 2542–2457, QM G300892.

RECORDED RANGE: The recorded range for *A. indicus* and its probable synonyms is: *A. longitestis* — New Caledonian (both sides of the Norfolk Ridge); *A. indicus* — the Indian Ocean, New Caledonia, off eastern Australia from 151°27' to 148°38'E and 12° to 42°S from the Coral Sea to eastern Tasmania; *A. seeligeri* — the Indian Ocean and Comoro Is.; *A. millari* — the Bali Sea (western Pacific); *A. eunuchus* — southwestern and northern Atlantic; *A. arcticus* — northeastern Atlantic; *A. antarcticus* — South Indian and Pacific Oceans.

The species is found at depths from 1000 to 5000m. The record for the specimen AM Y2125 from off the New South Wales coast, is from 151°27'E, not 51°27'E as reported by Kott (1989a).

DESCRIPTION

The newly recorded specimens are rounded posteriorly, 1.2 cm long, but contracted anteriorly, causing the fine hairlike projections mixed with foraminifers and other paricles to appear more crowded than they are posteriorly. Internally the 2 ventral muscle bands are short and broad, the rectum is crowded with hard particles including foraminifers, polychaetes, ostracods, cladocerans, isopods, gastropods and what appears to be particles of ophiurid (including spines). The remainder of the gut (the long oesophagus and stomach) are empty.

REMARKS

Specimens from the northern Atlantic (*A. ledanoisi*) and from the Cape Basin, south-eastern Atlantic (*A. dichotomus*) with long sperm ducts are not included in the above synonymy of *A. indicus*, although *A. eunuchus* (Monniot and Monniot, 1976) from the south-western and northern Atlantic, *A. arcticus* (Hartmeyer, 1923) from the Norwegian Sea, *A. antarcticus* (Monniot and Monniot, 1982) from the southern (polar) Indian and Pacific Oceans and *A. millari* from the Bali Sea have short male ducts as in *A. indicus*, and are here included in its synonymy, as is *A. seeligeri* (with both short on long male follicles) from the Indian Ocean, and *A. longitestis* (with long male follicles) from New Caledonia. *Asajirus indicus* (Oka, 1913) as well as being taken from off the eastern Australian coast, is from the Indian Ocean and New Caledonia.

Also from New Caledonia, and, for the present, excluded from the synonymy of *A. indicus*, are *Asajirus hemisphericus* and *A. ovirarus*, with more or less entire testis; and *A. gulosus* with a long vas deferens like *A. ledanoisi* and *A. dichotomus*.

Genus **Oligotrema** Bourne, 1903

Type species: *Oligotrema psammites* Bourne, 1903.

Although not designated a neotype, Monniot and Monniot (1990) redescribed the species from a specimen taken from near the type locality.

Monniot and Monniot's definition of the genus omits certain significant characteristics described by Bourne, which also are present in the type specimen of *Hexacrobylus psammatodes* Sluiter, 1905a (see Kott 1989a). Monniot and Monniot (1990) refer to the widely separated apertures but not to the posterior position and orientation of the atrial aperture; they refer to muscles extending the length of the body wall, but fail to indicate that these are circular muscles, sometimes interrupted; and that longitudinal muscles are very limited; nor do they refer to the flagellated epithelial covering of the branchial tentacles described by Bourne (see also Kott 1989a).

Monniot and Monniot (1990) indicate, as Kott (1989a) had suggested, that the branchial stigmata are circular perforations, rather than the rectangular stigmata described by Bourne. This removes the principal restraint to the synonymy of *H. psammatodes* Sluiter, 1905a with the present species. Other characters, viz. the branchial tentacles, the large endocarps and the large atrial cavity, are as described by Bourne, and by Kott (1989a) for the type specimen of *H. psammatodes* Sluiter, 1905a (ZMA TU564).

There is no additional evidence regarding the proposed synonymy of *Gasterascidia*, *Sorbera* with *Oligotrema* (see Kott 1989a). Nor is there any clarification regarding the apparent degeneration of the rectum in *Gasterascidia lyra*, which, if present, appears to be non-functional (see Monniot and Monniot, 1990 Fig. 5B).

Oligotrema psammites Bourne, 1903

Oligotrema psammites Bourne, 1903, p.233. Monniot and Monniot, 1990, p.253.
Hexacrobylus psammatodes Sluiter, 1905a, p.135; 1905b, p.135.
Hexacrobylidae juv., intermediate between *Sorbera* and *Gasterascidia*: Monniot and Monniot, 1984b, p.212; 1990, p.257.
?*Sorbera digonas* Monniot and Monniot, 1984b, p.209.
Oligotrema psammatodes: Kott, 1989a, p.529. Monniot and Monniot, 1990, p.258.

DISTRIBUTION

RECORDED RANGE: The species is recorded from New Britain (Bourne 1903; Monniot and Monniot 1990), Indonesia (ZMA TU564, Siboga, Station 211, Banda Sea, Sluiter 1905a), west of New Caledonia (Monniot and Monniot 1990); New South Wales coast (Kott 1989a) and the south-east Atlantic (the Cape Basin, Monniot and Monniot 1984b).

Sorbera digonas is recorded from the tropical Indian Ocean.

REMARKS

The specimens all have the shallow ventral groove in the pharynx; vertically flattened branchial tentacles with one or 2 short, pointed, projections anteriorly, an otolith-like black granule in the neural gland, and the parietal wall of the atrial cavity raised into long endocarps on each side of the oesophagus. These endocarps sometimes cover part of the gonads. In the thick pharyngeal wall the interconnected chambers (that the Monniots in 1984 and 1990 refer to as branching tubules) eventually open to the atrial cavity by small, rounded ciliated stigmata which vary in number according to the size of the specimen. The ligament attaching the oesophagus to the body wall (Kott 1989a) appears to be the ventral septum dividing the atrial cavity into two sections (Monniot and Monniot 1990). In fact, the atrial invagination is always from the dorsal surface and the cavity always is continuous over the dorsum. It never penetrates ventral to the pharynx, past the ventral sinus. The ligament or septum is merely the ventral body wall where it is not interrupted by the atrium.

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