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BY PATRICIA KOTT

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Introduction

This large collection of ascidians, mainly from St. Vincent Gulf, South Australia, was made by Mr. S. A. Shepherd of the Department of Fisheries and Fauna Conservation, South Australia. It is a valuable and representative collection and demonstrates the value of SCUBA collections of this benthic group from otherwise inaccessible localities. Colour notes made by the collector provide most useful data for comparison with the preserved specimens in which colours are generally lost or change completely. The large number of individuals of most species that are available in the collection has demonstrated a wide variability in certain characters and some synonymy has been established.

Information on the environmental conditions operating in various locations, also supplied by the collector, has been related to the morphology of the species present to contribute to an assessment of selective mechanisms affecting the ascidians. Full station lists of species are also given to facilitate consideration of the faunal associations and their ecological relationships.

The specimens are deposited in the South Australian Museum.

The following species have previously been recorded from South Australia (Kott 1952, 1957a, 1962, 1963) but were not in the present collection.

Polyclinum neptunium
Polyclinum marsupiale
Aplidium flavolineatum
Aplidium australiensis
Lissoclinum ostrearium
Didemnum turritum
Didemnum augusti
Didemnum pseudodiplosoma
Tridemnum natalense
Tridemnum cerebriforme
Leptoclinides imperfectus
Symplegma viride
Styela lobata
Asterocarpa cerea
Pyura stolonifera

Zoogeography

The fauna is typically that of the Flindersian marine region, together with *Distaplia viridis* which is also recorded from Port Phillip Bay, *Ascidia aclara* which has been taken from similar sheltered locations on the Victorian, New South Wales, and Queensland coasts, and *Aplidium colelloides*, previously recorded from South Africa. The new species, *Pyura scoresbiensis* and *Ctenicella antipoda*, may be endemic.

The records of *A. colelloides* from off South Africa and South Australia suggest a circumpolar distribution, as demonstrated for many ascidian species (Kott 1971a). A wide dispersal of larvae, however, does not provide a satisfactory explanation for this pattern of dis-

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tribution since, for successful sexual reproduction, minimal population densities of adults are required. The existence of so many circumpolar species in the extant fauna may be the result of a slow rate of evolution and the persistence of relict forms in certain areas.

Habit of the Ascidian Fauna

In the present collection, ascidians have been taken from a wide variety of locations, especially in St. Vincent Gulf. The terminology qualifying the conditions encountered is partly that described by Shepherd & Womersley (1970) and Womersley & Edmonds (1958), as follows:

(1) *"Rough Coast Subformation"* (R.C.S.) refers to coasts exposed to the southern ocean swell (wave periods 10-12 secs.). Water movement resulting from this swell is strong and pulsatile on the surface but decays with depth so that surge is moderate at 15 m and slight at 25 m depth.

(2) *"Sheltered Coast Subformation"* (S.C.S.) (see Womersley & Edmonds 1958) refers to sheltered coasts where there is no swell and the coast is subject to waves of short period (up to 5 seconds) which decay rapidly with depth. Much of the coast-line in both Spencer Gulf and St. Vincent Gulf is of this type.

(3) *"Offshore Benthic" locations* are those away from the shore where water movement results from tidal current rather than wave action. In St. Vincent Gulf tidal currents are generally about 1 m/sec., except over Tapley Shoal where they are 1–2 m/sec.

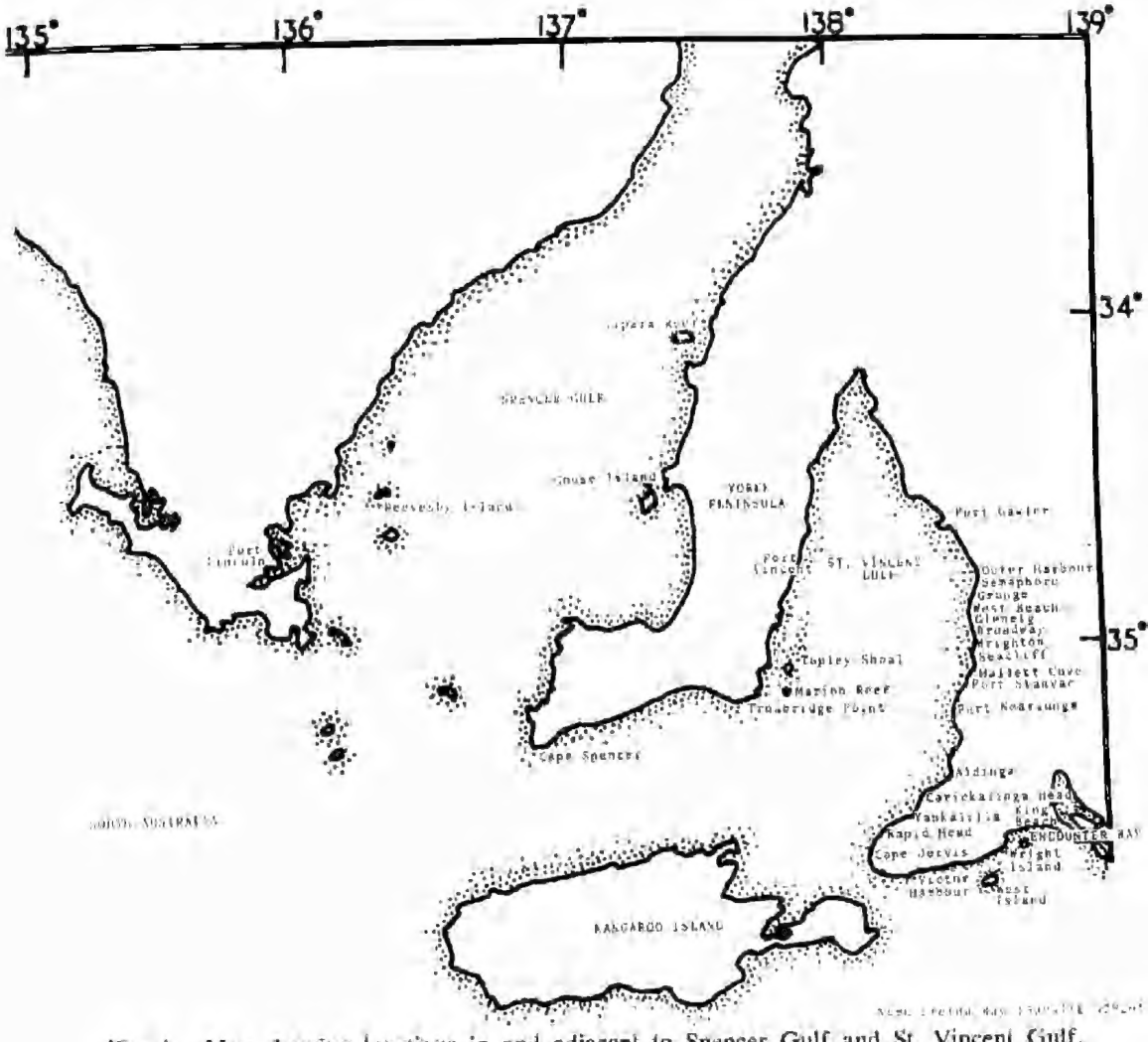


Fig. 1. Map showing locations in and adjacent to Spencer Gulf and St. Vincent Gulf.

These different locations provide environmental conditions favouring an ascidian fauna of very varied habit. For each species its shape, or size, or mode of fixation, or growth characteristics appear to operate as selective mechanisms contributing to its success in the environmental conditions operating:

(1) In Rough Coast Subformations, at depths less than 15 m where surge is moderate to strong (Wright I., West I.), the dominant ascidian fauna is adapted to the conditions by virtue of their colonial form, their viviparous larvae, their usually well-developed cloacal systems, and either

(a) an encrusting habit providing a large surface area for fixation (*Atapozoa fantasiana, Cystodytes dellechiajei, Didemnum candidum, Leptoclinides rufus, Lissoclinium* sp., *Oculinaria australis, Botrylloides nigrum*); or

(b) small stalks or sessile habit and cylindrical body form enabling them to occupy sheltered crevices (e.g. on *Ecklonia* holdfasts, under ledges, etc.). The stalks of these species are thick, and the colonies do not move freely with the currents (*Podoclavella cylindrica, Pseudodistoma cereum, Ritterella herdmania, Synoicium papilliferum*).

(2) In Rough Coast Subformations, at 15 m and greater depths (Wright I., West I.), the strong surge at the surface is reduced to moderate to slight water movement. Species with pliable stalks form a dominant component of the ascidian fauna and are best able to exploit the changing direction of the water movements by moving with the water so that their branchial openings are presented to the oncoming current which thus reinforces the ciliary feeding mechanism. Only some of these species have viviparous larvae (*Botrylloides magnicoecus, B. leachi, Polycarpa pedunculata, P. clavata, Pyura australis*).

(3) In Rough Coast Subformations, at all depths, are large species fixed by a relatively small part of their surface. At shallow depths, they appear to be more often on vertical rock faces or in caves, where firm fixation can be achieved, while at greater depths they are on the bottom (*Polycitor giganteum, Styela pedata, Cnemidocarpa etheridgii, Herdmania momus*).

(4) In Offshore Benthic locations with moderate currents and sandy bottoms and some sediment, there are, again, stalked species that are raised above the substrate and sometimes, by virtue of a pliable stalk, move with the current so that the branchial aperture is presented to the oncoming flow (*Aplidium colelloides, Polycarpa clavata, Pyura scoresbiensis, P. spinifera, P. australis*).

(5) In Offshore Benthic locations with sluggish to slow currents, there are:

(a) Large species lying on or partly embedded in, or fixed to, rocky bottoms or to solid objects in sandy, often mobile, bottoms. These individuals and colonies are oriented to take maximum advantage of the prevailing current flow by differential growth of the colony or of the test, especially in the region of the siphons (*Sycozoa cerebriformis, Ascidia* spp., *Phallusia depressiuscula, Ctenicella antipoda, Herdmania momus*). *Sycozoa cerebriformis*, which is abundant on the bottom, especially in upper St. Vincent Gulf, has its "fans oriented to receive maximum current" (S. Shepherd, pers. comm.). Its stalk is thick, short, and not pliable, and the species adapts to the direction of prevailing current flow by growth of the colony. In large sessile and partly embedded species, the orientation of the siphons in relation to the current is effected by their differential growth (e.g. *Phallusia depressiuscula*). *Ascidia aclara*, which is recorded only from sandy substrates in which it is probably partly embedded, is especially interesting in the presence of cylindrical tubes round the apertures creating a constant micro-environment.

(b) Species with a leathery test sometimes produced into roots, in a sometimes mobile sandy bottom or attached to the fibrous roots of the sea-grass *Posidonia australis*. These species often form aggregates of individuals. (*Polycarpa pedunculata, Pyura irregularis, P. vittata, Halocynthia hispida, Microcosmus* spp.).

(6) In Sheltered Coast Subformations with slight wave action at the surface and no sediment, collections have been made from 3 to 25 m. The species present represent all the groups previously distinguished:

(a) Stalked species common in Offshore Benthic locations and in Rough Coast Subformations where there is moderate to slight surge.

(b) Leathery aggregated specimens common at Offshore Benthic locations where the currents are slight to sluggish.

(c) Aplousobranch species which, in more exposed conditions, are present in sheltered niches or crevices or have an encrusting habit (*Podoclavella cylindrica, Distaplia viridis, Leptoclinides rufus, Polysyncraton orbiculum, Echinoclinum verrilli, Rhizella herdmania, Synoicum papilliferum*).

(d) The large stolidobranch and phlebobranch species which exploit clean (vertical) rocky substrates or protected locations at Rough Coast Subformations and which are also present in Offshore Benthic locations where the current is slight. These large individuals are more often found at shallower depths and in less protected niches in these Sheltered Coast Subformations than in Rough Coast Subformations (*Ascidia* spp., *Rhodosoma turcicum, Corella eumyota, Herdmania momus*).

The presence of some of the larger phlebobranch and stolidobranch individuals at shallower depths in certain areas where surge is greater, but where clean stony substrate is available for settlement, suggests that it is the strength of the current flow in relation to the type of fixation which can be achieved that is the critical factor in site selection for these species rather than depth or light conditions. On the other hand, aplousobranch and stolidobranch encrusting species, and others whose shape enables them to exploit narrow crevices, caves and ledges, appear to be affected more by light and their depth range is more limited. These species occur at shallow depths both in turbulent locations and in Sheltered Coast Subformations, and are not often taken in Offshore Benthic locations. They all have viviparous larvae and light sensitive organs which influence their settlement, and efficient adhesive apparatus which is needed where surge and turbulence is great. They are also common in areas of gentle water movement, together with the large phlebobranch species not usually found at shallow depths in more turbulent areas.

Seventy-six species are now recorded from St. Vincent Gulf and Spencer Gulf. This indicates a great diversity of ascidian species and suggests that conditions may be especially favourable for them. Records are more numerous, however, from Gulf regions than from the "open" coast, probably because more collecting has been done in these locations. It is not possible, therefore, with the information available, to compare the faunal diversity on the open coast with that in Spencer Gulf and St. Vincent Gulf.

Suborder APLOUSOBRANCHIA

Family CLAVELINIDAE

Subfamily CLAVELININAE

Clavelina baudinensis Kott, 1957a: 87, Millar, 1966: 363.

New Records: Carickalinga Head, Rapid Head. *Previous Records*: W. Aust. (Rottnest Island)—Kott 1957a. Vic. (Balnarring Beach, Laverton Bay, Williamstown)—Kott 1957a; Millar 1966. Recorded from the intertidal to 6 m.

Description: Two or more flat-topped lobes of variable size, joined by a common base that is equal in height to that of the lobes. Height of the colony to 4 cm, maximum diameter of a lobe 0.6 cm. The test is firm, gelatinous and transparent. Zooids are blue. Thorax rounded, 1.5 mm long; abdomen 2.5 mm long, with a well-developed posterior abdominal stolon. Zooids are parallel to the height of the colony. The branchial aperture, from the antero-ventral corner of the thorax, is directed to the side. The atrial aperture from the antero-dorsal corner of the thorax is directed vertically. There are 17 longitudinal muscles on each side of the body radiating from the apertures, 6 ventral to the branchial siphon, 7 extending along it, and 4 extending along the atrial siphon. Dark pigment spots are present, anterior to, posterior to, and on either side of the base of the atrial siphon. There are about 16 rows of about 30 stigmata in the branchial sac. Nine obscure indentations are present around the margin of the branchial siphon, although the border of the atrial siphon is smooth and entire. The transverse vessels of the branchial sac expand into triangular languets as they cross the dorsal line. The oesophagus is long, the stomach two-thirds of the distance down the abdomen is rectangular with 4 folds. Each zooid projects slightly above the flat top of each colony. Gonads are present in the gut loop.

Remarks: *Clavelina arafurensis* Tokioka, from the Arafura Sea, has similar colonies with zooids opening on the upper surface of the lobes, but is distinguished by the presence of distinct transverse muscles. *Oxycorynia fascicularis* Tokioka, 1952, also has similar zooids but there is a smooth stomach and zooids open all around a stalked head, thus distinguishing it from the present species. Two different types of larvae have been described from specimens

previously ascribed to this species, and it has been suggested (Kott 1969) that some colonies may in fact have been colonies of species belonging to the genus *Pycnoclavella*, distinguished from *Clavelina* by the fertilisation of eggs at the base of the oviduct. Those colonies with large numbers of eggs at the same stage of development in the peri-branchial cavity and apparently fertilised there, belong to the genus *Clavelina* as described. No other distinguishing character has been identified and as neither developing eggs nor larvae were present in these colonies, this point has not been clarified.

In St. Vincent Gulf the species is taken from sheltered locations where surge and wave action is slight. The record from Rottnest I. (Kott 1957a) is from the intertidal area where it could sometimes be subjected to surge and wave action typical of the Rough Coast Subformation. In such localities it would be found in sheltered caves and crevices as it forms large soft colonies and is unlikely to occur in areas where it is exposed to sand or wave action. The red colour of the preserved specimen from Rapid Head is probably the result of contamination from a sponge on which the specimen was growing, as all other colonies are bluish in preservative.

Podoclavella cylindrica (Quoy & Gaimard). Kott, 1957a: 91. Millar, 1960: 64; 1963: 716; 1966: 364.

Polyclinum cylindrica Quoy & Gaimard, 1834: 618.

Clavelina cylindrica. Michaelsen, 1930: 475 and synonymy.

New Records: West Beach, Hallett Cove, Port Noarlunga, Aldinga, West I. (Oedipus Point), Wright I. *Previous Records*: W. Aust. (Albany to Rottnest I.)—Michaelsen 1930; Kott 1957a; Millar 1963. Vic. (Westernport, Port Phillip Bay, Bass Strait)—Quoy & Gaimard 1834; Millar 1960, 1963, 1966; MacDonald 1858.

FIG. 2

Description: Zooids separate, joined by common basal test into which posterior abdominal stolons extend. Occasionally zooids branch off around a central common axis (Wright I.). In immature colonies from Aldinga reef "drop off" there is a central vascular stolon extending up into each lobe and very numerous enlarged terminal ampullae surrounding the central vessel along its length. The abdomen may be equal to or less than the length of the thorax. When the thorax is contracted along the dorsal line, the oesophagus originates from half way along the length of the thorax.

There is a dorsal pigment spot at the base of the atrial siphon, and some pigment on either side of the dorsal line at the base of the branchial siphon. The atrial aperture is terminal with a funnel-shaped siphon. The branchial aperture extends laterally from the antero-ventral corner of the thorax. About 20 muscles cross the thorax obliquely from the ventral to the postero-dorsal corner of the thorax and continue along both sides of the abdomen. When the dorsal line of the zooids is strongly contracted, the muscles on the thorax lie almost at right angles to the rows of stigmata. The oesphagus is long and there is a prestomach swelling halfway along its length. The stomach is large and square. Clumps of 18 or more embryos are present in brood pouches formed at the postero-dorsal corner of the thorax. Gonads are present in the gut loop.

Larvae: About 1.2 mm long. Anteriorly there is a flat frontal plate bearing three adhesive papillae with accessory cup, arranged in a triangle. The larval thorax is characteristically deep.

Remarks: This species is especially common. The relatively short abdomen, the prestomach, the form of the colonies, and the presence of pigment spots on the anterior part of the thorax are characteristic.

The colonies flourish only in protected caves or crevices and generally from vertical faces in areas where there is no silt or sediment. In the Rough Coast Subformation, the species is found at depths of 10–22 m, and in the Sheltered Coast Subformation at 3–10 m deep.

Podoclavella moluccensis Sluiter, 1904: 5; Hastings, 1931: 82 and synonymy. Kott, 1963: 90.

New Record: Tipara Reef (Spencer Gulf).

Previous Records: W. Aust. (Cape Boileau, Garden Island, Rottnest I.)—Sluiter 1895; Kott 1963. S. Aust. (Port Lincoln)—Kott 1963. Qld. (Great Barrier Reef)—Hastings 1931.

FIG. 3

Description: The colonies form extensive mats consisting of a basal membrane supporting a dense array of upright lobes, each consisting of a single zooid enclosed in a soft transparent test. Occasionally the basal half of adjacent lobes is fused. The zooids are pale to dark blue and there is no special accumulation into specific pigment spots around the apertures. The zooids are closely adherent to the test and extend the full length of the free lobe for

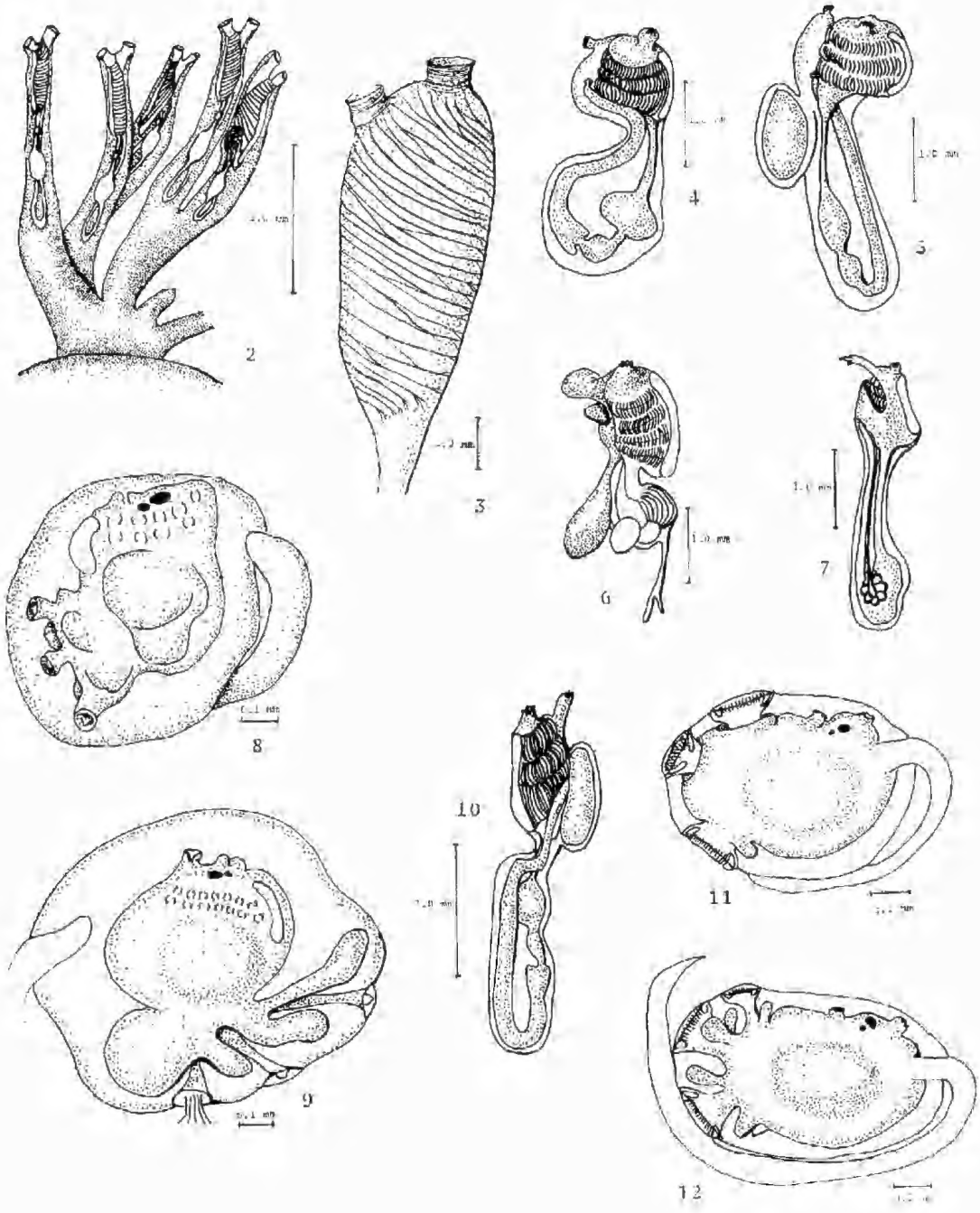


Fig. 2. *Podoclavella cylindrica*, (Hallett Cove, 8 m). Colony.
Fig. 3. *Podoclavella moluccensis*. (Tipara Reef). Thorax showing muscles.
Figs. 4, 5. *Atapozoa fantasiana*. (Wright I.). Fig. 4.—Contracted zooid. Fig. 5.—Zooid with brood pouch and embryo.
Figs. 6, 7. *Distaplia viridis*. (Reef off Hallett Cove, 8 m). Fig. 6.—Zooid with mature ♀ gonads and brood pouch. Fig. 7.—Zooid with mature ♂ gonads.
Figs. 8, 9. *Polycitor giganteum*. (Port Noarlunga). Fig. 8.—Immature larva. Fig. 9.—Mature larva.
Figs. 10–12. *Eudistoma renieri*. (Wright I., 10 m). Fig. 10.—Zooid, Fig. 11.—Immature larva. Fig. 12.—Mature larva.

their whole length. The atrial aperture is terminal and the branchial aperture from the antero-ventral part of the thorax is inclined at a slight angle to it but is not recurved. There are about 30 transverse muscles extending from the ventral to the dorsal border of the thorax and anastomosing with one another both ventrally and dorsally. About 6 of the most anterior transverse muscles extend from the short siphons to cross the dorsal line. The most posterior transverse muscles terminate around the region of the oesophagus. No muscles were detected on the abdomen. There are 17 rows of about 50 stigmata. There is a small prestomach enlargement half way down the oesophagus. The stomach is smooth walled, large and rounded half way down the abdomen.

Remarks: The specimens are easily confused with *Podoclavella cylindrica*, from which *P. moluccensis* is distinguished by the extensive basal membrane, the absence of a recurved branchial siphon, the very large number of transverse muscles which do not extend along the abdomen, by the close adherence of the body wall to the test, and by the absence of distinct pigment spots around the apertures.

Shepherd (pers. comm.) states that this species at Tipara Reef is seasonal, appearing in early winter and dying off during early summer.

Subfamily HOLOZOINAE

Atapozoa fantasiana (Kott)

Eudistoma fantasiana Kott, 1957a: 76; 1967: 187.

New Record: Wright I. *Previous Records*: S. Aust. (Reevesby I.)—Kott 1957a.

FIGS. 4, 5

Description: Flat irregular investing colonies about 0.5 cm thick. Test soft, jelly like, semi-transparent. Both apertures of zooids open separately to the exterior. The postero-dorsal aspect of the peribranchial cavity is expanded into a brood pouch with two embryos at different stages of development. Black pigment is scattered throughout the test, but the colony is a light purplish colour. Zooids up to 3 mm in length. Zooids have 16 to 20 fine longitudinal muscle bands forming a wide open meshwork with the transverse bands on the thorax. There are 3 rows of up to 25 elongate stigmata; the oesophagus is long, the stomach smooth and oval, and there is a rounded posterior stomach. The apertures are small and the 6 lobes of the margins indistinct.

Larvae: Large, as previously described, with characteristically elongate areas of adhesive cells.

Remarks: Even in the absence of the completely distinctive larvae and brood pouches, the species is characterised by the closely set apertures and short atrial siphon, by the open meshwork of muscles on the thorax, by the comparatively short zooid, and by the very large number of stigmata in each row.

Distaplia viridis Kott, 1957a: 96. Millar, 1966: 365.

New Records: Hallett Cove, Port Noarlunga Reef, Carickalinga Head. *Previous Records*: S. Aust. (Victor Harbour, Reevesby I.)—Kott 1957a. Vic. (Port Phillip Bay)—Millar 1966.

FIGS. 6, 7

Description: Living colonies from Hallett Cove had a transparent matrix with orange zooids, while these specimens are greenish in preservative due to the greenish colour of the enclosed zooids. Preserved colonies from Port Noarlunga are also greenish but the living colonies were blue-black with white markings. Test is semi-transparent and very soft. Zooids closely placed more or less in double rows. Colonies are irregular and investing, about 4 mm thick. The surface is always smooth. There are no sand inclusions. Common cloacal apertures are randomly distributed over the surface of the colony and zooids are arranged on either side of very shallow and narrow common cloacal canals. A brood pouch is developed from the postero-dorsal corner of the thorax and contains only a single embryo. The atrial lip is sometimes tridentate at the tip with a longer median lobe. This, however, may be obscured if the atrial lip is widely extended. In younger colonies the zooids may be in circular systems of 5 to 14 zooids. There are 4 rows of stigmata with para-stigmatic vessels. The stomach has glandular folds internally but externally is smooth. There are about 10 testis lobes in a rosette in the loop of the gut, and a single egg protrudes from the right side of the abdomen. A conspicuous gastric reservoir is also present in the loop of the gut.

The single embryo present in the brood pouch is as previously described. The tail of the larval form is especially short and extends only half way along the ventral surface. The larval test has a foamy appearance.

Remarks: The species conforms with specimens previously taken from Victor Harbour and Reevesby I., South Australia and the pre-

served colonies have the same greenish tinge in formalin resulting from the colour of the zooids. Colours present in the living specimens, however, appear to vary. The single embryo in the brood pouch is apparently characteristic of the species which is common in St. Vincent Gulf and Spencer Gulf although it has not been recorded from other localities.

Sycozoa cerebriformis (Quoy & Gaimard). Brewin, 1953: 58 and synonymy. Kott, 1957a: 99. Millar, 1966: 365.

Aplidie cerebriforme Quoy & Gaimard: 1834: 625.

New Records: Off Troubridge I., Orontes Bank (off Port Vincent), upper St. Vincent Gulf, Hallett Cove, Carickalinga Head, West I. (Toad Head), Wright I. *Previous Records*: North-west Aust.—Hartmeyer 1919, S. Aust. (Victor Harbour, Port Lincoln)—Kott 1957a; Caullery 1908. Vic. (Balnarring Beach, Westernport, Point Lonsdale)—Quoy & Gaimard 1834; Caullery 1908; Michaelsen 1924; Kott 1957a; Millar 1966. N.S.W. (Gunnamatta Bay, Jervis Bay, Port Jackson, Port Stephens) —Herdman 1899; Kott 1957a. South Africa—Hartmeyer 1912; Michaelsen 1923a.

Description: Colonies from fan-shaped to curved lamellae. Zooids arranged in double rows down both sides of these lamellae, branchial apertures opening to the exterior. Cloacal apertures, however, as is usual in this genus, open into common cloacal canals extending vertically down both sides of the colony. These cloacal canals open separately around the edge of the narrow flat top of the colony.

Remarks: In *Sycozoa sigillinoides* Lesson, from the Antarctic (see Millar 1960; Kott 1969), it has been found that the common cloacal cavities open into a ring canal round the anterior end of the colony and this ring canal is part of a common cloacal cavity opening by a terminal aperture. Brewin (1953) characterised the genus *Sycozoa* by the condition of the cloacal canals opening separately around the anterior border of the colony. Both Millar (1960) and Kott (1969), working with specimens of *Sycozoa sigillinoides* from the Antarctic, did not accept this interpretation of the cloacal openings and suggested that Brewin's colonies were distended to expose the openings in the cloacal cavity. Brewin's observations for both *Sycozoa cerebriformis* and for *S. tenuicaulis* are accurate. The situation in *S. sigillinoides*, however, indicates that separate openings of the canals is not a character shared by all species of the genus *Sycozoa*.

Colonies have been observed with their wide fans, from the short, sturdy stalk, oriented toward the oncoming current (S. A. Shepherd pers. comm.). The stalk is not flexible, as in *S. tenuicaulis*, and the orientation of the colony is unlikely to adapt to changes in direction of current flow. The species is most common attached to shell or rock surfaces at locations where there are slow to sluggish currents, and where the light intensity is not great due to depth and sediments. Larvae have an otolith but no ocellus (Caullery 1908). They have relatively short tails, their free swimming existence is short and they are probably not strong swimmers.

The species therefore is well adapted to an existence in locations with slow to sluggish currents where it is most commonly found. The low light intensity at these stations, due to depth or sediment, is coincidental and not likely to directly affect settlement of these light-insensitive larvae.

The species is taken from the Rough Coast Subformation at West I. and elsewhere in conditions of moderate surge, either at depth or in crevices, or under boulders where it is protected. Again, the low light intensity is only coincidental with the occasional occurrence of this species in these situations where light sensitive aplousobranch larvae that are attracted into shade are more common.

Sycozoa tenuicaulis (Herdman). Brewin, 1953: 57. Kott, 1957a: 99. Millar, 1963: 707.

Colella tenuicaulis Herdman, 1899: 64.

New Record: Off Broadway. *Previous Records*: W. Aust.—Millar 1963. Vic. (Port Phillip Bay, Lakes Entrance)—Kott 1957a. Millar 1963. Tas. (D'Entrecasteux Channel, Furneaux Group)—Millar 1963; Kott 1957a. N.S.W. (Botany Bay, Jervis Bay, Broken Bay, Port Stephens, Port Jackson)—Herdman 1899; Millar 1963; Kott 1957a.

Description: A single colony only is available and is the usual flattened inverted cone, fixed by a long stalk with basal hair-like rootlets. Zooids are present in closely set double rows along the length of the head. The longitudinal common cloacal canals extend the length of the head between each double row of zooids and open by a wide opening around the outside margin of the flat top of the head as previously described by Brewin (1953).

Remarks: The observations by Brewin on the separate cloacal openings around the top of the head are confirmed in the present colony. The species is distinguished from the superficially similar Antarctic species, *S. sigillinoides* Lesson, by these separate openings of the common cloacal canals, which, in *S. sigillinoides* open into a terminal chamber with a single common cloacal opening on the centre of the upper free surface of the head (Millar 1960; Kott 1969). The species are also distinguished by the flattened head and by the tuft of hair-like roots in *S. tenuicaulis* (see Millar 1963).

Records of *S. tenuicaulis* are confined to Australia, and at present the species is known only from fairly protected bays. It is possible therefore that its isolation has resulted in speciation separating it from the more widely distributed circum-polar *S. sigillinoides*. The latter is also known from South Australian localities (Kott 1969).

Brewin (1953) states that all records of this species are from deep water. Although this is not strictly accurate, there are indeed no records available from the inter-tidal region. Specimens have been taken from a depth of 4 m (Millar 1963) to 50 m (Kott 1967).

Shepherd (pers. comm.) has observed that it is fairly common at sub-littoral locations in deeper water, with tidal currents up to 0.5 m/sec. (one knot). The larva of this species does not have a light sensitive ocellus (Brewin 1953) and would be at a disadvantage in seeking suitably protected locations for settlement in waters where there is appreciable wave action or surge but, like *S. sigillinoides* (see Kott 1969), is well adapted for an existence on the sea floor.

Family **POLYCITORIDAE**

Polycitor giganteum (Herdman).

Polyclinum giganteum Herdman, 1889: 79.
Polyclinum globosum Herdman, 1899: 80.
Polycitor gelatinosa Kott, 1957a: 83.
non Polycitor giganteum Sluiter, 1919: 10 (*Diazona giganteum* Sluiter).

New Records: Tapley Shoal, Hallett Cove, Port Noarlunga, Aldinga, West I. (Toad Head), Wright I. *Previous Records*: W. Aust. (Rottnest I.). S. Aust. (Port Noarlunga). Vic. (Balnarring Beach, Lakes Entrance, North Brighton)—Kott 1957a. N.S.W. (Jervis Bay, Port Jackson)—Herdman 1899; Kott 1957a.

FIGS. 8, 9

Description: Large, fan-shaped or rounded lobes of varying size; sometimes smaller lobes occur together fixed to a common base. The test is firm, gelatinous without sand inclusions, and is semi-transparent and almost glassy in appearance. Zooids can be seen radiating from the basal constriction of the colony to open on the rounded upper surface. Living zooids are cream to bright orange but are pinkish in preservative. The diameter of the colony is gradually reduced toward the base where it is fixed to the substrate. In the colony from Tapley Shoal, two lobes branch from a common base and the test of the upper part of each lobe is coalesced. There are 15 longitudinal muscles per side continuing as 3 bands along each side of the abdomen. The stomach has 4 folds and there are 10–12 rows of 22 to 40 stigmata.

There are 3 to 9 developing embryos in the atrial cavity and in the distal portion of the oviduct. Larvae are large, about 1.2 mm, and large ampullae develop around the base of the 3 median papillae as previously described for *P. giganteum*.

Remarks: A re-examination of the type specimens of *P. gelatinosa* from Rottnest I., has shown that the colonies are slightly smaller than most colonies of *P. giganteum*. The zooids and the test are, however, identical with those of *P. giganteum*. Further investigation of larvae from typical colonies of *P. giganteum* has also shown that in the less mature larvae the anterior ampullae are not developed and these larvae appear identical with those described for *P. gelatinosa* (Kott 1957a). As there is so much variation in the shape and size of colonies of *P. giganteum*, from spherical individual lobes to numerous pyriform lobes from a common base, this cannot be regarded as a valid character on which to separate the two species. The gelatinous test, large zooids and larvae are characteristic.

Eudistoma pyriforme (Herdman), Hastings, 1931: 84. Kott, 1957a: 75, Tokioka, 1950: 120; 1967: 110. Vasseur, 1969: 918.

Psammaplidium pyriforme Herdman, 1886: 419.

New Record: Off West Beach. *Previous Records*: S. Aust. (Port Noarlunga)—Kott 1957a. Qld. (Great Barrier Reef, Flinders Passage)—Herdman 1886. Pacific (Palau Is., Gilbert I.)—Tokioka 1950, 1967. Indian Ocean (Madagascar)—Vasseur 1969.

Description: Rounded lobes, narrowing towards the base where the test expands into a basal plate from which several heads may rise. Sand is absent from the outer 5 mm of test on the upper half of the colony but is present internally and is also present through the test in the basal half of the lobes. Maximum diameter of head is 4 cm. The test is firm and gelatinous. The colony is grey in preservative. Zooids are present, opening over the upper surface of the head. They are arranged in circular systems, with the atrial apertures opening separately in a circle in the centre of the outer circle formed by the branchial openings. Each atrial aperture is protected by a lobe of test that covers the opening from its dorsal surface and it appears that the excurrent stream from each zooid would be directed towards the centre to reinforce the excurrent stream from zooids in the same circular system. The incurrent ciliary stream is probably drawn from an area immediately adjacent to the branchial aperture. This arrangement of apertures represents a stage before the development of true cloacal systems.

Zooids are 5 to 7 mm long, of which the thorax is only 1 mm. They cross one another in the test. Both siphons are well developed, anteriorly directed, and are surrounded with circular muscles to form a distinct sphincter. The atrial sphincter is especially well developed. There are about 20 longitudinal muscles on the thorax although these may be reduced to 12 in contracted specimens. The transverse musculature is fairly strong.

There are 3 rows of about 9 to 12 stigmata. The stomach is smooth and rounded and in contracted specimens the intestine behind the stomach forms an "S" bend as previously described for this species. The rectum forms the ascending limb of the gut loop.

Remarks: Specimens of *Eudistoma* are notoriously difficult to characterise and the variable condition of the intestine in the present specimens suggests that this feature, previously regarded as a diagnostic feature, is dependent on the degree of contraction of the abdomen. Specimens identified as *E. pyriforme* from Heron I. and North West I. (Capricorn Group) have been examined. Zooids are arranged in similar systems to those described above, although these may be obscured by sand in the surface test; the proximal part of the intestine forms either an "S" bend or a loop, and pigment is present in spherical cells in the surface test. Despite the variation in the external appearances of these colonies they all appear to belong to *E. pyriforme*, characterised mainly by the condition of the thoracic musculature, the long oesophagus, the atrial sphincters and the arrangement of zooids in the colony. These characters are, to some extent, shared by other species and it is possible that more than a single species is represented by the records ascribed to this species.

Eudistoma renieri (Hartmeyer). Michaelsen, 1923a: 10. Kott, 1957a: 74. Millar, 1962: 160.

Polycitor renieri Hartmeyer, 1912: 309.

New Record: Outside Wright I. *Previous Records*: W. Aust. (Point Peron) Kott 1957a. South Africa—Hartmeyer 1912; Michaelsen 1923a; Millar 1962.

FIGS. 10–12

Description: Fleshy investing colony, 0.6 cm thick. Test semi-transparent with reddish to black pigment cells in streaks on the surface. The surface of the test is smooth, without foreign bodies or sand, and is depressed over the zooids. Zooids are arranged in circles of about 4 mm diameter, the branchial openings around the periphery of the circle and the atrial openings toward the centre, protected by lobes of test. The atrial openings are in a pigment-free area. The zooids do not cross one another in the test. The abdomen is about twice the length of the thorax. The atrial aperture is on a cylindrical siphon which is about three times the length of the branchial siphon. The body wall is fairly muscular with at least 12 longitudinal muscle bands of 4 to 5 strands crossing numerous transverse bands. The longitudinal bands appear to separate out into separate strands. When not so strongly contracted, the circular muscles around the atrial siphon are strong and conspicuous although they are spread along the siphon rather than forming a large sphincter muscle. There are about 20 long rectangular stigmata in each row. The rounded smooth stomach is halfway down the abdomen. There is a long duodenal area and a short round posterior stomach. The part of the intestine distal to the stomach is sometimes kinked in contracted specimens. The gonads are in the gut loop. There is an expansion from the dorsal aspect of the posterior end of the thorax accommodating a loop of the oviduct with one to two embryos, and although the brood pouch is not separated from the thorax by a narrow stalk as in the true brood pouch of the Holozoinae, it is structurally homologous.

The larvae are about 1 mm long, typically polycitorid, with the 3 median papillae developing on short stalks from depressions in the centre of rounded swellings around the anterior end of the larva. The margins of these depressions become attenuated in the mid-line to form median ampullae at the base of the papillary stalk. The area of adhesive cells in these papillae is lengthened longitudinally to different extents for each papilla. This lengthening is reminiscent of the condition in *Atapozoa* larvae.

Remarks: Distinctions between *Eudistoma* spp. are not altogether satisfactory and many characters such as the body musculature, length of gut, and looping of the intestine, all vary with the degree of contraction of the body. The present species is identified by the gelatinous nature of the test, by the large number of stigmata, by the long oesophagus and the position of the stomach mid-way down the abdomen. The extended adhesive area of the larval papillae was not recognised previously (Kott 1957a). A re-examination of Kott's specimens from Point Peron, Western Australia, has demonstrated that the papillae are identical with those in the present collection. This character therefore appears to be distinctive for the species.

The zooids of the Australian specimens resemble Hartmeyer's (1912) South African specimens, although the colony of the South Australian specimens is thinner. Millar's (1962) specimens appear to differ in many characters, however; notably in the reduced size of the thorax, in the position of the stomach at the posterior end of the abdomen, in the number of muscle bands and rows of stigmata in the length of the atrial siphon, and in the cylindrical form of the colony.

Cystodytes dellechiajei (Della Valle). Kott, 1954: 154 and synonymy. Tokioka, 1950: 120. Millar, 1953: 284; 1960: 82; 1962: 143; 1963: 713; 1966: 365.

Distoma dellechiajiae, Della Valle, 1877: 40.
? Aplidium lobatum. Delle Chiaje, 1841: 30 (not Savigny 1816).
Cystodytes dellachiaiae. Kott, 1957a: 68.
Cystodytes Delle Chiajei. Pérès, 1948: 171.

New Record: West I. (near Penguin Rock)
Previous Records: W. Aust. (Dampier Archipelago to Albany)—Michaelsen 1930; Kott 1954, 1957a; Millar 1963. Vic. (Port Phillip Bay, Barwon Heads)—Millar 1966. Tas. (Maria I.)—Kott 1954. Pacific (Palao Is.)—Tokioka 1950. New Zealand (North I., Chatham Is.)—Michaelsen 1924; Brewin 1948, 1951, 1952a, 1956; Millar 1960. California (Coronado I., Puerto Escondido)—Van Name 1945. Indian Ocean (Ceylon)—Herdman 1906. Mediterranean—Della Valle 1877; von Drasche 1883; Lahille 1890; Harant 1925, 1929. Africa (Mozambique, Gold Coast, Cameroons, Senegal)—Michaelsen 1915; Pérès 1948; Millar 1953, 1962. The species is also known from the Atlantic Ocean, along the east coast of the American continent from Patagonia (Millar 1960) to the Caribbean and from the Azores (Michaelsen 1923a), the Canary I. (Hartmeyer 1912) and Virgin Is. (Van Name 1945). It has been taken intertidally and to a maximum depth of 736 m (off Brazil, Herdman 1886).

Description: Irregular investing colonies. Living colonies purple with colourless "splotches", but in formalin the colonies are brown with white blotches where zooids are present in the test surrounded by the calcareous spicules that are typical of this species. The species is especially constant and the present colonies and zooids conform exactly with previously described specimens. Larvae are present in brood pouches attached to the parent zooid or free in the test. The larvae have the usual large papillae surrounded by ectodermal ampullae which have coalesced distally to form a circle around the papilla as described previously for the species (Kott 1954, 1957a).

Family **POLYCLINIDAE**

Subfamily EUHERDMANIINAE

Ritterella herdmania Kott, 1957a: 102 (nom. nov.); 1963: 78 and synonymy.

New Record: Port Noarlunga. *Previous Records*: W. Aust. (Green Pools)—Kott 1957a. N.S.W. (Newport, Port Jackson, Wattamolla)—Herdman 1899; Kott 1957a, 1963.

FIGS. 13–17

Description: Sandy finger-like lobes joined basally. The lobes are long and slender, spoon-shaped terminally, with 1 to 5 zooids in each lobe. The branchial apertures open into the concavity of each lobe and the atrial apertures open round the convexity of the anterior tip of the lobe. Both apertures are 6-lobed and on very short siphons. The branchial aperture is terminal and the atrial aperture rises from opposite the first row of stigmata. There are circular siphonal muscles, very delicate longitudinal muscles and some weak transverse

muscles on the thorax. There are five rows of 8 to 16 stigmata in the branchial sac; sometimes, in the larger zooids, parastigmatic vessels are present in some of the rows of stigmata and appear to bisect them horizontally to form extra rows. Triangular languets are present in the mid-dorsal line expanded from both the transverse vessels and the para-stigmatic vessels. Smaller rounded papillae are also present in the middle of each transverse vessel on either side of the branchial sac. These papillae have not previously been described for this genus. The fact that they do not arise on the parastigmatic vessels suggests that they may be present as relicts of papillae supporting longitudinal vessels in the branchial sac and homologous with the papillae present in the Antarctic genus *Tylobranchion*.

The condition of the stomach varies according to its degree of contraction and when extended there are apparently four to six stomach folds, but these are not always distinct. Four folds sometimes appear to be present only in the anterior part of the stomach. There is also a small posterior stomach as previously described. The posterior abdomen may be very long and thread-like and testis follicles are arranged in it in a single row. The extended thorax and abdomen together measure 4–5 mm. The posterior abdomen is considerably longer.

Larvae are present in the thoracic cavity of some of the zooids. They have 3 anterior papillae in the median line alternating with paired anterior ampullae. Dorsally and ventrally paired rows of ampullary vesicles extend posteriorly. There is an otolith and ocellus.

Remarks: The variations in the number of rows of stigmata resulting from their bisection by parastigmatic vessels and the increase in the size of the zooid-bearing lobes, both of which occur with increasing maturity, suggests that confusion could arise regarding the identity of specimens assigned to this and to related species. Part of the type colony of *Ritterella asymmetrica* Millar, 1966, from Port Phillip Bay, has been examined. The external appearance of the colony resembles *R. herdmania* and the 10 rows of stigmata could have resulted from the bisection of 5 primary rows by parastigmatic vessels, as the triangular dorsal languets are of two alternating sizes. There are no papillae on the transverse vessels in Millar's species, however, and the stomach folds are also distinctive.

Five primary rows of stigmata appear to be characteristic of most *Ritterella* spp. although the number can be increased probably by subdivision with parastigmatic vessels which subsequently are not distinguished from primary transverse vessels. *Ritterella herdmania*, *R. pedunculata* Tokioka and *R. vestita* Millar, 1960 (from North I., New Zealand) have parastigmatic vessels and sometimes increased numbers of rows of stigmata; *R. proliferus* (Oka) (≥*R. dispar* Kott, 1957a) from Japan and from the central east coast of Australia (see Tokioka 1953a; Kott 1957a, 1963), and *R. sigillinoides* Brewin, 1958a, from Stewart I., have only the 5 primary rows of stigmata and no parastigmatic vessels; *R. asymmetrica* Millar has increased numbers of rows of stigmata and apparently no parastigmatic vessels.

The type species of the genus *Eutherdmania*, *E. claviformis* (Ritter) (see Van Name 1945), together with *E. solida* Millar, 1953 from the African Gold Coast, *E. vitrea* Millar, 1961 from Brazil, and *E. digitata* Millar, 1963 from northwestern Australia are easily distinguished by a long oesophagus, a large number of rows of stigmata and the absence of parastigmatic vessels and, where their larvae are known, by the modified adhesive organs as described for this genus and for *Placentela* spp. (Kott 1969). *Eutherdmania australis* Kott, 1957a, however, from South Australia, Victoria and New South Wales, has a short oesophagus, 12 to 13 rows of stigmata, parastigmatic vessels, and a papilla in the middle of the transverse vessels on each side of the body. It is distinguished from *R. herdmania* by the single zooid in each lobe of the colony, the absence of stomach folds, the number of rows of stigmata and the testis follicles which are bunched in the posterior abdomen.

Larvae are known for *R. proliferus* and *R. herdmania*, and are typically polyclinid with ampullary vesicles.

In the present species and in *E. australis* the papillae on the transverse vessels are reminiscent of *Tylobranchion* and related genera, and probably represent a primitive character.

Pseudodistoma cereum Michaelsen, 1924: 364. Kott, 1963: 77 and synonymy. Monniot, 1969: 437

New Record: Nora Creina Bay. *Previous Records*: N.S.W. (near Eden)—Kott 1963. New Zealand (Stewart I. (Paterson Inlet), Foveaux Strait, Otago coast, Little Papanui, Great Barrier I.)—Michaelsen 1924; Brewin

1950c, 1958a. Atlantic Ocean (Dakar)—Monniot 1969. The species is known intertidally and down to 87 m.

FIGS. 18, 19

Description: Soft, gelatinous, semi-transparent, rounded or cylindrical heads of slightly greater diameter than the more leathery stalk of up to 5 cm length. In some specimens the stalk is expanded into a thick mat from which numerous heads arise. The zooids are numerous and open all around the head by separate 6-lobed branchial and atrial openings. The contracted thorax and abdomen together measure only 2 cm. Fine longitudinal muscle bands on the thorax number 20 to 30 and these extend along both sides of the abdomen. There are 15 to 20 rows of stigmata in each of the 3 rows. The 4 stomach folds are obscure and may be artefacts resulting from the collapse of the stomach. A duodenal swelling and a rounded posterior stomach are also present. There is a long ovary, with numerous eggs more than halfway down the abdomen, but no testis follicles were present in the colonies from these stations. There is a single developing embryo in a brood pouch from the postero-dorsal corner of the thorax.

Remarks: The general form of the colonies, arrangement of body musculature, the branchial sac, gut and the situation of the ovary some distance down the posterior abdomen, all agree with the previously described specimens. All other species of the genus have a similar situation for the ovary some distance along the posterior abdomen: *P. africanum* Millar, 1954, 1962; *P. fragilis* Tokioka, 1958; *P. cyrnusense* Pérès, 1952; *P. untinboja* Tokioka, 1949; *P. opaca* Brewin, 1950c; *P. brieni* Pérès, 1949. The stalked colonies of *P. africanum* are also reminiscent of the present species in the presence of a single developing embryo in a thoracic brood pouch and are distinguished only by a smaller number of longitudinal thoracic muscles. As there has been considerable variation demonstrated in this character, the distinction is rather doubtful, and the species or its relatives appear to have a wide circumpolar distribution in the southern temperate region as Monniot (1969) has already indicated.

Subfamily POLYCLININAE

Aplidium pliciferum (Redikorzev), Kott, 1963: 106

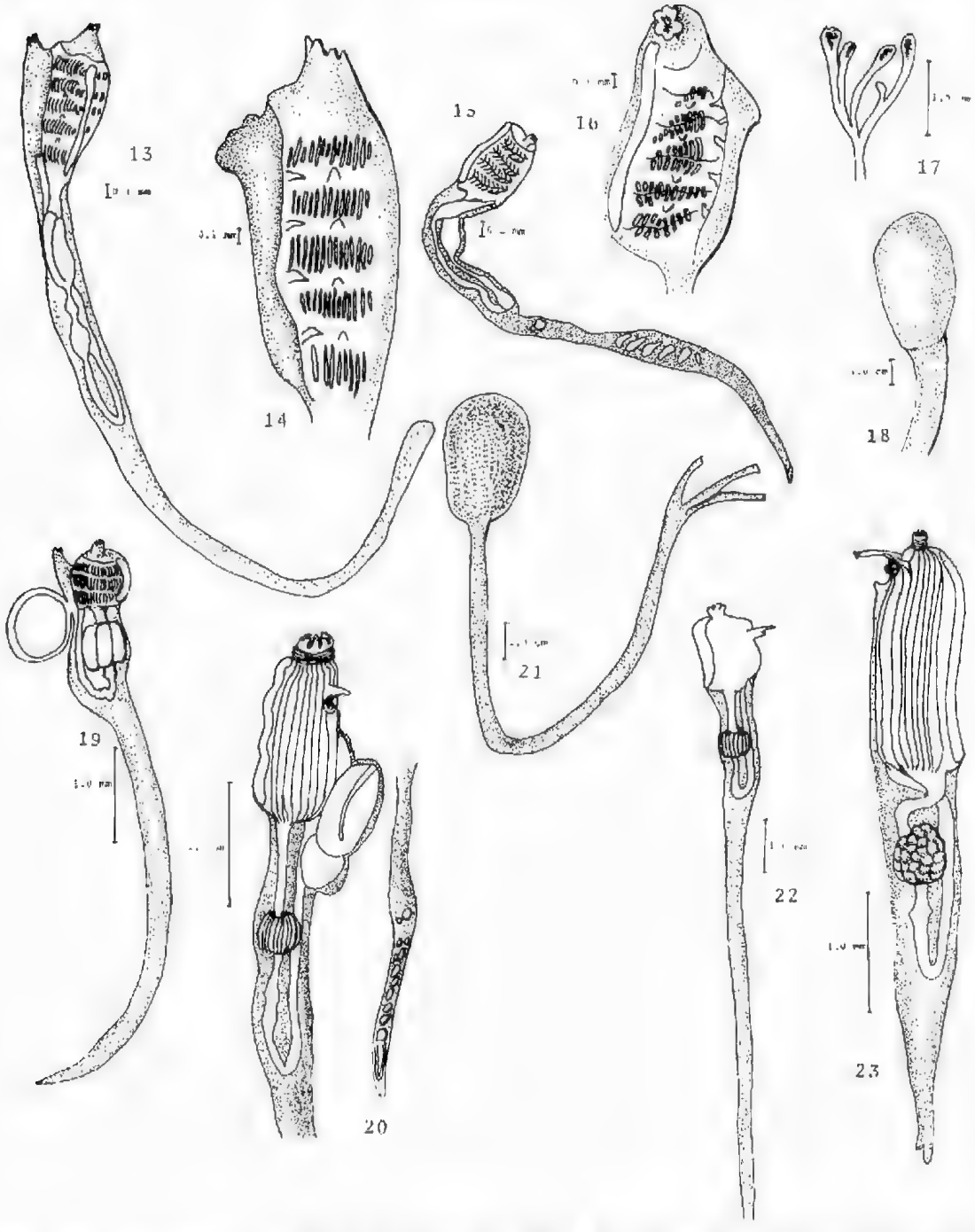
Amaroucium pliciferum Redikorzev, 1927: 390, Tokioka, 1953a: 183; 1962: 2; 1967: 32. *Aplidium phortax*, Millar, 1966: 359.

New Records: Troubridge Shoal, Hallett Cove. *Previous Records*: W. Aust. (Point Peron, Rottnest I.)—Kott 1963. Vic. (Port Phillip Bay)—Millar 1966. Japan (coastal water of Honshu, Shikoku and Kyushu and the Inland Sea)—Redikorzev 1927; Tokioka 1953a. Hawaiian Is. (Auau Channel)—Tokioka 1967.

FIG. 20

Description: Rounded, soft, sessile colonies, 2 cm in diameter. In life the colonies are bright yellow. The surface of the colony has deep furrows marking it off into extensive rounded areas with up to 3 common cloacal openings from which double row systems radiate. Test transparent, zooids orange in the living specimen. Thorax and abdomen are of equal length and together measure 2.5 mm. The posterior abdomen is long, up to 8 mm. There are 6 well-defined branchial lobes, a strong circular branchial sphincter and 8 fine longitudinal muscle bands which extend down each side of the thorax. The upper border of the atrial opening is extended into a small pointed lip sometimes tridentate. There are 8–10 rows of about 15 stigmata. The oesophagus is long and the stomach, about half way down the abdomen, has 19 to 25 well defined folds. There is a duodenal swelling and a small posterior stomach. Two developing embryos are present in a brood pouch formed by the expansion of the distal end of the oviduct at the postero-dorsal corner of the thorax. The ovary is present about halfway down the posterior abdomen and a single series of pyriform testis lobes attached to a single duct are present behind the ovary. Larvae have the usual three median suckers with three ampullae between the suckers and many small ampullary vesicles in two rows from each lateral line as described previously for specimens from Western Australia (see Kott 1963).

Remarks: The species is closely related to *Aplidium phortax* (Michaelsen) from New Zealand, which has a similar number of fine longitudinal muscle bands, and stomach folds, and also has a brood pouch. Consequently, there has been some confusion between these species. Unfortunately, Michaelsen (1924) did not describe larvae from his species. *Aplidium plicilerum* (see Kott 1963) from Western Australia has smaller zooids (thorax and abdomen together about 1 mm long, posterior abdomen 2 mm) and are densely distributed in the test, largely obscuring the systems. In *Aplidium phortax* (see Kott 1963) from eastern Australia



Figs. 13–17. *Ritterella herdmania*. (Port Noarlunga). Fig. 13.—Young zooid, contracted thorax. Fig. 14.—Extended thorax of young zooid. Fig. 15.—Zooid with contracted thorax showing parastigmatic vessels. Fig. 16.—Thorax of more mature zooid showing parastigmatic vessels successively subdividing rows of stigmata. Fig. 17.—Portion of colony.

Figs. 18, 19. *Pseudodistoma cereum* (Nora Creina). Fig. 18.—Outline of colony. Fig. 19.—Zooid with brood pouch.

Fig. 20. *Aplidium pliciferum*. (Hallett Cove, 8 m). Zooid.

Figs. 21, 22. *Aplidium coleltoides*. (Taplcy Shoal, off Troubridge Light, 17 m). Fig. 21.—Colony. Fig. 22.—Zooid.

Fig. 23. *Synoicium papilliferum*. (West I., sheltered coast, 3 m). Zooid (showing muscles on thorax only).

and the Pacific, the larger zooids (thorax and abdomen together 3.5 mm long, and posterior abdomen 1.5 mm long) are arranged in circular systems, sometimes extending into more elongate and double row systems radiating from the common cloacal openings. In all Kott's (1963) specimens the test is gelatinous and semi-transparent with red-purple spherical pigment cells, and the larvae provide the main distinguishing character between the two species. *A. phortax* has larvae with a limited number of ampullary vesicles and a complete absence of median ampullae, while the larvae of *A. pliciferum* retain median papillae and have many small ampullary vesicles from the lateral lines either side of the three median suckers. Millar (1966) described specimens from Port Phillip Bay as *A. phortax*. He points out that *A. phortax* (see in Kott 1963), is not apparently the same species as his colonies although he can only distinguish them by the different larval form. He apparently overlooked the similarity in the size and form of the larvae of his specimen and of *A. pliciferum* (Redikortzev); Tokioka 1953a; Kott 1963; and based his identification on the ratio of length to depth of the larvae of Michaelsen's species and his own specimens from Port Phillip Bay. However, Kott (1963) has already indicated that larvae of *A. phortax* (Brewin 1946) from New Zealand, do have the same rounded form as the larvae of specimens of *A. phortax* (Kott 1963) from eastern Australia. It is apparent, therefore, that specimens from Port Phillip Bay were erroneously identified by Millar.

The adult zooids can definitely be distinguished by the longer posterior abdomen, the smaller size, and the greater crowding of zooids of *A. pliciferum*.

The specimen from Hallett Cove was taken with a specimen of *Distaplia viridis* in which the zooids are the same orange colour. The specimen from Troubridge Shoal was taken from a spiny crab.

Aplidium ruhricollum Kott, 1963: 103.

New Record: Upper St. Vincent Gulf. *Previous Records*: W. Aust. (Rottnest I.). S. Aust. (Reevesby I.). Vic. (Balnarring Beach)—Kott 1963.

Description: The single colony is flattened, about 0.7 cm thick and 3.5 cm in maximum diameter. The borders of the colony are rounded. Sand is present basally and some is enclosed in the common test but the surface is smooth and without sand. The common cloacal apertures with frilled and protuberant lips are present on the surface of the colony about 0.3 cm from one another. Spherical pigment cells are present in the test and zooids show as clear points between the pigmented test. In this preserved specimen the pigment cells are pale pink. Zooids are small, up to 2 mm long. There are 10 longitudinal thoracic muscles. A short pointed atrial languet arises from the dorsal surface just anterior to the atrial opening which is generally on a short protuberant siphon surrounded by a circular sphincter muscle. There are 11 rows of 6–8 stigmata, and 4 stomach folds.

Remarks: The species is distinguished by the form of the atrial aperture and lip, by the narrow branchial sac with relatively few stigmata in each row and by the body musculature and stomach folds. In the present specimen the test is not so thickly invested with sand as previously described for this species.

Aplidium colelloides (Herdman): Millar, 1962: 125.

Amaroucium colelloides Herdman, 1886: 223. *New Record*: Off Troubridge I. *Previous Records*: South Africa (Cape of Good Hope—Herdman 1886; Millar 1962.

FIGS. 21, 22

Description: Rounded gelatinous heads on a long hard stalk. The head is up to 4 cm in length and 2 cm in diameter. The stalk, up to 20 cm in length, is hardened by dense sand inclusion in the surface test which fades out in the test of the head region. The stalk is branched basally into short root-like processes. Zooids are minute, opening around the surface of the head. Long thread-like posterior abdomina criss-cross in the centre of the head and sometimes extend down into the stalk. Some common cloacal apertures are evident around the head and some longitudinal cloacal canals were identified, although the form of the systems is obscure and difficult to distinguish. The thorax and abdomen are of equal length and together measure only about 1.5 mm. The long, thread-like post-abdomen is at least four times the combined length of the thorax and abdomen. There are about 6 delicate longitudinal muscles on the thorax. The

branchial lobes are distinct and rounded. The atrial aperture is sometimes produced on a fairly long cylindrical siphon but in another colony is sessile, the upper border of the atrial aperture produced into a pointed languet. There are 18 rows of about 10 short oval stigmata. The oesophagus is long, the stomach is present halfway down the abdomen and has 15 very distinct folds. The gonads are not developed in these specimens and it is not known to what extent they fill the long posterior abdomen in mature zooids.

Remarks: This is the only species of *Aplidium* known with a long stalk. The size and form of the colony, the size of zooids and their arrangements in the present colony are identical with the South African specimens previously described. The delicate longitudinal thoracic muscles and the stomach folds are similar. The present specimens differ from those described from South Africa only in the larger number of rows of stigmata. This does not represent a sufficient difference on which to establish a new species and in view of the great similarity in most characters the specimens probably represent one species with a wide circumpolar distribution in the southern cold-temperate region.

Synoicium papilliferum (Michaelsen). Kott, 1963: 87. Millar, 1966: 360.

Macroclinum papilliferum Michaelsen, 1930: 530.

New Records: Port Noarlunga reef, West I. (near Penguin Rock). *Previous Records*: W. Aust. (Bunbury to Nornalup)—Michaelsen 1930; Kott 1963. Vic. (Nepean Peninsula)—Millar 1966. The species is known intertidally and to 18 m.

FIG. 23

Description: In life the colony is dark red or bright brick red. Flat-topped to rounded colonies, narrowing basally to a common stalk or encrusting. Zooids lie parallel in the test and open on the upper surface. The colony is firm, gelatinous. There are circular systems around protuberant common cloacal apertures. The branchial aperture has 6 small pointed lobes and there is a small circular sphincter muscle at the base of the branchial siphon. The atrial aperture is opposite the first to second row of stigmata. It is surrounded by a well developed circular sphincter muscle, and is extended into a short cylindrical siphon. The anterior border of the atrial aperture is produced into a long muscular lip, broken into 3–4 minute pointed lobes terminally. There are 10 very fine longitudinal muscle bands on the thorax which is very delicate and transparent. There are 10–12 rows of about 10 stigmata in each row. The body wall below the atrial aperture is produced into the small rounded papillae characteristic of *Synoicium* spp. The wall of the stomach is raised into faint mulberry-like swellings. The posterior abdomen is short and there is no constriction between it and the abdomen.

Remarks: Both colony and zooids conform with previous descriptions in all characters except the reduced number of rows of stigmata. The species has been recorded from south-western Australia along the south coast of Australia to the Nepean Peninsula in Victoria (Millar 1966).

Family **DIDEMNIDAE**

? Trididemnum spiculatum Kott, 1962: 281.

New Record: West I. (near Penguin Rock). *Previous Records*: W. Aust. (Rottnest I., Point Peron). S. Aust. (Outer Harbour) Tas. (Wreck Bay). Qld. (Heron I.)— Kott 1962.

Description: Living colonies pale pink, encrusting. Small, almost spherical spicules with up to 12 points in optical transverse section, evenly distributed throughout the test, and occasionally large spicules with fewer rays. There are small thoracic common cloacal cavities. Zooids are small with three rows of stigmata. The atrial aperture is wide, exposing a large part of the branchial sac. Gonads are not mature in the present specimens.

Remarks: Colonies generally conform with specimens previously assigned to this species, although the proportion of smaller burr-like spicules to larger stellate spicules with about 8 rays in optical section, is greater in the present specimen. Colonies with mature zooids are desirable for positive identification.

Leptoclinides rufus (Sluiter). Tokioka, 1952: 92. Kott, 1962: 286 and synonymy. Eldredge, 1967: 221.

Polysyncraton rufus Sluiter, 1909: 72; 1913: 77.

New Records: Off Port Gawler, Hallett Cove, Port Noarlunga, Rapid Head, West I., Wright I. *Previous Records*: S. Aust. (Port Noarlunga). Vic. (Shoreham). Tas. (Maria I.). N.S.W. (Port Jackson)—Kott 1962. Qld. (Heron I.)—Hastings 1931. New Zealand (?Great Barrier I., *L. sluiteri*)—Brewin 1950b; (?Stewart I., *L. novaezelandiae*)—

Brewin 1958a, (?Chatham Rise, *L. auranticus*)—Brewin 1956; (North I.)—Michaelsen 1924; Brewin 1958b; Millar 1960, Indo-Pacific (Arafura Sea, Indonesia, Hawaii)—Tokioka 1952; Sluiter 1909; Eldredge 1967. The species is known intertidally and to 36 m (Sluiter 1909).

Description: Encrusting colonies. Living specimens: white matrix with grey or dark animals, or orange to light fawn (Port Noarlunga); or dark reddish brown (off Hallett Cove), mottled white to uniform light grey colour (Wright I.). In preservative all colonies are white to orange-white or streaked and blotched with grey. The colonies are investing, sometimes extensive. Cloacal cavities radiate from randomly distributed apertures. Zooids are sometimes present in the roof of the common cloacal cavity. Spicules are present in the surface test but basally the test is jelly-like and transparent. There are 9 longitudinal muscles on the thorax. The posteriorly directed atrial siphon has a wide circular sphincter muscle. There are 4 rows of 10 to 12 stigmata. There is a superficial layer of bladder cells and small oval to spherical pigment cells are present amongst the surface layer of spicules. A lateral organ is present opposite the middle of the fourth row of stigmata. Cloacal apertures are present, especially around the borders of the colony. Canals at thoracic level radiate from the cloacal apertures between clumps of zooids although sometimes they extend deeper to abdominal level. The cloacal canals around the border of the colony are often completely sub-abdominal. The spicules are of the usual stellate form, 0.01–0.04 mm in diameter. Larvae are present in some colonies from Hallett Cove. They are of usual form, fairly deep with 4 paired ampullae. In one colony from Hallett Cove (dark reddish brown in life) no common cloacal cavities were present and zooids were not mature, nor were zooid openings to the exterior detected. The arrangement of spicules is characteristic of this species and it is probable that the colony is one in which sexual reproduction is completed and new vegetative buds are developing.

Remarks: The species is distinguished by the complete absence of spicules from the basal layer of the test, sometimes giving the colony a very fleshy appearance. The characteristic common cloacal system and the distinct musculature on the thorax, together with the posteriorly directed atrial siphon and the spherical to oval pigment cells are distinctive.

Leptoclinides kingi Michaelsen.

Polysyncraton dubium. Van Name, 1918: 155, Hartmeyer, 1919: 136.
Leptoclinides dubius f. *kingi* Michaelsen, 1930: 507, Kott, 1962: 289

New Record: Upper St. Vincent Gulf. *Previous Records*: W. Aust. (Fremantle, Albany)—Michaelsen 1930. Qld. (Sarina)—Kott 1962. Philippines (Jolo Light)—Van Name 1918. The species is known intertidally and to 18 m.

FIGS. 24, 25

Description: The colony is massive with the surface raised into mounds and single cloacal apertures at the apex of each mound. Each mound is formed by thickened basal test often with embedded parasites. Zooids are present in the surface test above the very extensive posterior abdominal spaces around the centre of each lobe or mound. The zooids are large with 4 rows of about 12 stigmata. There are 9 very fine longitudinal muscles on the thorax. The spicules are very small, 0.01 to 0.02 mm, and are ranged in a shallow layer at the level of the branchial siphons. They are only very sparse elsewhere in the test. There is a surface layer of bladder cells.

Remarks: The elevation of the surface of this colony into mounds or lobes with terminal common cloacal apertures characterises this species, which was previously regarded as a form of *Leptoclinides dubius* (Sluiter). *Leptoclinides dubius* is distinguished from the present species by its larger spicules and by the arrangement of common cloacal system with openings around the margins of each colony, as in *L. rufus*. In *L. kingi* large cloacal systems with terminal openings develop from the centre of the colony. As both forms have been recorded more or less over the same geographic range it is unlikely that they represent geographic subspecies of the one species, and in view of the different development of the common coacal systems it is probable that they represent different species. The long gut loop which is bent anteriorly to form a double loop is a character shared with *Leptoclinides dubius*. Posteriorly directed atrial siphons of the zooids open into the common cloacal cavities and canals. The openings sometimes appear 5 lobed due to the arrangement of spicules around the aperture. The genus *Askonides* Kott, 1962, therefore cannot be distinguished from *Leptoclinides* and *A. imperfectus* and *A. coelenteraeus* are distinguished from other species of *Leptoclinides* only by the extent to

which zooids open directly into the common cloacal chamber rather than into cloacal canals. Their relations are set out in the following key:

1. Single systems develop around central common cloacal cavities with terminal openings 2
1. Numerous systems develop around periphery of colony 3
2. Spicules accumulated in surface layer of test; spicules 0.01–0.02; larvae with 4 paired ampullae; most zooids open into cloacal canals . . . . . *L. kingi*
2. Spicules throughout; spicules 0.04–0.08; larvae with reduced ampullae; most zooids open direct into common cloacal cavity . . . . . *L. coelenteratus* and *L. imperfectus*
3. Spicules 0.01–0.02; double gut loop . . . . . *L. dubius*
3. Spicules 0.02–0.04; simple gut loop . . . . . *L. rufus*

Leptoclinides reticulatus (Sluiter). Kott, 1962: 285 and synonymy.

Didemnum reticulatum Sluiter, 1909: 60.

New Record: Tipata Reef. *Previous Records*: Qld. (Noosa to Mackay, Heron I., Low Is.)—Hastings 1931; Kott 1962. New Zealand (North I.)—Michaelsen 1924. Japan—Oka 1927; Tokioka 1953a, 1953b. Indonesia—Sluiter 1909. ?Philippines—Van Name 1918. Indian Ocean (Ceylon)—Herdman 1906.

FIG. 26

Description: Young colonies were taken investing *Microcosmus squamiger* and *Pyura irregularis*. Frequent common cloacal openings are scattered over the surface. There is a superficial layer of bladder cells with orange and black pigment in stellate cells forming streaks on the surface. Spicules are present beneath this superficial layer and are reduced in density toward the base of the colony. The spicules are stellate with about 7 conical rays in optical transverse section and from 0.03 to 0.05 mm in optical section.

The primary cloacal canals are deep, but in these specimens do not extend posterior to the zooids. The zooids are small with the usual 4 rows of stigmata and a large posteriorly directed atrial siphon. There are 4 testis lobes and 44 coils of the vas deferens.

Remarks: This is the most southerly record for this conspicuous and widespread species, distinguished by its unique stellate pigment cells which form the characteristic "tiger-like" markings on the surface.

Didemnum lambitum (Sluiter). Kott, 1962: 317 and synonymy; 1971: 19.

Didemnoides lambitum Sluiter, 1900: 18.

New Record: Aldinga "drop off". *Previous Records*: N.S.W.—Kott 1954, 1962. New Zealand (Chatham I., North I., South I.)—Sluiter (1900; Michaelsen 1924; Kott 1971; and unpublished records from Otago (coll. *R. Crump*) and Stewart I. (coll. *H. Batham*).

Description: Two clavate lobes arise from a common base. Maximum diameter 1.5 cm and maximum height 3.0 cm. There are traces of orange pigment in the surface test, but no superficial layer of bladder cells. There is a layer of spicules in the surface test which ceases abruptly at oesophageal level. Thin layers of spicules line the common cloacal canal. Spicules are absent at the abdominal level of the zooids, and in the central test core. They are 0.01 to 0.05 mm and stellate. Terminal cloacal aperture opens into the characteristic common cloacal cavity surrounding the central core of test. Zooids are small and crowded in the surface layer of test. The atrial aperture is wide and open. There are 8½ coils of the vas deferens around a single testis lobe.

Didemnum patulum (Herdman).

Leptoclinum patulum Herdman, 1899: 92.

New Record: Aldinga. *Previous Records*: Vic. (Port Phillip Bay)—unpublished record N.S.W. (Port Jackson) Herdman 1899.

FIG. 27

Description: Tough, investing colonies. In preservative the specimens are white with grey streaks and blotches formed by patches of stellate pigment cells in the surface test, especially in the region of the common cloacal canals. The surface of the colony is marked off into slightly raised rounded areas where solid pillars of test traverse the common cloacal cavity. Zooids are embedded in the periphery of these pillars of test and open to the surface around the raised area. The cloacal cavity is thoracic. The surface layer of test is especially thick and the zooids have especially long and muscular branchial siphons which extend through this surface layer of test. Spicules often form a plug inside the branchial siphon—possibly caused when the superficial layer of test is pulled down into the aperture as it is retracted into the surface of the test. The branchial siphon is almost the same length as the rest of the thorax. The atrial opening is wide, exposing a part of the dorsal surface of the branchial sac. The anterior border of the atrial opening

is produced into a narrow pointed languet, sometimes bidentate at the tip. There are conspicuous circular muscles in the branchial siphon, in addition to the usual longitudinal muscles that extend down the length of the thorax and into the test to form a short retractor muscle. The abdomen, of the usual form for this genus, is especially small. Oesophageal buds are present but the gonads are not mature.

Remarks: The grey veins in the surface identify this specimen with Herdman's species. The long branchial siphon and atrial lip are also distinctive. The species is especially common in Port Phillip Bay, but is not common in St. Vincent Gulf. The species also strongly resembles *D. tabulatum* Sluiter from the East Indies and Aru I. (see Sluiter 1913; Kott 1962).

Didemnum moseleyi (Herdman). Van Name, 1918: 151. Tokioka, 1955a: 212; 1955b: 44; 1959: 226; 1961: 106. Kott, 1957b: 136; 1962: 328 and synonymy. Eldredge, 1967: 213.

Leptoclinum moseleyi Herdman, 1886: 272. *Leptoclinum incanum* Herdman, 1899: 90. Herdman & Riddell, 1913: 888.

New Records: Goose I., Carickalinga Head. West I. *Previous Records*: W. Aust. (Rottnest I., Point Peron, Trigg I.). S. Aust. (Reevesby I.). Vic. (Balnarring Beach)—Kott 1962. Tas. (Spring Bay, Maria I.). N.S.W. (Port Jackson, Port Stephens, Coffs Harbour)—Herdman 1899; Kott 1962. Indian Ocean (Southern Arabia)—Kott 1957b. Indonesia (Arafura Sea)—Sluiter 1909, 1913; Tokioka 1955a. Pacific Ocean (Palau Is., New Caledonia, Philippines, Hawaiian Is., Marshall Is.)—Herdman 1886; Van Name 1918; Tokioka 1955b, 1961; Eldredge 1967.

FIG. 28

Description: Investing sheets. There is a very thin layer of surface test which is often raised into spicule-filled conical papillae between the branchial apertures. The cloacal cavity is thoracic and the thoraces of zooids are enclosed in an independent test sheath. The atrial opening is wide, in all cases exposing the branchial sac to the cloacal canal. Spicules are 0.02 to 0.04 mm in diameter with no more than 10 pointed rays in optical transverse section and are densely distributed throughout. Zooids are colourless. They are minute, the branchial sac especially small with four rows of only 6 stigmata. The vas deferens coils 6½ times around a single undivided testis follicle. In the specimens from West I. and Carickalinga Head there is a small lateral organ opposite the last two rows of stigmata.

Remarks: Eldredge (1967), discussing the difficulties in distinguishing between the present species and *D. candidum*, has suggested that in *D. candidum* the surface test is always smooth, the atrial aperture is a small slit and lateral organs are always absent. He has not been able to confirm the presence of larger numbers of vas deferens coils for *D. candidum* (Kott 1962) nor is the condition of any of these characters constant in specimens previously ascribed to the species. Only the regularly stellate spicules and dark pigmented zooids of the present specimens appear to distinguish them from *D. moseleyi* which has a variety of different types of spicules.

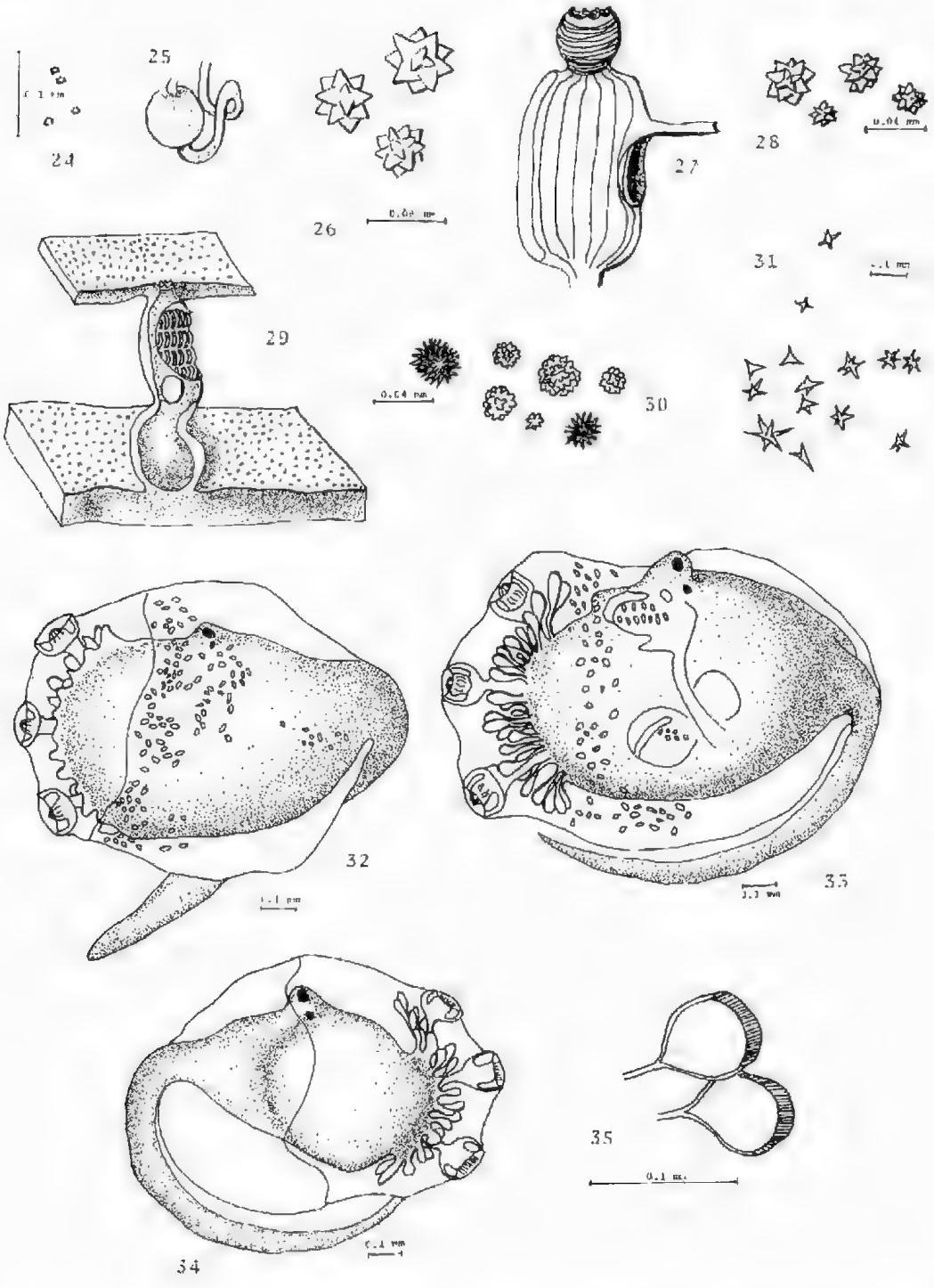
Didemnum candidum Savigny, 1816: 194. Michaelsen, 1924: 358 and synonymy. Van Name, 1945: 83. Hastings, 1931: 94. Brewin, 1946: 98; 1950a: 55; 1950b: 345; 1951: 104; 1952b: 188; 1956: 122; 1957: 577; 1960: 119. Tokioka, 1954a: 246; 1955a: 45. Kott, 1954: 162; 1962: 327. Eldredge, 1967: 213.

The above synonymy refers only to Indo-Pacific records. For full list of synonyms see Eldredge 1967: 213.

New Records: West I., Wright I. *Previous Records*: South-western Australia, Tasmania, north-eastern Australia, the English Channel, Irish Sea, West Africa, South Africa and East Africa, Red Sea, Mediterranean Sea, New Zealand, west and mid-Pacific Ocean (Marshall Is. and Hawaiian Is.), the Caribbean and West Indies and the east coast of the U.S.A. Records are lacking from the north Pacific and west coast of the American continent; but elsewhere the species occurs widely in temperate and tropical regions.

FIGS. 29, 30

Description: Colonies are flat and investing, small and rounded or more extensive sheets. The test has dense spicules throughout. In preservative the zooids are brown and show through the white spicules. The common cloacal cavity is thoracic but extensive and limited only by thin layers of surface and slightly thicker basal test in which the abdomina of the zooids are embedded. Thoraces cross the common cloacal cavity in an independent sheath of test. Spicules are dense throughout. They are 0.02 to 0.03 mm in diameter



and demonstrate the same range in form pre-almost cylindrical marginal rims stiffened by viously described for this species with up to 15the dense spicules enclosed in the test. Zooids or more rays in optical transverse section. Con-are very small. There are 4 rows of about 8 spicuous common cloacal apertures present onstigmata. No gonads were distinguished in the the surface are surrounded by protuberant,present colonies.

Remarks: The present colonial systems are typical of the species although no gonads appeared to be mature. It was not possible to confirm Eldredge's observations concerning the slit-like atrial opening as in the extended zooids of the present colonies, these were wide open, exposing a great part of the dorsal aspect of the branchial sac. The variety of spicules, therefore, remain the principal distinguishing character for this species. Carlisle (1954) has characterised specimens of *D. candidum* Savigny from the North Sea, the English Channel, north-west Africa, the Mediterranean and the Red Sea (type locality) by the absence of the third adhesive papilla in the larvae, and Lafargue (1968) confirms the condition for specimens from the French coast. The specimens agree in all other respects with those described from New Zealand, Australia, Malaysia, Japan and the Atlantic coast of America. Carlisle concludes, therefore, that: "*D. candidum* is a tropical and temperate species extending from the West Indies to the East Indies, New Zealand and Japan".

However, later workers have not observed the universal absence of a third adhesive papilla in larvae from these localities, while there are the usual three larval papillae in Australian, New Zealand and Japanese specimens. It is possible, therefore, that two separate species are involved.

Polysyncraton orbiculum Kott, 1962: 300.

New Record: Rapid Head. *Previous Records*: W. Aust. (Rottnest I.), S. Aust. (Port Noarlunga)—Kott 1962.

Description: The preserved colony is light pinkish brown, owing to the darkly pigmented zooids seen through the single layer of spicules present in the thin surface test. The dark coloured zooids are also seen through the branchial openings clearly marked on the surface test. There are the usual vesicular cells arranged in a complete circle around the branchial openings, and interrupting the otherwise even distribution of the spicules in the surface test. There is an extensive thoracic cloacal cavity, crossed by the thoraces of the zooids, each with a discrete ventral sheath of test. There is a lateral organ about halfway down the thoracic test sheath. The zooids are small, with 4 rows of stigmata. There is a long retractor muscle. These specimens conform with those described previously (Kott 1962) in all respects; however, the gonads are not mature in the present zooids.

Remarks: The condition of the cloacal cavity, the dark pigmented zooids, the rather large stellate spicules and the unique, large transparent vesicles in regular circles in the surface, together, characterise the species.

Echinoclinum verrilli Van Name, 1902: 372.
Kott, 1962: 312 and synonymy.
Diplosoma (Lissoclinum) verrilli, Eldredge, 1967: 242.

New Records: Hallett Cove. The species has been observed investing the underside of rocks at a depth of 5–20 m at many locations in St. Vincent Gulf where conditions are quiet. The colonies are so fragile, however, that they usually break up when removed (S. Shepherd, pers. comm.) *Previous Records*: Tas. (West Coast)—Kott 1954. America (West Indies, Florida)—Van Name 1902, 1945; Hartmeyer, 1909–11; Plough & Jones 1937. Africa (Accra)—Millar 1953. Japan (Sagami Bay)—Tokioka 1958.

FIGS. 31–35

Description: Living colony soft, white, jelly-like. In preservative the present colony is delicate and soft. It appears to be investing but is, unfortunately, damaged and its exact form could not be determined. Spicules are mostly 6-rayed, but there are also spicules with 4 and with 3 rays. They form a dense spiny, tough capsule around the abdomina of the zooids but are sparse in the remainder of the colony. Zooids are arranged more or less in the double rows previously described (Van Name 1945) although common cloacal openings were not detected. The cloacal canals spread out beneath the zooids which are retained in the

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Figs. 24, 25. *Leptoclinides kingi*. (Upper St. Vincent Gulf, 10–12 m). Fig. 24.—Spicules. Fig. 25. Gut loop.
Fig. 26. *Leptoclinides reticulatus*. (West I., under boulder). Spicules.
Fig. 27. *Didemnum patulum*. (Aldinga "drop-off", 3–8 m). Thorax, diagrammatic, showing musculature.
Fig. 28. *Didemnum moseleyi*. (Carickalinga Head, 5–6 m). Spicules.
Figs. 29, 30. *Didemnum candidum*. (Wright I., rough coast, 10 m). Fig. 29.—Diagram of colony. Fig. 30.—Spicules.
Figs. 31–35. *Echinoclinum verrilli*. (Hallet Cove, 8 m). Fig. 31. Spicules. Figs. 32, 33, 34.—Larvae of increasing maturity. Fig. 35.—Mature anterior ampullae of larvae.

surface test. Zooids are small with large lateral organs on each side of the thorax.

Larvae are large with a short tail which, when extended, is only half the total length of the larva. There is a large ocellus and an otolith. At least one precocious bud is present although the exact number is obscured by the layer of spherical to oval granulate bodies that extend around the posterior half of the body of the larva.

Anteriorly there are the usual three adhesive papillae in the median line and 14 ampullae from the lateral lines on either side of the suckers. Initially these lateral ampullae are very small and sessile. Subsequently they increase in size and become "tear-drop" in shape supported by very narrow stalks from the lateral line.

Remarks: It is unfortunate that the present colony is so damaged that its shape cannot be discerned. Although previously described specimens have been clavate (Kott 1954; Van Name 1945) the present damaged colony is investing and living colonies have been observed investing the under-surface of rocks. It is possible therefore that two distinct species may be involved, characterised by a difference in the consistency of the test and in the shape of the colony.

The soft nature of the colony and its tendency to break up has probably been the cause of the lack of records of this form, which is reported as common in St. Vincent Gulf.

Eldredge (1967) has suggested that the genus is synonymous with *Diplosoma* (*Lissoclinum*), due to the similarity of the cloacal systems and the fact that tetrahedral spicules are not unique in the family Didemnidae. Eldredge's contention cannot be maintained. The common cloacal cavity in the two genera is extensive and extends posterior to the zooids which remain connected to the basal test by strands of test. However, the cloacal system in *Echinoclinum* differs from that in *Diplosoma* (*Lissoclinum*) in the absence of the secondary cloacal spaces around the thoraces of the zooids which remain connected to and in the surface test in continuous rows. In *Diplosoma* (*Lissoclinum*) the secondary cloacal spaces separate either the thoraces, or the whole zooids, from one another. Further, the spicules in *Echinoclinum* are very much larger (0.05–0.1 mm) than those generally found in other genera of the family and, in addition to their unusual form and size, their distribution in the colony differs entirely from other genera of the Didemnidae. The capsules formed around the zooids by the spicules are reminiscent of the capsules formed in *Cystodytes* spp. and in no other genus of the Didemnidae do the spicules remain in such an intimate relationship with the zooid.

The genus is further distinguished by a unique larval form with a multiplicity of narrow-stalked epidermal ampullae and precocious buds. The larvae of *P. aspiculatum* and *D.* (*Lissoclinum*) spp. show a similar marked increase in the number of lateral ampullae. The ampullae in *Echinoclinum* are unique, however, in their distinct "tear-drop" shape, their narrow stalks and their discrete origin from the lateral line without subsequent subdivision. Precocious budding generally occurs in the larvae of *Diplosoma* spp. and in *D.* (*Lissoclinum*) spp. However, it also occurs in *Didemnum* (*D. pseudodiplosoma*—Kott 1962, and *D. ternatanum*—Kott 1966) and in *Polysyncraton* (*P. aspiculatum*—Kott 1962) so cannot be considered characteristic of any single genus.

The granular bodies present in the larval test are indeed similar to those found in *D.* (*Lissoclinum*) *fragile*—Eldredge 1967 and *D.* (*Lissoclinum*) *ostrearium*—Kott 1962. They do not take up haematoxylin stains (Eldredge 1967) and thus do not appear to be calcareous spicules nor their precursors, as Kott (1962) had suggested. However, despite the relationship with *D.* (*Lissoclinum*) indicated by these enclosed granules, the genus is distinct from other genera in the Didemnidae and entirely justifies its taxonomic position as a monotypic genus in that family.

Didemnum sp.

Record: West I. (near Penguin Rock).

Description: Living colony "yellow, crustose". In preservative the investing colony is a light fawn colour. There are common cloacal apertures with large spicule-filled lips scattered over the surface of the colony. Zooids are suspended between the basal and surface layers of test by connecting columns of test in which the abdomina are embedded in clumps, although the zooids are separated from one another in their own discrete sheath of test, open to the common cloacal cavity on the dorsum. Stellate spicules are thick throughout the test. The branchial siphons are fairly long with distinct circular muscles. There are large oval lateral organs on either side of the thorax. There are four rows of stigmata.

Remarks: The gonads are not developed and a definitive identification of the genus is therefore not possible. The condition of the colony with a well developed posterior abdominal cloacal canal is reminiscent of certain species of *Didemnum*.

Suborder PHLEBOBRANCHIA
Family CORELLIDAE
Subfamily RHODOSOMATINAE

Rhodosoma turcicum (Savigny). Kott, 1952: 317 and synonymy; Tokioka, 1952: 111; 1953a: 230.

Phallusia turcica Savigny, 1816: 102.
Rhodosoma papillosum, Van Name, 1918: 113 and synonymy, Hartmeyer, 1919: 95.

New Record: Hallett Cove. *Previous Records*: N.W. Aust. (Cape Jaubert)—Hartmeyer 1919. S. Aust. (Port Noarlunga). Qld.—Kott 1952. Indonesia—Sluiter 1904; (Aratura Sea)—Tokioka 1952. Indian Ocean (Ceylon)—Herdman 1906. Pacific Ocean (Philippines, California)—Van Name 1918, 1945; (Chile)—Traustedt 1882, 1885; (China)—Stimpson 1855; (Japan)—Oka 1927; Hartmeyer 1906; Tokioka 1953a. Red Sea—Ehrenberg 1828. Mediterranean—Lacaze-Duthiers 1865. The species is also recorded from the Caribbean region (Van Name 1945).

Remarks: Nothing further can be added to the description of this cosmopolitan but rare species. It is never taken in large numbers, nor is it taken very often. The species is, however, not inconspicuous. It is probable that, with its highly developed closing mechanism, it may exhibit a high degree of viviparity. In which case it is probable that relatively few larvae are incubated, and that the free-swimming time of larvae is short. The dispersal of larvae could be, therefore, limited, and the survival of the apparently small populations of the species enhanced by larval settlement close to the parent zooids. The species has been taken from a wide variety of depths. Unfortunately, little is known of the current conditions at locations from which the species has been taken, but it is possible that it favours less turbulent conditions where there is minimal current flow so that the larvae would be even less exposed to dispersal.

Only a single specimen is present in this collection.

Subfamily CORELLINAE

Corella eumyota Traustedt, 1882: 271; Kott, 1969: 84 and synonymy; 1971: 20.

New Records: Hallett Cove, King Beach. *Previous Records*: W. Aust. (Trigg I.)—Kott 1952. Vic. (Balnarring Beach, Frankston)—Kott 1952; Millar 1966. Tas. (D'Entrecasteaux Channel). New Zealand (North and South Is.)—Sluiter 1898; Michaelsen 1922; Brewin 1946, 1948, 1950a, 1957, 1960. South Africa—Sluiter 1898; Michaelsen 1915; Millar 1955, 1962. The species also has a wide circumpolar distribution in the Antarctic (Kott 1969).

FIG. 36

Description: The living specimens were noted as transparent and no colour was recorded. There are both separate individuals and individuals aggregated together more or less in a line. Zooids are generally fixed to one another or to the substrate by almost the whole of the right side. The test is thick, gelatinous and semi-transparent. On the right side of the body where it is fixed to the substrate the body wall is especially thin and there are no muscles except those which radiate a short distance from the branchial siphon. On the upper or left side of the body there are mostly transverse muscles branching and ramifying and some short and more regular transverse muscles in a single row extending around the ventral border. The branchial siphon is terminal and on a short cylindrical siphon. The atrial aperture is sessile and from the posterior third of the dorsal border. The branchial sac, gut and gonads are of the usual form characteristic of the genus.

Remarks: These specimens do not differ in any way from other specimens of this ubiquitous species which has been recorded in very large numbers from open sea locations in circumpolar waters of the Antarctic and the sub-Antarctic (Kott 1969, 1971). The northern extent of the recorded range is at Trigg I. (Kott 1962) on the western coast of Australia, but the species has not been taken on the eastern coast of the Australian mainland; the most easterly record on the Australian coast is at Frankston in Victoria (Millar 1966).

Family ASCIDIIDAE

Phallusia depressiuscula (Heller). Kott, 1972: 8 and synonymy.

Ascidia depressiuscula Heller, 1878: 5; Herdman, 1906: 305.
Ascidia julinea, Vasseur, 1967: 129.

New Records: Tapley Shoal, off Port Gawler, off Grange, off West Beach, Hallett Cove, off Port Stanvac, Wright I. *Previous Records*: W. Aust. (N.W. Aust., Shark Bay, Fremantle)—Hartmeyer 1919; Michaelsen & Hartmeyer 1928; Millar 1963. N.S.W. (Port Jackson)—Herdman 1899. Qld. (Great Barrier Reef)—Hastings 1931; Kott 1952, 1966. Bass Strait (East Moncoeur I.) —Herdman 1882. Pacific (Philippines, Palao Is., New Caledonia)—Van Name 1918; Tokioka 1950; Vasseur 1967. Indo-Malaya (Ceylon, Indonesia, Arafura Sea)—Heller 1878; Herdman 1906; Sluiter 1919; Tokioka 1952. The species is known intertidally and to 52 m.

Description: Living specimens from off Hallett Cove are noted as large, white or transparent, and common on sandy bottom. Many living specimens, however, are bluish, with black and yellow markings. The preserved specimens may be whitish, or blackish grey and may have black spots in the surface test. The test is thick and firm, smooth on the surface with rounded ridges and swellings. The individuals reach a large size. The present specimens exhibit the range of variation described by Kott (1966) for the species.

Remarks: The relationship of *Phallusia julinea* Sluiter to the present species remains in doubt. The specimens in the present collection have the atrial aperture from the anterior third of the body while specimens of *P. julinea* have been distinguished by the position of the atrial aperture from the posterior third of the body.

Ascidia sydneyensis Stimpson (?part), 1885: 387, Kott, 1972 and synonymy.

New Records: Tapley Shoal, Hallett Cove, Port Noarlunga, Wright I. *Previous Records*: W. Aust. (Cape Jaubert to Albany)—Hartmeyer 1919; Michaelsen & Hartmeyer 1928; Millar 1963. S. Aust. (Victor Harbor, Port Noarlunga). Vic. (Balnarring Beach, Point Leo, Port Phillip Bay)—Kott 1952; Millar 1960; 1963; 1966. Tas. (Spring Bay). N.S.W. (Port Jackson)—Stimpson 1855; Herdman 1882, 1899. Qld. (Caloundra to Townsville)—Schmeltz 1879; Kott 1962, 1966. Indonesia (Arafura Sea)—Sluiter 1886, 1904; Tokioka 1952. Pacific Ocean—Traustedt 1885; (Palao Is., New Caledonia) —Tokioka 1950; Vasseur 1967. Japan—Hartmeyer 1906; Tokioka 1953a, 1954b. Indian Ocean (Seychelles) — Michaelsen 1918; (Zanzibar)—Traustedt & Weltner 1894; (East Africa)—Millar 1956. South Africa—Heller 1878; Hartmeyer 1911, 1913; Sluiter 1898; Millar 1955, 1962. The species is also recorded from the Caribbean region (Van Name 1945). It is taken intertidally and to 30 m.

FIGS. 37, 38

Description: The living specimens are transparent and fleshy. The largest specimens in the present collection are 20 cm long and 12 cm wide. The test is thin, but firm and tough, and in larger specimens slightly leathery. There is sometimes, especially on the larger specimens, a very sparse encrustation of weed and worm tubes. Both the branchial and atrial apertures are on short cylindrical siphons and are usually about half the body length distant from one another. Specimens may be fixed to the substrate by the posterior, ventral, or left side of the body. The branchial siphon is turned away from the atrial siphon to varying extents. There is a row of short transverse muscle bands around the dorsal and ventral borders of the right side of the body. The gut is always filled with mud, which appears to accumulate during the life of the individual until in larger specimens the gut is so swollen with mud that the branchial sac is occluded and confined to a small area to the right and dorsal to the mud-filled gut. This mud begins to collect, in smaller specimens, in the descending limb of the primary gut loop, beyond the stomach, and it extends from there into the rectum and continues to accumulate in these sections of the intestine.

Remarks: The physiological significance of the mud-filled gut which appears to be characteristic of this species is not known. It has been noted in specimens from all parts of the Pacific. Abbott (pers. comm. 1955) noted that it appears to be associated with the termination of the typholosole at the top of the gut swelling instead of extending further down the intestine. The stomach appears to be free from the mud accumulation, but distal to the stomach the gut becomes so distended and the whole body inside the test becomes so compressed by it that it is difficult to imagine normal feeding and respiratory functions proceeding. Some of the mud must be lost through the anus and

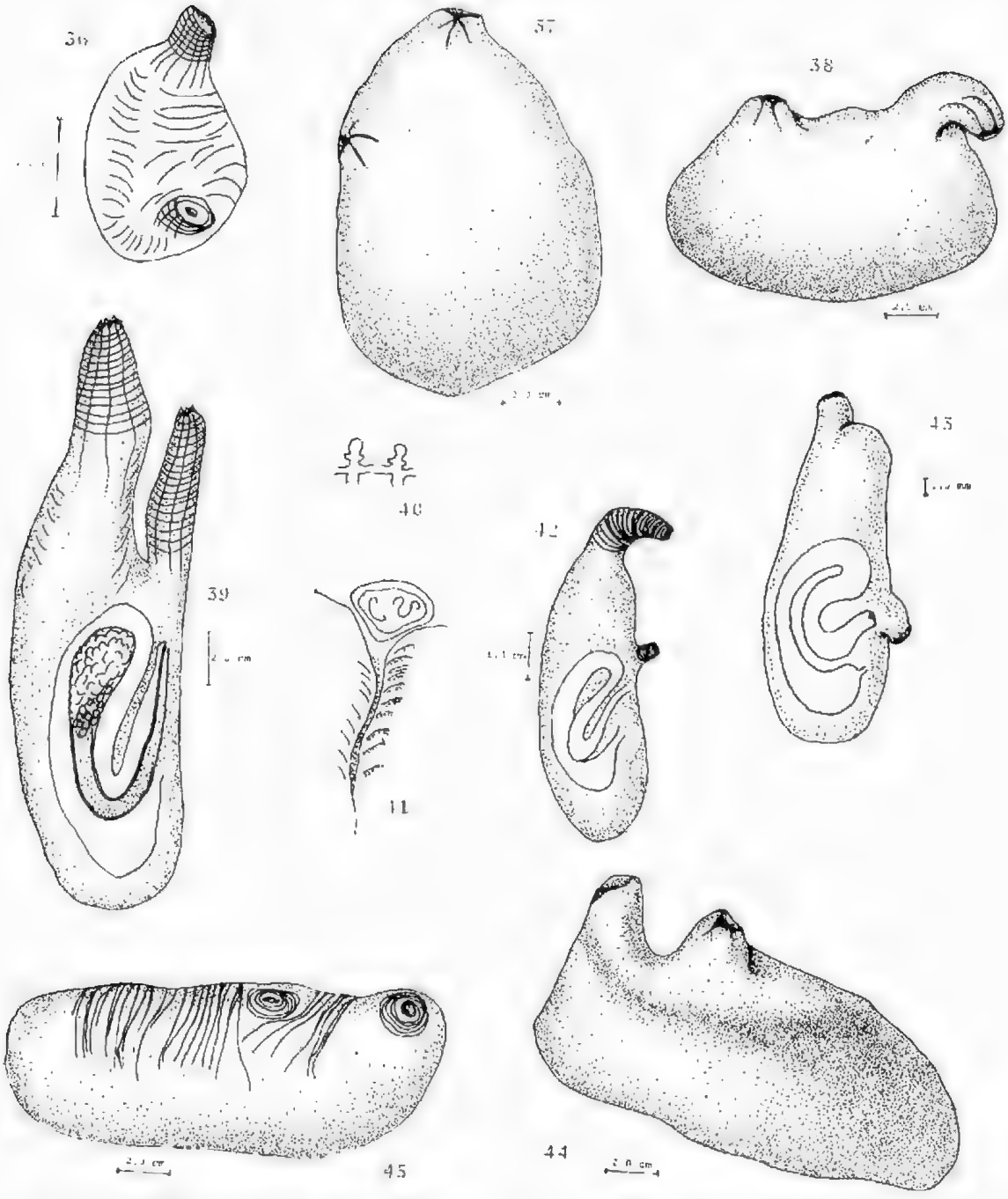


Fig. 36. *Corella eumyota*. (Hallett Cove, 25 m). Individual removed from test.
Figs. 37, 38. *Ascidia sydneyensis*. Fig. 37.—Individual from Tapley Shoal, 13 m. Fig. 38.—Individual from Wright I., 10 m.
Figs. 39, 40. *Ascidia gemmata*. (Upper St. Vincent Gulf, 10–12 m). Fig. 39. -Individual removed from test. Fig. 40.—Diagrammatic section through branchial papillae.
Figs. 41–43. *Ascidia thompsoni*. Fig. 41.—Dorsal lamina. Fig. 42.—Individual removed from test (Carickalinga Head, 5–6 m). Fig. 43.—Individual in test (off West Beach, 8 m).
Figs. 44, 45. *Ascidia aclara*. (Off Seacliff, 16 m). Fig. 44.—Whole individual. Fig. 45.—Individual removed from test.

atrial opening and until observations are made on living specimens, it must be assumed that the property of the distal part of the gut to distend itself in this way is characteristic of the species and results in the accumulations of gut contents at a greater rate than they are removed from the body.

Ascidia gemmata Sluiter, 1895: 177. Kott, 1966: 296 and synonymy. Tokioka, 1967: 140.

New Records: Upper St. Vincent Gulf, off Port Gawler, off Glenelg. *Previous Records*: W. Aust. (Cape Jaubert to Albany)—Hartmeyer 1919; Michaelsen & Hartmeyer 1928; Kott 1952. Vic. (Port Phillip Bay)—Kott 1952; Millar 1966. N.S.W. (Port Jackson, Arrawarra)—Herdman 1899; Kott 1952. Qld. (Hervey Bay)—Kott 1966. Indo-Pacific (Indonesia)—Sluiter 1904; Tokioka 1952; (Palao Is., New Caledonia, Marianas Is., Caroline Is., Wake Is.)—Tokioka 1950, 1961, 1967.

FIGS. 39, 40

Description: Externally the test is fairly thin and flaccid and is slightly irregular. The branchial aperture is terminal on a short cylindrical siphon. The atrial aperture is on a similar but generally shorter siphon from the antero-dorsal aspect of the body. Both siphons are regularly grooved externally along their length. Individuals are attached by almost the whole of the left side. Internally the atrial siphon arises from half way down the body and is especially long. The branchial siphon is also long internally. There are circular and longitudinal muscles around both the siphons and these extend only a short distance posterior to the siphons on the left side of the body where there is no musculature. On the right side of the body the longitudinal muscles from the siphons mingle with the irregular meshwork of muscles which occupy the whole body wall on the right side. There is only a very narrow prebranchial area terminated anteriorly by very numerous branchial tentacles, and covered with minute papillae. The dorsal tubercle is a fairly large circular cushion with a U-shaped slit turned to the right and with the posterior horn turned in. The peritubercular area is shallow and is completely filled by the dorsal tubercle. The dorsal lamina is a broad, single membrane, strongly ribbed on both sides. The ribs of the dorsal lamina extend into pointed languets on the free margin. There is a long neural gland almost one-third of the body distant from the dorsal tubercle. The branchial sac is simply folded between each longitudinal vessel and has 4 to 8 stigmata in each mesh. There are large spatulate papillae at the junctions of the longitudinal and transverse vessel and these are expanded into rounded expansions on either side of their base. The gut forms a deep double loop enclosing the gonads in the primary loop. The pole of the gut loop in the large specimens available in this collection does not extend anterior to the base of the atrial siphon and is level with the anus. There is, however, some variation according to the size of the specimens and in smaller specimens (Michaelsen & Hartmeyer 1928; Millar 1966) the gut loop extends anterior to the atrial siphon and occupies a relatively larger portion of the left side.

Remarks: This species has been recorded often from locations around Australia extending north to Indonesia and into the Pacific (Tokioka 1967). The species is distinguished by the absence of intermediate papillae in the branchial sac, by the heavily ribbed broad dorsal lamina, and by the origin of the atrial siphon from the middle of the body. Although in the present specimens the atrial siphon is long and directed anteriorly, in specimens previously described there is a great variation both in the length of the atrial siphon and in its orientation (Michaelsen & Hartmeyer 1928). Specimens have been described with sessile external apertures and it is probable that the present specimens with short grooved cylinders represent more mature individuals. Externally the species resembles both *A. sydneyensis* and *A. thompsoni* and it is probable that in all these species the test is firmer and relatively thicker and the external siphons less evident in the younger specimens, while in older specimens the test becomes rougher externally and less transparent, and the external siphons develop as short grooved cylinders. The body musculature, concentrated on the right and on the siphons, is so arranged that the left side, fixed to the substrate, does not contract over the voluminous gut. In these species the gut occupies a relatively smaller proportion of the body wall as the individual increases in size. In *A. gemmata* growth appears to increase the proportion of the body anterior to the gut, and although the point of origin of the atrial siphon remains about one half to two thirds of the distance down the body, the gut does not appear to increase in size at the same rate as the rest of the body. The orientation of

the rectum and the curvature of the gut loop is therefore reduced as growth proceeds. It is also possible that this differential growth causes the variations that have been observed in the length and orientation of the atrial siphon, although this may also be affected by the orientation of the body on the substrate.

Ascidia malacca australiensis Hartmeyer, 1928, resembles the present species in the presence of a broad ribbed dorsal lamina with the free margin produced into pointed projections corresponding to the ribs. However, the species is distinguished by the specially long external siphons, by the dorsal ganglion which is only one-ninth to one-thirteenth of the body length from the dorsal tubercle, and by the small stumpy cone-like branchial papillae as opposed to the spatulate papillae of *A. gemmata*. Hartmeyer's subspecies was recorded from a seasonally brackish environment in Freshwater Bay, a considerable distance up the Swan River estuary from Fremantle Harbour and he regarded it as an isolated endemic species.

Ascidia thompsoni Kott, 1952: 312.

New Records: Off West Beach, Hallett Cove, Carickalinga Head. *Previous Records*: Tas. (Great Taylor Bay)—Kott 1952.

FIGS. 41–43

Description: In smaller specimens the test is firm and almost glassy and transparent. Anteriorly, expanded terminal ampullae of the test vessels are clearly visible through the test. Individuals from 2 to 7 cm long are available in the present collection. Both apertures are sessile, the branchial aperture terminal and the atrial aperture two-thirds of the distance down the dorsal surface. Most individuals are firmly fixed by the whole of the left side, however the specimen from Carickalinga Head is fixed posteriorly. The body musculature is present only on the right side, consisting of a mesh of transverse and longitudinal vessels. Internally the atrial aperture is on a siphon of variable length rising opposite, anterior or posterior to the external opening. The atrial siphon shows the same variations in length and orientation as have been described previously for *A. gemmata* (Michaelsen & Hartmeyer 1928; Millar 1966). Both siphons are well equipped with circular and longitudinal muscles. There are about 40 branchial tentacles, a papillated prebranchial area, a shallow peritubercular area completely filled by the dorsal tubercle which generally has a simple U-shaped opening. In an especially large and opaque specimen from West Beach (at 8 m) there is a second opening to the right of the larger U-shaped opening. The dorsal ganglion is about half the body distant from the dorsal tubercle. The dorsal lamina is a wide membrane, double for about one-sixth of its length. The right section of the double membrane is plain, the left section is ribbed on the left. For the remainder of its length the dorsal lamina is a single membrane ribbed on the left side, although these ribs do not extend to the outer margin of the membrane. There are minute and irregular papilla-like expansions from the free border of the membrane in its posterior extent. Intermediate branchial papillae are generally present, especially in the posterior part of the branchial sac. The intermediate branchial papillae are half the size of the primary papillae, and both are pointed. The gut is voluminous and forms a deep double loop which varies slightly in relation to the atrial siphon as the individual grows, as in *A. gemmata*.

Remarks: The double dorsal lamina with slightly irregular membranous border posteriorly and the form of the intermediate and primary branchial papillae distinguish this species from the very similar *A. gemmata* with which its geographic range overlaps. The origin and the variable orientation of the atrial siphon are shared by the two species, and in both, owing to differential growth of the body, the gut loop is confined to the posterior half of the left side in larger specimens. It is of considerable interest that the present species has been recorded only from fairly sheltered coastal environments (subject however to some wave action) in the present collections, while *A. gemmata* was taken only from Offshore Benthic locations subject to currents in middle and upper St. Vincent Gulf.

Ascidia aclara Kott, 1952: 309. Millar, 1963: 721.

New Record: Off Seacliff. *Previous Records*: Vic. (Lakes Entrance, Port Phillip Bay)—Kott 1952; Millar 1963. Qld. (Moreton Bay)—unpublished records.

FIGS. 44, 45

Description: There are two specimens in the present collection, maximum length 17 cm and 10 cm high. The body is slightly dorso-ventrally flattened. The test is rigid and encrusted with sand and shell particles and is produced into two rigid cylindrical tubes from around

the branchial and atrial apertures at the anterior end of the dorsal surface and from about one-third of the distance along the dorsal surface respectively. The apertures are completely sessile and lie at the base of these tubes. The body musculature, within this rigid test, is reduced to strong bands across the dorsal surface posterior to the atrial aperture and between the atrial and branchial apertures. Internally the specimens are exactly as previously described with the branchial sac forming a fold across the dorsal tubercle. The gut forms the usual simple open loop, opening adjacent to the atrial aperture.

Remarks: This unusual species appears to be highly specialised for an existence on a sandy bottom, with the rigid tubes extending vertically from the apertures forming a permanently open channel through the layer of sand in which the species is probably buried. It is probable that the immediate environment outside the apertures is modified by these permanently open chambers to facilitate a less interrupted feeding process and confer distinct advantages in locations where steady flowing currents and absence of sedimentation pertain. The species is also of considerable interest in that its records are confined to the semi-enclosed waters indicated above. It is possible that there is a wider, more continuous distribution on the continental shelf or, alternatively, that it represents a relict population of a species which once had such a continuous distribution on the open coast.

Suborder STOLIDOBRANCHIA

Family STYELIDAE

Subfamily POLYZOINAE

Stolonica australis Michaelsen, 1927: 202. Michaelsen & Hartmeyer, 1928: 352. Kott, 1952: 253.

New Records: Tipara Reef, Port Noarlunga. *Previous Records*: W. Aust. (Albany)—Michaelsen 1927; Michaelsen & Hartmeyer 1928. Tas. (Spring Bay)—Kott 1952.

FIG. 46

Description: Rounded, sandy, stalked or sessile individuals connected to basal stolons, 0.6 to 0.7 cm maximum diameter. The colonies in the present collection are encrusting specimens of *Pyura irregularis* and *Polycarpa pedunculata*. The apertures are both sessile on the upper surface. There are two folds on either side of the branchial sac with 6 to 9 internal longitudinal vessels. The gut loop is simple and open with a gastro-intestinal ligament enclosing a rounded endocarp in the pole. The short stomach has about 18 folds. It is reduced in diameter at either end and has a thick pyloric caecum of moderate length. Gonads are not mature in the present specimens and their arrangement could not be determined. The ligaments anchoring the gut to the body wall extend in a row along the lateral aspect of the intestine. There are also large ligaments anchoring the stomach and the pole of the gut loop.

Remarks: This species appears to be confined to the southern coast of Australia, but has been recorded only from locations away from the open coast. It is inconspicuous, however, and it is possible that its occurrence in protected locations on the open coast has been overlooked. In the absence of mature gonads the species may be distinguished from *Amphicarpa diptycha* by the low rounded branchial folds, the presence of a curved pyloric caecum and the less developed musculature.

Stolonica carnosa Millar, 1963: 734.

New Record: Tipara Reef. *Previous Record*: W. Aust. (Cottesloe).

FIG. 47

Description: The colony is oval, 3 cm long, 2 cm wide and 1 cm thick and, as in the type specimen, has developed around an algal stem. The 4-lobed apertures of zooids are close together on slight swellings all around the outer surface which is encrusted with sand. There is no sand inside the colony. Each individual is dorso-ventrally flattened and most of its left side is directed toward the centre of the colony. There are 2 folds on each side of the branchial sac with internal longitudinal vessels according to the following formula: E O(5)4(6)1 DL. There are only 5 stigmata between the endostyle and the ventral fold.

The gut forms a rounded loop and the rectum turns anteriorly and dorsally at a sharp angle. The stomach is pyriform, narrowest at the cardiac end, has 15 narrow folds and a very long, curved pyloric caecum in the pole of the gut loop. There is a gastro-intestinal ligament and ligaments connecting the gut loop to the body wall as in *Distomus diptycha* (see Kott 1952). The anus is 2-lipped. The gonads are in single rows on each side of the endostyle. The testes are flask-shaped and the ovaries contain 3 eggs of varying sizes, and a testis and an ovary are generally loosely associated so that there are 6 to 7 hermaphrodite gonads on each side of the body.

Remarks: Although in Millar's specimen the testes and ovaries appeared often to be separate, the condition and the arrangement of the gonads in the present colony suggest that this is more apparent than real, and may depend on the relative stages of development of the ovary.

In Millar's specimen the stomach is folded internally but externally the folds were probably obscured by the membrane covering them. The course of the rectum in the present specimen also differs from Millar's specimen and is bent back against the gut loop, probably by dorso-ventral flattening of the individual. The extent of this dorso-ventral flattening, therefore, is an individual, rather than a specific, character.

Oculinaria australis Gray, 1868: 564. Kott, 1952: 251 and synonymy. Millar, 1963: 734; 1966: 369.

New Records: West I. (Seal Rock), Wright I. *Previous Records*: W. Aust. (Fremantle to Albany)—Gray 1868; Michaelsen & Hartmeyer 1928; Kott 1952; Millar 1963. Vic. (Port Phillip Bay)—Millar 1966.

Description: Colonies of the usual form with numerous zooids closely coalesced, identified only by the paired apertures on wart-like siphons from the anterior surface of each zooid which project slightly from the otherwise compact colony. The test is very brittle and completely impregnated with sand. There are 4 branchial folds on each side of the body with 4 to 8 longitudinal vessels on each fold and about 4 between the folds. The gut loop is as previously described, with about 18 spiral folds in the stomach wall. No pyloric caecum has been detected. There is an elongate gastric gland reservoir extending between the stomach and the intestine. There are up to 9 long gonads on the right side of the body, a larger number than has previously been recorded for this species. There is a single row of testis lobes beneath each short ovary.

Remarks: The species is well adapted, by its compacted form, for the occupation of turbulent locations and, in fact, it has been recorded only from the exposed open coast. Externally it resembles colonies of *Polyandrocarpa* spp. from which it is readily distinguished not only by the location of the gonads on one side of the body, but also by the spiral course of the stomach folds, the presence of a gastro-intestinal reservoir and the form of the gut loop.

Subfamily BOTRYLLINAE

Botryllodes leachi (Savigny). Michaelsen & Hartmeyer, 1928: 341 and synonymy. Millar, 1952: 24; 1962: 177. Kott, 1952: 258; 1966: 297.

Botryllus leachii Savigny, 1810?: 7.

New Records: Tipara Reef, Port Noarlunga, West I., Wright I. *Previous Records*: W. Aust. (Geraldton to Albany)—Michaelsen & Hartmeyer 1928; Kott, 1952. N.S.W. (Port Jackson)—Herdman 1899. Qld. (Moreton Bay)—Kott 1952; (Sarina)—unpublished record. Northern Territory (Darwin)—Kott 1966. New Zealand (Hauraki Gulf)—Michaelsen 1921; Brewin 1948; (Stewart I.)—Michaelsen 1921; (French Pass)—Sluiter 1900; (Otago Harbour)—Brewin 1946; (Auckland I.)—Bovien 1922. South Africa—Hartmeyer 1912; Millar 1962. The species is also known from the North Atlantic, the North Sea and the Mediterranean and Adriatic (see Hartmeyer 1923, Ärnbäck 1923, and Millar 1952).

Description: Living colonies from Oedipus Point, West I. have a colourless matrix and red zooids, while in those from Port Noarlunga the matrix is transparent and the zooids yellow-bright orange. All the colonies have translucent test and purple zooids in preservative. Colonies form flattened, long, lobes with a short stalk. There are circular to oval systems of closely packed zooids. The test is firm and transparent. The system of zooids are arranged in rows along the length of the head. These systems may appear to be confluent and form almost continuous rows, but in fact separate cloacal openings remain in the centre of a limited number of zooids and discrete circular to oval systems are maintained. There are 9 to 12 rows of about 20 stigmata. The stomach is long, with 10 folds and a very short caecum.

Remarks: The form of the colonies is very similar to those of *B. magnicoecum* but the circular systems and firm test, with common cloacal openings along the sides of the lobes are distinctive. The shape of the stomach and the form and length of the pyloric caecum is similar to the condition found in *B. nigrum*. However, the smaller number of rows of stigmata with more stigmata in each row also distinguishes this species from both *B. magnicoecum* and from *B. nigrum*. Records for this species extend from the North Atlantic to the Mediterranean and Pacific Oceans, and from all around Australia. It is not known from the

Indian Ocean beyond the West Australian coast nor is it known from the South Atlantic.

Botrylloides nigrum Herdman, 1886: 50. Van Name, 1945: 227 and synonymy. Kott, 1952: 257

Sarcohotrylloides jacksonianum Herdman, 1899: 102.
Sarcohotrylloides pannosum Herdman, 1899: 105.

New Records: Port Gawler, off West Beach, off Seacliff, Carickalinga Head, Rapid Head, West I. (near Penguin Rock, Seal Rock), Wright I. *Previous Records*: W. Aust., S. Aust. Vic.—Kott 1952. N.S.W. (Port Jackson)—Herdman 1899; Kott 1952. Qld.—Kott 1952. Indo-Malaya (Ceylon)—Herdman 1906; (Red Sea)—Michaelsen 1919. East Africa—Sluiter 1898; Michaelsen 1918. ?South Africa—Hartmeyer 1912. The species is also recorded from the Caribbean region (Van Name 1945).

Description: Colonies investing sheets sometimes extended into irregular lobes. The zooids are arranged in long double row systems well separated from one another with transparent test between. In preservative the zooids are purple-black with the pigment contained in cells in the body wall. The colour of the preserved specimens does not reflect the variations in colour of the living specimens which are: "dark blue and bright purple" zooids (West I.); or "yellow and mustard" (off West Beach). There are 16 rows of about 12 stigmata with 3 internal longitudinal vessels on each side of the branchial sac. The atrial opening exposes the anterior half of the dorsal surface of the branchial sac, but the lip from the anterior border of this opening is not especially pronounced. The stomach is the usual long organ characteristic of this species, with 10 folds. It is wider at the cardiac end and reduced in width at the pyloric end where there is a very short caecum.

Remarks: Although the variation in colour and the irregularity of the colonies make this species difficult to identify in the field, the shape of the stomach with its short caecum and the widely spaced double rows of zooids are distinctive. Its recorded distribution is wide in the Indian Ocean and from the West Indies. At this stage there is no known character available to indicate that all these records refer to more than the one species with an almost circumpolar distribution, in the southern temperate region, absent only from the middle and eastern Pacific Ocean.

Botrylloides magnicoecum Hartmeyer. Kott, 1952: 258. Millar, 1966: 368.

Botrylloides nigrum var. *magnicoecum* Hartmeyer, 1912: 271.
Botryllus magnicoecus. Michaelsen, 1923b: 50; 1923c: 6. Michaelsen & Hartmeyer, 1928: 331 and synonymy. Hastings, 1931: 79. Brewin, 1951: 109. Millar, 1955: 195; 1962: 175. Tokioka, 1967: 153.
Botryllus aureus Michaelsen & Hartmeyer, 1928: 335. Millar, 1963: 736.
Polycyclus rufus Oka, 1927: 608
Botryllus rufus. Tokioka, 1953b: 240.

New Records: Off West Beach, West I., Wright I. *Previous Records*: W. Aust (Shark Bay)—Michaelsen & Hartmeyer 1928; S. Aust., Tas.—Kott 1952. Vic (Port Phillip Bay)—Millar 1963, 1966. N.S.W. (Port Jackson) -Herdman 1891; Millar 1963. Qld. (Great Barrier Reef)—Hastings 1931. New Zealand (North I.)—Michaelsen 1921; Brewin 1951. Japan—Tokioka 1952; Oka 1927. China (Hong Kong)—Michaelsen 1923a; Tokioka 1967. Indian Ocean (Paumbur) — Michaelsen 1923a. South Africa—Hartmeyer 1912; Millar 1955, 1962. South West Africa—Hartmeyer 1913; Michaelsen 1915. Natal—Michaelsen 1918, 1921. Europe (Portugal) ?var.—Michaelsen 1923b; (Mediterranean) ?var.—Michaelsen 1923b.

Description: The living colonies from West I. are "bright yellow" although other specimens are "greyish with pale zooids". In preservative, however, all the colonies are purple owing to the pigmentation of the zooids which shows through the very soft transparent test. The colonies in this collection always consist of soft, long, narrow, flattened, stalked lobes with zooids arranged in closely set double rows running parallel to the length of the lobes. Zooids are absent from the stalks. In preserved specimens there is always an accumulation of dark pigment at the top of the endostyle and on either side of the base of the branchial aperture. Common cloacal openings are always present around the free end of the lobe as in *Sycozoa* spp.

There are 14 rows of stigmata in the present specimens with 3 to 4 stigmata between the longitudinal vessels. The stomach is short and rounded with 9 folds and a long caecum curving into the pole of the gut loop.

Remarks: Millar (1963) regards the form of the colony of the Australian specimens (long stalked lobes) as providing a character which distinguishes it from the South African forms which are irregularly lobed and investing, as

are Brewin's specimens from New Zealand. The closely set double row branching systems are present in all the specimens represented in the synonymy above and all these specimens have the characteristic short, rounded, stomach with a long curved caecum, distinguishing them from other species of the genus. It is possible that the Australian members of this species may represent a geographic subspecies characterised by the particular form of the colony with terminal cloacal apertures and close-set double rows of zooids parallel to the longitudinal axis of the head. *Botrylloides leachi* colonies are similarly lobed but the cloacal apertures are present along the side of the head between the double row of zooids.

Botryllus schlosseri (Pallas). Van Name, 1945: 220 and synonymy. Kott, 1952: 259 (part).

Alcyonium schlosseri Pallas, 1766: 355.
Non *Botryllus schlosseri*. Kott, 1952, from Hamelin Bay and Green Pools, W.A.

New Record: Off Hallett Cove. *Previous Records*: W. Aust. (Shark Bay, Fremantle)—Hartmeyer & Michaelsen 1928; Kott 1952. Vic. (Port Phillip Bay)—Millar 1966. Elsewhere the species has a wide distribution from the Faeroe Is. and southern Norway, the British Isles, the North Sea, the Mediterranean, Adriatic and Black Sea; from the eastern and western seaboards of the U.S.A. and from New Zealand (see Van Name 1945).

The local abundance of this species and its occurrence on wharf piles, ship hulls, buoys, etc. in shallow water has been pointed out by Van Name (1945). This wide cosmopolitan distribution suggests that, like *Ciona intestinalis*, the species favours sheltered locations and is transported largely by ships.

Description: The specimens are delicate and invest the sea grass *Posidonia australis*. The test is almost completely transparent and the zooids are pale grey. Zooids form small circular systems which are crowded close together in the test. The zooids are relatively short, with only about 8 rows of stigmata. The atrial aperture is on a siphon produced to a varying extent and the upper margin of the aperture is produced into a lip. There is a conspicuous pyloric caecum with a large bulb-like expansion on its free end. The stomach has about 10 very fine folds, is longer than wide, and is only of slightly greater diameter than the rest of the gut. Developing embryos are present in the peribranchial cavity of some of the zooids, but on the right side of the body only.

Remarks: The zooids in a colony of the present specimens are identical with those described for *Botryllus gracilis* Hartmeyer & Michaelsen, 1928; Millar, 1966, from Shark Bay, Western Australia and from Port Phillip Bay. Millar (1966) regards this type of thin transparent colony as a species distinct from *B. schlosseri*. Juvenile colonies of *B. schlosseri* as described by Verrill (Verrill & Smith 1873) are identical with the present colony and the zooids are identical with those previously described for this species especially in regard to the atrial opening, stomach and pyloric caecum, and it is unlikely that *B. gracilis* is distinct from *B. schlosseri*.

Subfamily STYELINAE

Cnemidocarpa etheridgii (Herdman)

Styela etheridgii Herdman, 1899: 38. Kott, 1952: 219 and synonymy; 1964: 139 (f. *personata*). Millar, 1966: 370.

New Records: Tapley Shoal, off West Beach, West I. (off Oedipus Point), Wright I. *Previous Records*: W. Aust. (Trigg I.), S. Aust. (Spencer Gulf and St. Vincent Gulf). Vic. (Phillip I.)—Kott 1952; (Port Phillip Bay)—Millar 1966. Tas. (D'Entrecasteaux Channel)—Kott 1952. N.S.W. (Port Jackson, Port Stephens)—Herdman 1899. Qld. (Moreton Bay)—Kott 1964. The species is known intertidally and down to 30 m. It is abundant in St. Vincent Gulf on sandy bottoms at 7–20 m with slow currents, and on open coasts in deeper water of 20–30 m (Shepherd, pers. comm.).

FIGS. 48, 49

Description: Individuals are large, up to 11 cm high, rounded and of greatest diameter posteriorly, gradually reducing in diameter to the terminal branchial aperture. The terminal branchial aperture is sometimes curved. The atrial aperture is on a slight rounded projection from about half way along the dorsal surface. Colour of living specimens varies from pale cream to bright yellow (most often the latter). In preservative the test is white and opaque, with longitudinal furrows converging to the branchial aperture on that part of the body anterior to the atrial aperture. The test is thin and leathery. There are up to 25 internal longitudinal vessels on the folds and up to 7 between, although in some specimens there are as few as 4 internal longitudinal vessels between the folds. There are 6 stigmata per mesh.

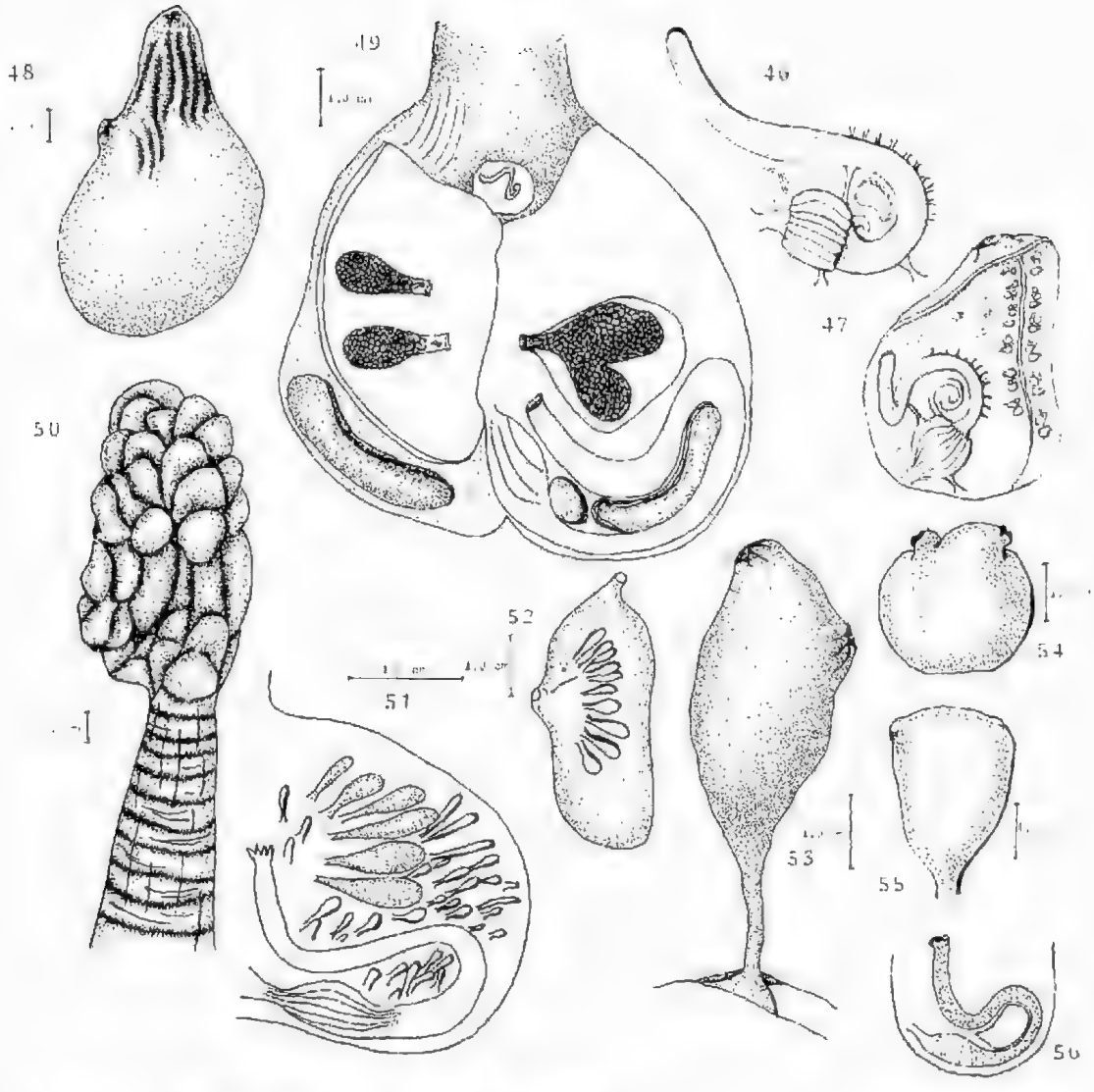


Fig. 46. *Stolonica australis*. (Tipara Reef). Gut loop.
Fig. 47. *Stolonica carnosa*. (Tipara Reef). Right side of body removed to show organs on left body wall.
Figs. 48, 49. *Cnemidocarpa etheridgii*. (Tapley Shoal, 13 m). Fig. 48. Whole individual. Fig. 49.—Individual bisected along the ventral surface, branchial sac removed, showing gonads and endocarps in body wall.
Fig. 50. *Polycarpa clavata*. Whole individual.
Figs. 51, 52. *Polycarpa papillata*. (Off Glenelg, 15 m). Fig. 51.—Body wall on left showing gut loop, gonads and endocarps. Fig. 52.—Individual showing gonads on right side of the body.
Figs. 53–56. *Polycarpa pedunculata*. Fig. 53.—Individual from Aldinga (10–25 m). Fig. 54.—Individual from Tapley Shoal (24 m). Fig. 55.—Individual from West I. (25 m). Fig. 56.—Gut loop and endocarp.

The gut forms a gently curved, fairly narrow loop across the left side of the posterior end of the body, enclosing a long narrow curved endocarp which is continuous with the body wall on both the right and left side. The gut loop is almost entirely posterior to the branchial sac; the elongate stomach and proximal part of the intestine forming the proximal limb of the gut loop lie almost in the mid line postero-ventrally and the distal limb of the gut loop passes to the left of the posterior end of the branchial sac. The gut loop is almost

entirely embedded in the thickened body wall and is covered by endocarp which encloses the left gonad (in the curve of the gut) and extends ventrally across the pole of the gut loop to join the thickened body wall ventrally and posteriorly. The pole of the gut loop thus projects into a pocket in the thickened body wall. The oesophagus is short and the stomach is long and elliptical with internal longitudinal glandular folds. The anal opening has a smooth border.

There are one or two flask-shaped gonads on the right side of the body. On the left the gonad is embedded in a single large endocarpal thickening of the body wall. Here there may be a single branched gonad with single ♂ and ♀ ducts emerging from the endocarp and directed to the atrial aperture. This condition may have resulted from the fusion of two gonads. In another specimen there are two discrete gonads embedded in the left side of the body with their own sets of ♂ and ♀ ducts emerging from the endocarp. The testis lobes are enclosed by the ovarian tube as is characteristic of this genus.

Remarks: The present large specimens conform with those ascribed (Kott 1952) to the "*etheridgii*" condition of this species. It is most probable that this distinction relates only to the stage of maturity of the individual, where the "*persimata*" condition represents less mature individuals. Both forms have been taken from the same locations in both east and western Australia.

Polycarpa clavata Hartmeyer. Millar. 1963: 723.

Polycarpa aurata (Quoy & Gaimard) f. *clavata* Hartmeyer, 1919: 40; Michaelsen & Hartmeyer, 1928: 363; Kott, 1952: 236, Tokioka, 1961: 123, Vasseur, 1967: 133.

New Records: Tapley Shoal, near Marion Light, off Troubridge Light. *Previous Records*: W. Aust. (Bathurst I. to Rottnest I.)—Hartmeyer 1919; Kott 1952; Millar 1963. Pacific (Noumea, New Caledonia) Tokioka 1961; Vasseur 1967.

FIG. 50

Description: Large stalked specimens from fawn to reddish-brown. The test is very soft and gelatinous and the surface is marked with rounded longitudinal ridges which are sometimes interrupted horizontally. The branchial aperture is on a short siphon from the basal one third of the dorsal surface, directed toward the substrate. The atrial aperture is sessile and inconspicuous from the middle third of the dorsal surface. The upper, or posterior, end of the head is high and rounded. The stalk, about the same length as the head, is also thick and fleshy, wider toward the base in the larger specimen, and bulbous, or, in smaller specimens (Marion Light) fairly narrow. In the smaller specimens there are randomly distributed concavities, surrounded by well defined lips, on the sides and base of the stalk. These concavities are richly supplied with blood vessels which end in terminal ampullae in the base and lips of the concavity. It is possible that these organs are involved in the fixing of these individuals to the substrate, especially as they do not appear to be present in the larger specimen where the surface test of the stalk is uniformly transversely ridged.

The musculature is rather diffuse in the thick body wall which is produced into a tongue-like projection extending about one third of the distance down into the stalk. The stalk is composed of solid test material for the remainder of its length. The dorsal tubercle is large, completely filling the peritubercular area and has a complicated, convoluted and interrupted opening. There are 4 branchial folds on either side of the body, sometimes only apparent as an accumulation of longitudinal vessels. The branchial sac does not project into the anterior tongue of the body wall where it projects into the stalk.

The gut forms a double loop confined to the posterior part of the body. The anal border has small rounded lobes. Endocarps enclosed in the gut loop may be subdivided terminally into two or more branches. Gonads, more or less in 3 rows down each side of the body wall, are "foot" shaped, fixed to the body wall by the metaphorical "ankle", with the "toe" pointing toward the atrial aperture.

There are numerous upright endocarps scattered over the body wall between the gonads.

Remarks: The dorsal tubercle of *Polycarpa pedata* Herdman (*Styela pedata*) which Hartmeyer (1919) listed as a synonym of the present species is distinguished by the presence of numerous pit-like openings while the dorsal tubercle of the present species, although complicated, has a convoluted slit-like opening interrupted several times along its length. The present species appears closely related to *Polycarpa longiformis* Tokioka (Kott 1966).

which has similar gonads and appears to be distinguished only by the orientation of the body, the absence of the distinctive stalk and the simple opening of the neural gland. *Polycarpa atrollens* Herdman (1899) has a similar convoluted opening on the dorsal tubercle, sometimes broken into several openings along its length. The gonads in *P. atrollens*, however, are upright.

Millar (1963) drew attention to the difference between *P. aurata* (Quoy & Gaimard) and the present species first described as *P. aurata clavata* Hartmeyer.

P. aurata; Hastings, 1931, is described as agreeing well "with Hartmeyer's (1919) and Herdman's (*P. sulcata*; Herdman 1886) descriptions". Hartmeyer's description, however, is of *Polycarpa aurata* f. *clavata* (=*P. clavata*) and it is with *P. aurata* (=*P. sulcata*) that Hasting's specimen is identical. A re-examination of the type specimen of *P. aurata* var. *plana* Herdman, 1899 from Port Jackson has shown that its gonads are also the usual short polycarps of *P. aurata* which is now known from Port Jackson and the Great Barrier Reef and from the Indian Ocean, Malaya, and Indonesia. The range of *P. aurata*, therefore, does not overlap that of *P. clavata*.

Polycarpa papillata (Sluiter).

Styela papillata Sluiter, 1886: 192. Tokioka, 1952: 117. Vasseur, 1969: 925.
Polycarpa intestinata Kott, 1952: 238.

New Records: Tipara Reef, off Port Gawler, off Glenelg, Aldinga "drop-off". *Previous Records*: N.S.W. (Port Jackson)—Kott 1952. Indian Ocean (Madagascar)—Vasseur 1969. Indonesia—Sluiter 1886; (Arafura Sea)—Tokioka 1952.

FIGS. 51, 52

Description: Small aggregates of individuals, the posterior test sometimes extended into a short stalk. The branchial aperture is terminal, the atrial aperture one third to one half of the distance along the dorsal surface. Both apertures are sessile. The test is tough, rough and wrinkled externally, with some sand and algae irregularly adhering but generally the surface test is naked. The body musculature consists of a moderately thick continuous external coat of circular muscles with longitudinal bands internally. The dorsal tubercle is a large blister-like swelling with a simple U-shaped opening; it completely fills the V of the peri-tubercular area. There are 4 wide overlapping folds with about 15 internal longitudinal vessels on each fold and 3 to 4 between folds. There are 4 to 8 stigmata in each mesh. Anteriorly the endostyle follows a winding course, which is effected by the subdivision of transverse vessels and multiplication of the number of rows of stigmata ventrally, in a localised region along the anterior extent of the endostyle. The gut forms a horizontal loop in the posterior end of the body. The stomach is elliptical with longitudinal striations. The rectum extends anteriorly toward the atrial opening. The anal border is broken up into 14 long finger-like lobes. Tall endocarps are present in the gut loop and scattered over the body wall. Seven to 12 oval to elongate polycarps are present in 1 to 2 rows in the centre of each side of the body, directed toward the atrial aperture. These polycarps are fixed to the body wall along their whole length. In smaller specimens with smaller immature gonads there are more often 2 rows of polycarps, and, as the gonads increase in length and the body length increases, these rows appear to merge into a single irregular row, while in a single specimen with well developed gonads there is only a single regular row.

Remarks: The present species resembles *Polycarpa clavata* (Hartmeyer), *P. longiformis* Tokioka and *P. atrollens* Herdman, in the tall endocarps enclosed in the gut loop, but is distinguished by the rows of recumbent gonads fixed along their whole length to the body wall. The anal lobes also resemble those of *P. atrollens* and *P. longiformis*.

The form of the body, the position of the atrial aperture, the form of the dorsal tubercle, and the form and arrangement of the gonads are similar to *P. circumarata* (Sluiter); Vasseur, 1967, which is distinguished by its short oval stomach, greater number of rows of gonads and greater number of internal longitudinal vessels between the branchial folds.

Cnemidocarpa madagascariensis madagascariensis Hartmeyer from Madagascar and *C. madagascariensis regalis* Michaelsen from New Zealand (see Kott 1971a) also resemble the present species in external appearance and in the arrangement of gonads, and are distinguished principally by the greater length of the gut loop and greater number of internal longitudinal vessels between the branchial folds. The papillae on the branchial sac described by Sluiter (1886) are not present either in the South Australian specimens or in the specimens from the Arafura Sea (Tokioka 1952). It is possible that Sluiter mistook particles adhering to the branchial sac for papillae.

The species has a wide geographical distribution from Indonesia and apparently around the east coast of Australia, from rocky substrates in sheltered localities, or in offshore Benthic locations where there are slight currents.

Populations of this species do not appear to be dense and records are few.

Polycarpa pedunculata Heller, 1878: 106. Kott, 1952: 232 and synonymy. Millar, 1966: 369.

Polycarpa obscura. Kott, 1952: 245 and synonymy.

Polycarpa stephensensis Herdman, 1899: 45. Kott, 1952: 232. Millar, 1963: 726.

Polycarpa muehli. Kott, 1952: 244 and synonymy; 1966: 299. Vasseur, 1967: 136.

Polycarpa obtecta. Kott, 1952: 242 (not *P. obtecta* Traustedt).

New Records: Tipara Reef, Tapley Shoal, near Marion Light, upper St. Vincent Gulf, off Port Gawler, off Semaphore, off Grange, off West Beach, off Glenelg, off Broadway, off Hallett Cove, Port Noarlunga, Aldinga, Carrickalinga Head, Rapid Head, West I., Wright I. *Previous Records*: W. Aust. (Cape Jaubert to Bunbury)—Hartmeyer 1919; Michaelsen & Hartmeyer 1928; Kott 1952. S. Aust. (Reevesby I.). Vic. (Balnarring Beach)—Kott 1952; (Bass Strait)—Heller 1878; Michaelsen 1905; (Port Phillip Bay)—Millar 1966. N.S.W. (Port Jackson, Twofold Bay)—Herdman 1881. Qld. (Moreton Bay)—Kott 1964. The species has also been recorded from New Caledonia (Vasseur 1967).

FIGS. 53-56

Description: This is by far the most common ascidian in St. Vincent Gulf and is very variable in external appearance. The colour of living specimens from Port Noarlunga has been described as "bright to pale yellow". These specimens are black to greenish in preservative. Most often living specimens are sandy with a "reddish tinge" to "reddish brown" becoming brown to purplish brown when preserved in formalin. They are slightly laterally flattened and almost oval shaped, and are most often 3 to 4 cm long and 2 to 3 cm wide. Larger specimens up to 8 cm long are usually greenish-black in preservative. The apertures are sessile, the branchial aperture terminal but directed slightly to the side, away from the dorsal surface, and the atrial aperture one-third of the distance down the dorsal surface.

The test is firm and gelatinous and the surface is generally smooth and naked. There is often, however, a light encrustation of sand or the test may be more heavily encrusted, or may become almost brittle with included sand. In larger specimens the test becomes thinner, more flaccid and leathery.

Posteriorly the test may be produced into a narrow stalk up to half the length of the body, or the body may taper gradually from a straight upper or anterior surface where the branchial aperture is central and the atrial aperture is on the antero-dorsal corner. The posterior end of the body, with or without a stalk, may be produced into root-like structures, or the individual may be fixed to the substrate by the postero-ventral surface.

The body wall is light to dark brown, brownish-green, greenish-black, or black. It is not very closely adherent to the test and is thick, firm and very muscular with internal longitudinal bands and a continuous thick external coat of circular muscles. Both layers of musculature are often embedded in fleshy non-muscular tissue and generally spherical vesicles are embedded in the muscle layers interrupting the regularity and continuity of the fibres. The body wall is more flaccid in larger specimens.

There are about 100 simple tentacles of at least 4 orders. The prepharyngeal area has small papillae and is of moderate width. The dorsal tubercle varies and is sometimes small, in the centre of a fairly large peritubercular area. It is sometimes much larger but never completely fills the peritubercular area. The opening forms a U with horns turned in or out and directed to the side, anteriorly or posteriorly and in larger specimens may be interrupted. The dorsal lamina is a plain edged narrow membrane. The branchial folds are low and rounded with 2 to 3 thick internal longitudinal vessels between the folds and 11 to 13 on the folds. There are 6 to 8 stigmata in each mesh between the folds but on the folds the internal longitudinal vessels are more crowded together. There are often vesicles, similar to those embedded in the body wall, embedded in the branchial vessels and in the dorsal tubercle. The gut is confined to the posterior end of the body distal to the atrial aperture. The intestine forms a short rounded loop enclosing a circular endocarp. The stomach itself is elliptical with pronounced folds. There may be a second small endocarp separating the rectum from the oesophagus as the former extends anteriorly toward the base of the atrial opening. In smaller specimens the anal border is broken into 7 sometimes subdivided rounded

lobes. In larger specimens there are up to 25 lobes. The circular endocarp enclosed by the gut appears to be the major mechanism anchoring the gut loop to the body wall and is confluent with the connective tissue surrounding the gut. There are 20 to 50 short oval polycarps on the left and 25 to 60 on the right. These are sometimes, but not always, embedded completely in the body wall. When completely embedded only the openings of the ducts are apparent as holes in the inner surface of the body wall. Primarily there appear to be about 3 longitudinal rows of polycarps on each side of the body. As each polycarp increases in length it sub-divides and new gonoducts open from the proximal half to form secondary rows of gonads overlapping the primary row closest to the atrial opening. It is possible that this process, resulting in increases in the number of polycarps present, explains the great variation in the number recorded for this species.

Remarks: Michaelsen & Hartmeyer (1928) drew attention to the similarity between species listed in the synonymy above and suggest that *P. obscura* is a variety of *P. pedunculata* (*P. viridis*). Michaelsen regarded *Polycarpa moebii*, however, as a distinct species characterised by differences in the gut and gonads. In this collection there are individuals demonstrating every condition previously described for *P. pedunculata*, *P. moebii*, *P. obscura* and *P. stephensensis*. There are specimens demonstrating every condition from stalked or rooted to sessile individuals; every colour and every condition of the test is found and there is considerable variation in the number of polycarps and the extent to which they are embedded. The gut loop is always constant and encloses the circular endocarp which has a pointed tip dorsally. The thick internal longitudinal vessels of the branchial sac, their crowding on the narrow folds, the spherical vesicles embedded in the branchial sac and body wall, the thick layer of circular muscle, and the papillated prebranchial area can be regarded as characteristic of this otherwise highly variable single species. The extent to which gonads are embedded in the body wall, and the extent to which the body wall is marked off into areas probably indicates more mature specimens.

Polycarpa maculata Hartmeyer, 1906, has a similar endocarp enclosed by the gut loop and the same type of vesicles embedded in the body wall. It is distinguished from the present species, however, by the weaker musculature which also distinguishes it from the West Indian species *P. obscura* Traustedt.

P. pedunculata is the most common ascidian in St. Vincent Gulf and generally both greenish and reddish brown specimens occur. Large black specimens were also taken from Seal Rock, West I. from Hallett Cove, and from Tapley Shoal. There is no apparent correlation between the type of environment and the colour of the individuals at each Station. A case of genetic polymorphism in Ascidiacea has been described for *Boltenia ovifera* (L.) (Plough 1969). This dominant in the ascidian population of the Gulf of Maine, has colours ranging from white to crimson red in a single haul, and variations in test texture and in muscle band colour and thickness can be related to these colour variations. It has been suggested that the species demonstrates genetic segregation of the ability of individuals to accumulate pigments. The situation in *Polycarpa pedunculata* may indicate a similar genetic segregation.

Family **PYURIDAE**

Pyura scoresbiensis n.sp.

Type Location: Off Semaphore: 18 m, in sparse *Posidonia*, 27.1.69 (Holotype: South Australian Museum, registration number E876). *Further Records*: Off Tapley Shoal, 18 m, 22 m

FIGS. 57–59

Description: Rounded heads on stalks of varying length, sometimes thick and no longer than the head, but sometimes long and narrow (up to 20 cm), supporting a head 8 cm long and 3 cm wide. The head is more or less egg-shaped with its greatest diameter basally before narrowing abruptly to the stalk. The apertures are both sessile, either side of a more or less pointed projection forming the anterior apex of the head. The atrial aperture is slightly more posterior than the branchial aperture.

The test is thin, hard and tough with a dense sandy encrustation on the outer surface of the head and the stalk. The body wall is thin and semi-transparent with moderately developed fine and diffuse musculature, with muscle bands most closely placed around the anterior part of the branchial sac and siphon.

The branchial tentacles have a large flanged axis, fairly short primary branches, stumpy secondary branches and minute tertiary branches and are not very bushy. The siphons are lined with long needle-like spines, closely set, up to 0.275 mm long. There are no spi-

cules in either the test or the body wall. The dorsal tubercle is a simple U-shaped opening with both horns turned inwards. The dorsal lamina has pointed languets but is very short owing to the close-set branchial and atrial siphons and contracted dorsum. The branchial sac is delicate with 6 high, overlapping folds on each side of the body with up to 20 internal longitudinal vessels on the folds and only 2 or 3 between. There are 4 to 6 stigmata in each mesh.

There is a simple and fairly narrow gut loop enclosing the gonad on the left. The gonad on the right occupies a corresponding position. There are very arborescent liver lobules in the region of the stomach. The gonad may consist of an undulating ovarian tube with fringing testis follicles along both sides with the testis ducts extending along the mesial surface of the ovary. In some specimens the undulations of the ovarian tube extend out into pinnate branches with testis follicles around their extremities. These pinnate branches may subsequently separate off into separate polycarp sacs on either side of a ventral duct. The anal border is divided into 3 large shallow lobes.

Remarks: Specimens demonstrate the development of the polycarp sacs of the pyurid gonad from the continuous tubular styelid type of gonad. All stages of this development can be observed in the specimens available and it may be that the condition of the gonad indicates the age of the individual. The stalk of this species also shows great variation in length and thickness. Despite these variations the species is characterised by the relatively smooth test, sand encrusted, but without tubercles or furrows, and by the constant position of the apertures. The position of the apertures, on the upper end of the head, fairly close together, with the branchial and atrial openings on opposite sides of the apex, is unusual in a stalked species of the Ascidiacea, where, more generally, both apertures are on the dorsal side of the head with the branchial aperture directed downwards, and the atrial aperture uppermost and directed upwards.

The relationships of this species are indicated by the siphonal spines, which resemble those described for *Pyura albanyensis* Michaelsen & Hartmeyer, 1928, from Oyster Harbour, Albany, Western Australia, in which apertures are also separated by a cushion of test in the middle of the upper surface and in which the dorsal surface of the body is very much contracted and the dorsal lamina consequently very short. *Pyura albanyensis* has, however, characteristic papillae on the convex border of the scabre-shaped stem and primary branches of the branchial tentacles.

Pyura curvigona Tokioka, 1967, from the Palao Is, is a similar closely related species, sometimes stalked, with a similar arrangement of endocarps, gonads and gut. The anus, however, has many lobes and the long (2.75 mm) siphonal spines extend outside the siphons onto the lobes surrounding the apertures, as in *Pyura vittata* (present in this collection). The needle-like siphonal spines found in the present species are not found in the various forms of the *Pyura pachydermatina* group of stalked species. In a specimen from Tapley Shoal (Station 6) there are barnacles growing around the branchial aperture.

Pyura vittata (Stimpson). Pérès, 1949: 195. Tokioka, 1952: 134; 1953a: 273; 1967: 202. Millar, 1960: 126. Kott, 1964: 142; 1966: 300; 1969: 133. For further synonymy and literature to the species in the Atlantic and West Indies see Van Name 1945: 321.

Cynthia vittata Stimpson, 1852: 230.

Pyura jacatrensis. Kott, 1952: 273; 1954: 127. Millar, 1960: 125.

New Records: Tapley Shoal, off Troubridge Light. *Previous Records*: W. Aust. (S.W. Aust.)—Kott 1952. Tas.—Kott 1954. Qld. —Kott 1964, 1966. Pacific (Arafura Sea) —Tokioka 1952; (Palao Is.)—Tokioka 1967; (Japan)—Tokioka 1953a; Van Name 1945. Atlantic—Van Name 1945; Pérès 1949; Millar 1960. Sub-antarctic (Macquarie I.)—Kott 1954, 1969; (Kerguelen I.) —Kott 1954; (Marion I.)—Millar 1966.

The species has a wide circumpolar distribution in the southern hemisphere and extends north through the Indo-Malayan region to Japan. It is also found in the Atlantic and in the Caribbean (see Van Name 1945).

FIG. 60

Description: Only a single individual is available, 3 cm long with a terminal branchial aperture and the atrial opening half the distance along the dorsal surface. Both apertures are almost sessile. The external surface of the test is rough and has sand and foreign particles adhering. The siphons are lined with long needle-like spines, 0.1 mm to 0.2 mm long, overlapping. These extend onto the outer surface of the siphons, cover the lobes bordering the siphons and extend onto the outer layer of test. The spines have a slight iridescence

which confers on this outer siphonal area a greenish tinge. The siphon is lined with red stripes in the preserved specimen.

The test is thin, leathery and firm. The dorsal tubercle is a rounded cushion filling the peritubercular area with a simple U-shaped slit with both horns turned in. The branchial tentacles are not bushy and have only primary branches and very short secondary branches. The internal siphons are fairly long. Longitudinal muscle bands radiate from both siphons but do not extend very far down the body on the left. Circular muscles form a fairly irregular network over the right side of the body, becoming more sparse posteriorly. They are practically absent from the posterior half of the body on the left side, over the gut loop. The branchial sac is fairly delicate. It has 18 internal longitudinal vessels on each fold and 4 between. There are 6 stigmata per mesh. The gut forms the usual loop enclosing the left gonad. The anal border is smooth and bilabiate. The gonads consist of the usual central ovarian tube with pinnate branches on both sides terminating in polycarp-like sacs. Endocarp-like tissue is present on the free surface of the gonads where it is broken up into lobes.

Remarks: The synonymy of this widespread species has been very confusing owing to the variation in the length of the siphonal spines and the variation in the condition of the anal border. It appears, however, that Sluiter's species from Indonesia and Northern Australia (*P. jacatrensis*), with very much smaller siphonal spines that do not extend onto the outer surface of the apertures, may be a distinct species despite the spines of intermediate length that are present in specimens from the Palau Islands (Tokioka 1950; see Kott 1971). *Pyura curvigona* Tokioka, 1967, from Palao Is., is another closely related species in which the very long (2.75 mm) siphonal spines extend onto the outer surface of the apertures. In *Pyura albanyensis* Michaelsen & Hartmeyer, 1928, and *P. recoresbiensis* n.sp. the siphonal spines extend up to 0.275 mm, only slightly longer than the present species. However, these siphonal spines do not extend onto the outer surface of the apertures.

Pyura irregularis (Herdman), Kott, 1952: 271
Millar, 1963: 739; 1966: 370.
Cynthia irregularis Herdman, 1881: 60; 1882: 141

New Records: Tipara Reef, off Beach Hut, 1 km off Port Vincent, upper St. Vincent Gulf, off Grange, off West Beach, off Glenelg, Port Noarlunga, Aldinga "drop-off", Carrickalinga Head. *Previous Records*: S. Aust. (Outer Harbour), Vic. (Port Phillip Bay)—Millar 1963, 1966. Tas. (D'Entrecasteaux Channel)—Kott 1952. N.S.W. (Port Jackson)—Herdman 1882. The species has not previously been taken in waters of less than 25 m in depth.

Description: Living specimens are red, orange to light fawn. Externally the test is very hard, leathery and wrinkled and thickened into small polygonal plates. There are also wart-like protuberances, especially anteriorly.

Individuals are usually clumped together in tight aggregates and the shape of the body is consequently very irregular. The maximum body length is about 2.5 cm. Both apertures are present at the end of fairly long siphons which are generally oriented away from one another. The test is very strong with internal longitudinal and outer circular muscle bands as in all species of Pyuridae.

Delicate cup-shaped scales, 0.02 mm long, line the siphons. There are 15 branchial tentacles with short sparse primary branches and minute secondary branches. The primary opening from the neural gland is U-shaped with horns turned in or out. The dorsal tubercle is blister-like and there is often an accessory opening from the neural gland. The tubercle is not always longitudinally attenuated, however the peritubercular arc is always a very deep V-shape and generally the tubercle does extend down into it. The neural ganglion is especially long, extending most of the distance along the dorsal lamina. The dorsal lamina has a double row of languets. These are fine and pointed, closely set on the left, and on the right they are stouter and more sparsely arranged.

There are from 6 to 10 branchial folds on each side of the body with about 12 longitudinal vessels on the folds and 2 between. There are 6 to 8 stigmata in each mesh crossed by parastigmatic vessels. The gut loop is simple and curved and encloses the left gonad which is subdivided into 15 to 20 separate polycarp sacs arranged on either side of central male and female ducts. There is a corresponding gonad on the right.

Remarks: This species resembles very closely the Antarctic species *Pyura discoveryi* Herdman (see Kott 1969). The tough, wrinkled external test with embedded polygonal thickenings is also reminiscent of the Antarctic *Pyura squamata* Herdman although the polygonal

scales and the body shape of *P. squamata* are more highly specialised than in either *P. discoveryi* or in the present species. The branchial tentacles with their sparse branches and the long siphons are also similar to those of *P. discoveryi* and it is possible that the protection afforded the individual by these long siphons may be associated with the absence of the more bushy tentacles usually found in this genus.

The individuals are never very large and their leathery test and habit of occurring in aggregates suggests a species adapted for very turbulent conditions. The present records do not support this, however, as they are either from Offshore Benthic locations in St. Vincent Gulf, or from reefs in sheltered coastal locations.

Pyura australis (Quoy & Gaimard) s.sp. **australis** Quoy & Gaimard.

Ascidia australis Quoy & Gaimard, 1834: 614.
Pyura australis f. *typica*, Kott, 1952: 266 and synonymy.
Pyura australis, Millar, 1963: 739.

New Records: Tiparra Reef, Tapley Shoal, near Marion Light, off West Beach, off Broadway, off Hallett Cove, off Yankalilla Bay, West I., N.W. of Robe. *Previous Records*: W. Aust. (Geraldton to Albany)—Quoy & Gaimard 1834; Michaelsen & Hartmeyer 1928; Kott 1952; Millar 1963. Vic. (Westernport, Flinders)—Quoy & Gaimard 1834; Kott 1952. Tas. (D'Entrecasteaux Channel, Tinderbox)—Kott 1952.

FIG. 61

Description: Specimens of all sizes up to a maximum of 4 cm long head with a stalk of 30 cm. The test is usually without foreign bodies adhering, though in one specimen there are some cirripedes growing on the stalk. The surface of the test is marked with variable longitudinal furrows and ridges but is sometimes almost smooth. In preservative the specimens are pinkish-fawn, although living specimens are usually dark red and, occasionally, yellow. Both apertures are close together on the dorsal surface, the atrial aperture directed upwards and the branchial aperture directed basally. The lobes of the atrial aperture are clearly continuous with the ridges in the dorsal part of the test.

There are stellate spicules of about 0.02 mm diameter with 6 rays in optical transverse section in the body wall, and the siphons are lined by conical spines of 0.02 mm maximum height from base to apex.

The branchial sac, gut loop and gonad are as previously described and there are 18 long flattened characteristic lobes fringing the anal border (see Kott 1952).

Remarks: Nothing can be added to previous descriptions of this constant species which appears to occupy a wide range of conditions in exposed to sheltered locations from Geraldton, in Western Australia, to Flinders in Victoria. It is common in wave beaten areas from the low water mark to 22 m.

Pyura spinifera (Quoy & Gaimard). Kott, 1952: 269 and synonymy.

Ascidia spinifera Quoy & Gaimard, 1834: 617.
Cynthia multiradicata Herdman, 1899: 30.

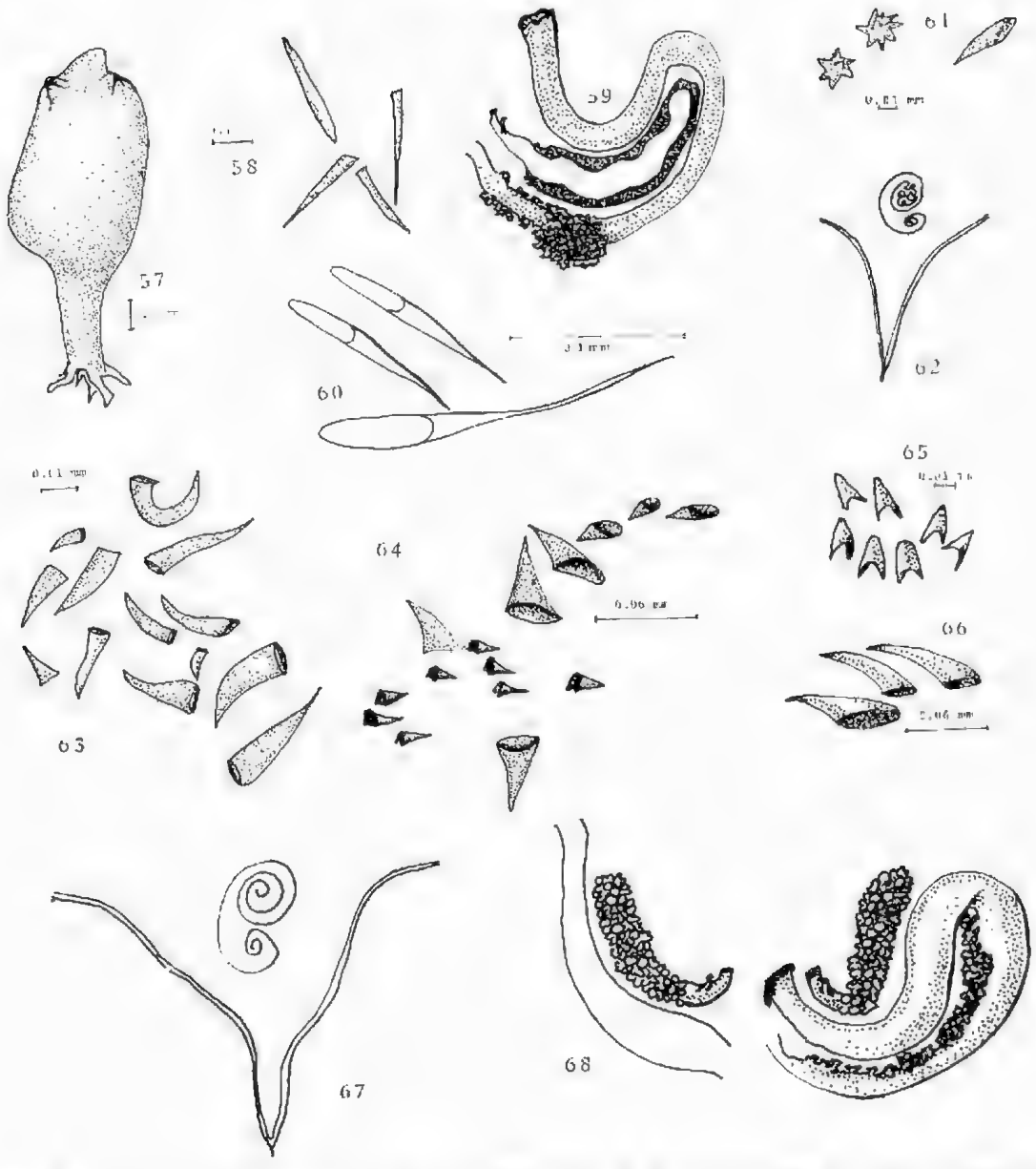
New Records: Upper St. Vincent Gulf, off Hallett Cove, Aldinga. *Previous Records*: W. Aust. (Albany)—Quoy & Gaimard 1834. Vic. (Bass Strait)—Michaelsen 1905; Heller 1878. N.S.W. (Port Jackson, Port Hacking)—Herdman 1891, 1899; Kott 1952.

FIGS. 62, 63

Description: Specimens with head to 8 cm long and 4.5 cm wide. Stalk is of very variable length, maximum 20 cm. Externally the test is smooth without longitudinal furrows, but with characteristic tubercles, varying in their density, and sometimes, especially in larger specimens, absent altogether. The head is often completely enveloped by an investing sponge which in specimens from off Hallett Cove has been noted in the field as yellow.

Minute overlapping scales, 0.05 mm maximum length from posterior part of the base to their apex, line localised areas where thickened lobes of the test project into the siphons. Otherwise, there are no spicules in the test or in the body wall. There are 7 branchial folds on either side of the body wall in the larger specimen but only 6 on each side in average-sized to smaller specimens. There are about 25 branchial tentacles alternating with rudimentary tentacles. The larger tentacles have regular pinnate primary branches with secondary branches and minute tertiary branches and are very bushy. The dorsal tubercle has a double coiled opening, both horns coiled inwards and the inner spirals of each coil are slightly convoluted. There is a short dorsal lamina with pointed languets.

There are up to 30 internal longitudinal vessels on the folds and 2 to 3 between. In larger specimens the under sides of all the major



Figs. 57–59. *Pyura scoresbiensis*. Fig. 57.—Individual (off Semaphore, 18 m). Fig. 58. Siphonal spines. Fig. 59.—Gut and gonads.
Fig. 60. *Pyura vittata*. (Tapley Shoal, off Troubridge Light, 17 m). Siphonal spines.
Fig. 61. *Pyura australis*. (Hallett Cove, 8 m). Spicules embedded in siphonal lining, and siphonal spine.
Figs. 62, 63. *Pyura spinifera*. (Upper St. Vincent Gulf, 10–11 m). Fig. 62.—Dorsal tubercles. Fig. 63.—Papillae from inner body wall.
Fig. 64. *Microcosmus nicholisi*. (Off Yankalilla Bay, 20m). Siphonal spines and scales.
Fig. 65. *Microcosmus squamiger*. (Off Semaphore, 18 m). Siphonal scales.
Fig. 66. *Microcosmus stolonifera*. (Port Noarlunga, 5–6 m). Siphonal spines.
Figs. 67, 68. *Ctenicella antipoda*. (Yankalilla Bay, 12–20 m). Fig. 67.—Dorsal tubercle. Fig. 68.—Inner body wall showing gonads and gut loop and heart on left and right respectively.

blood vessels and the transverse vessels (but not the parastigmatic vessels) support minute pointed languets to form a fur-like covering. These projections also cover the gonads and

the whole inner surface of the body wall extending into the base of the atrial siphon although here they are reduced in density.

The gut forms a narrow curved loop enclosing the left gonad. The right gonad forms a corresponding curve on the right side of the body. The anus is bordered by 12 shallow lobes. There is a mass of orange arborescent liver lobes. In larger specimens there is a blister-like structure on either side of the atrial opening, extending into the curve of the gut loop and into the curve of the gonad on the left and right sides of the body respectively. This also has a fur-like surface formed by dense, small, pointed projections. The inner cavity of this blister-like organ is continuous into the lumen of the atrial siphon and, presumably, if swollen or distended could occlude the lumen of the siphon. There are also two flaps of tissue, anterior and posterior to the atrial opening to form an atrial velum.

Remarks: This distinctive species, in which variation in external appearance involves only the number of tubercles on the test and the length of the stalk has, in St. Vincent Gulf, only been taken from fairly sheltered situations. Other records, however, suggest that the species could occupy greater depths in offshore situations from which it was uprooted only with turbulence occurring during storms. The large head supported on the thin but tough stalk does not appear to favour very rough conditions, although it could be an advantage in locations where there is steady current flow or surge.

Halocynthia hispida (Herdman). Kott, 1968: 77 and synonymy.

Cynthia hispida Herdman 1882: 146.
Halocynthia cactus. Vasseur, 1967: 144.

New Records: Tipara Reef, Tapley Shoal, near Marion Light, off Beach Hut, Port Vincent, upper St. Vincent Gulf, off Outer Harbour, off West Beach, off Glenelg, off Port Stanvac ("The Barges"), Aldinga, Carickalinga Head, off Yankalilla Bay, Rapid Head. *Previous Records*: See Kott, 1968.

Remarks: This species apparently occupies a wide variety of conditions but generally favours sheltered bays or estuaries (see Kott 1968, for description and further discussion of this and related species).

Herdmania momus (Savigny) Michaelsen, 1919: 30 and synonymy.

Cynthia momus Savigny, 1816: 143.
Pyura momus f. *kyanhanensis* Michaelsen, 1919: 31.
? *Pyura momus* f. *palana* Michaelsen, 1919: 31.
Pyura momus f. *complanata*. Michaelsen, 1919: 54.
Pyura momus f. *galei* Michaelsen & Hartmeyer, 1927: 194; 1928: 443.
Pyura momus Savigny f. *grandis*. Michaelsen & Hartmeyer, 1928: 441.
Herdmania momus. Van Name, 1945: 341
Herdmania momus f. *galei*. Kott, 1952: 281. Tokioka, 1961: 132; 1967: 205.
Herdmania momus f. *grandis*. Kott, 1952: 279; 1964: 142; 1966: 301. Millar, 1960: 126; 1963: 740; 1966: 374. Tokioka, 1949: 61; 1952: 137; 1953a: 277; 1967: 206.
? *Herdmania momus* f. *curvata* Kott, 1952: 282; 1964: 143.

New Records: ("*grandis*" type)—Tipara Reef, off West Beach, off Glenelg, Carickalinga Head, N.W. of Robe. ("*galei*" type)—Goose I., upper St. Vincent Gulf, Aldinga Reef, West I., Wright I. *Previous Records* ("*grandis*" type): W. Aust. (Fremantle to Albany)—Michaelsen & Hartmeyer 1928; Millar 1963. Vic. (Port Phillip Bay, Westernport)—Millar 1960, 1963, 1966. N.S.W. (Port Jackson)—Heller 1878; Herdman 1882; von Drasche 1884; Tokioka 1967; Millar 1963. Qld. (Bowen)—Kott 1952. Indonesia (off West Irian—Herdman 1886; Arafura Sea)—Tokioka 1952. Japan—Tokioka 1949. Pacific (Fiji Is.)—Herdman 1882; Palmo, Tahiti)—Heller 1878. Indian Ocean (West Indian Ocean)—Michaelsen 1908; Heller 1878; (Red Sea)—Michaelsen 1919; Savigny 1816; (Dar-es-Salaam)—Michaelsen 1905; (Ceylon) Herdman 1906. Africa (Cape of Good Hope, Simons Bay)—Herdman 1882. West Indies (Jamaica)—Heller 1878. ("*galei*" type)—W. Aust. (Shark Bay, Point Charles, Dirk Hartog I.)—Michaelsen & Hartmeyer 1927, 1928. Tas. N.S.W. (Port Stephens). Qld. (Bowen, Nelson's Bay)—Kott 1952. Pacific (Melanesia)—Tokioka 1961; (Marianas Is.)—Tokioka 1967; (Japan)—Tokioka 1967. (For records of specimens recorded as "*pallida*" form, see Van Name 1945).

Michaelsen (1919) has considered, in some detail, the distribution of all the forms of this species. Apart from certain forms represented by single records, many of the ranges overlap and no separate geographic ranges can be assigned. The range of the species, represented by the range of the form *pallida*, for which there are most records, is circumtropical, and extending south to the Cape of

Good Hope. Forms from the south coast of Australia have been described as forma *grandis*. This form is not, however, distinct from f. *pallida* (see below) and it is doubtful whether there is justification for separating any of the specimens assigned to the species. Their morphological variations are most probably indicative of different stages of maturity.

Description: The distribution of the several forms, *H. momus* f. *grandis*, *H. momus* f. *pallida* and *H. momus* f. *galei*, overlaps and in the present collection all forms have been taken from the same location and it is apparent that *H. momus* f. *grandis* with an opaque whitish test, a convoluted dorsal tubercular opening and with testis follicles covering the ovary, represents mature individuals of a species in which the juvenile specimens have a transparent to translucent test with the testes follicles arranged regularly around the periphery of the ovary (f. *galei*). Sometimes in intermediate sized specimens the ovarian tube undulates along its length and the testis follicles may remain close to the ovary (as described for f. *pallida*; Van Name, 1945). In other specimens in this collection (3 km off Glenelg) the testis follicles form an even border around an area in which the ovarian tube is undulating. In the smallest specimens the anal lobes are rudimentary, later develop into even fingerlike flattened lobes, which become less regular and may be absent in larger specimens, but are sometimes present in two clumps at either side of the opening.

Remarks: It is apparent from the present collection that the *galei*, *grandis* and *pallida* forms of this species represent different stages of maturity of a single species. The relationship of the present forms, in which the ovaries undulate with the testes follicles which sometimes cover it, to *H. momus* f. *typica* Savigny (=*H. momus* f. *curvata* Kott, 1952; 1964) in which the testes follicles are arranged in an undulating line along the ovary, is problematical. However, it is probable that the undulation of the ovarian tube could have forced the testes follicles into a similarly undulating line.

Microcosmus nichollsi Kott, 1952: 290.

New Records: Off Beach Hut, 1 km off Port Vincent, off West Beach, off Hallett Cove, Aldinga, Carickalinga Head, West I., Wright I. *Previous Records*: Vic. (Flinders)—Kott 1952

FIG. 64

Description: Test generally thick, whitish and coriaceous with pinkish colour around siphon but sometimes tough and almost leathery externally with rounded ridges or thin, stiff, rough and embedded with sand, uneven and marked by horny scale-like areas. Externally both apertures are sessile and close together on the upper surface, each surrounded by raised, rounded projections of the test. Posteriorly the test may be produced into root-like processes. There is a network of longitudinal and rectangular muscles.

The siphons are long and the siphonal musculature is especially strong. Outer circular sphincter muscles surround the base of each siphon and the longitudinal muscles extend across the body but are absent from the region over the gut. Pointed conical spines and smaller spines and more numerous scales line the siphons. There are sometimes calcareous spicules embedded in the body wall and in the tentacles and branchial sac. Branchial tentacles have primary, secondary and minute tertiary branches. The dorsal tubercle is U-shaped with horns turned in. The dorsal ganglion is elongate, half the length of the wide, plain-edged dorsal lamina. There is a pronounced branchial velum. On each side of the body wall there are high overlapping branchial folds with up to 20 internal longitudinal vessels on the folds and 1 to 3 between. There are about 10 stigmata per mesh, between the folds, crossed by parastigmatic vessels. The gut forms a simple closed and narrow loop around the ventral border of the body enclosing the terminal lobe of the gonad in its loop. The descending limb is crossed by gonad. There is a stomach enlargement obscured by liver lamellae which are smaller at the pyloric end of the stomach. Minute finger-like projections from the surface of the liver lamellae give it a furry appearance. The anus is bordered by 12 rounded lobes.

On the right, the gonad curves around the ventral border and on the left curves into the loop of the gut just distal to the liver lobes. The gonads are broken into 2 rounded clumps on the right and 3 on the left, often covered by endocarp.

Remarks: The small siphonal scales and the gonad across the gut loop, together with the whitish and more gelatinous test of the smaller specimens, distinguish the species from *M. stolonifera*.

Microcosmus squamiger Michaelsen.

Microcosmus claudicans sub. sp. *squamiger* Michaelsen & Hartmeyer, 1928: 405.
Microcosmus exasperatus sub. sp. *australis*. Michaelsen, 1908: 272; 1918: 63 (in part, excluding *M. australis* Herdman, and *M. ramsayi* Herdman).

New Records: Tipara Reef, off Semaphore, off West Beach, off Glenelg. *Previous Records*: W. Aust. (Shark Bay to Albany)—Michaelsen & Hartmeyer 1928. N.S.W. (Sydney)—Michaelsen 1908. Qld. (Bowen, Rockhampton)—Michaelsen 1908. Red Sea—Michaelsen 1918.

FIG. 65

Description: Small, leathery, pinkish specimens, aggregated together. The surface of the test is raised into ridges and mounds. The body wall is very muscular. The dorsal tubercle is large with a double spiral opening. There are the usual 8 branchial folds on each side of the body and the left gonad crosses into the gut loop. The gonad on each side of the body is divided into 3 clumps. There are close-set liver lamellae. Closely set curved scales 0.02 mm long line the branchial siphon.

Remarks: There has been some confusion between *M. exasperatus*, *M. australis*, and the present species, all common around the Australian coast and all demonstrating a fairly wide diversity in external appearance. The reddish colour and aggregated habit, the large number of tough branchial folds, the deeply curved gut loop and the gonad crossing into the gut loop, are characters shared by all three species. *Microcosmus squamiger* is distinguished by flattened scale-like siphonal scales, while both *Microcosmus australis* Herdman and *M. exasperatus* have pointed spines.

Microcosmus stolonifera Kott, 1952: 291.

New Records: Tipara Reef, Port Noarlunga. *Previous Record*: Tas. (Tiny Is., east coast)—Kott 1952.

FIG. 66

Description: Only two specimens are available. They are very irregular externally, and posteriorly are produced into root-like processes. The apertures are on siphons of variable length, turned away from one another and, in the largest specimen available (2 cm greatest dimension) the siphons are especially long. The test is very tough, hard and leathery. There are large (about 0.1 mm) pointed spines, arranged in fairly regular horizontal rows, lining the siphons. The branchial tentacles are bushy. The branchial sac has 7 high and delicate overlapping folds, with a single internal longitudinal vessel in the interspace. The gut forms a narrow curved loop with the usual elongate liver lamellae with short finger-like papillae from its surface. The gonads form a single rounded mass in the curve of the gut loop on the left but do not extend into the primary gut loop. On the right there may be a corresponding single rounded mass or the right gonad is sometimes divided into two rounded lobes joined by the central ducts.

Remarks: The test of this species is harder and less regular than all other species of this genus. It is further distinguished by the long siphonal spines, the large rounded gonad that does not develop inside the gut loop, and the high delicate overlapping folds of the branchial sac.

It does not appear to be a very common species and the only two records are from the southern coast of Australia. However, the tough and roughened test, forming a very strong attachment, causes the species to be inconspicuous and difficult to collect.

Microcosmus helleri Herdman, 1880: 54; 1882: 131. Sluiter, 1895: 184. Hartmeyer, 1919: 19. Michaelsen & Hartmeyer, 1928: 397. Kott, 1952: 292; 1972: 12. Millar, 1963: 742.

Microcosmus goanus Michaelsen, 1918: 12.

New Records: Tapley Shoal, off Beach Hut (1 km off Port Vincent). *Previous Records*: W. Aust. (Cape Jaubert to Fremantle)—Hartmeyer 1919; Michaelsen & Hartmeyer 1928; Kott 1952; Millar 1963. Qld. (Great Barrier Reef)—Kott 1952; (Torres Strait)—Herdman 1882. Malaysia—Sluiter 1895. Portugese East Africa (Delagoa Bay)—Michaelsen 1918.

Description: The single spherical specimen from Tapley Shoal is 6 cm in diameter. This large diameter is contributed to by a 1 cm thick coating of sand held together by terminally branching and coalescing projections from the test to form a thick dense layer enclosing a space around the body. This coating is interrupted to form a single opening above the apertures. The specimen from off Beach Hut is more typically rough externally and is a purple colour. The apertures are sessile, one-third of the body circumference apart. At the base of the branchial siphon there are 3 flap-like projections.

The body musculature is of the usual pyurid type with muscle bands from each of the siphons crossing one another on both sides of

the body. There are very strong circular muscles circling each siphon.

Branchial tentacles have primary and secondary branches and wide, flat, membraneous extensions from their anterior or concave border. The dorsal lamina is plain. There are 6 high, overlapping folds on each side of the body with up to 18 internal longitudinal vessels on the folds and 3 between. The gut forms the usual long, narrow attenuated loop, typical of the species, and the proximal lobe of the 3 lobed left gonad is accommodated in the open pole of the otherwise closed gut loop.

Remarks: The tough flap-like projections in the branchial siphon sometimes appear as cones. These structures, together with the gut loop and branchial sac, distinguish the species.

The sandy coating has not been described previously for this species, but has been described for *Pyura cancellata* Brewin from New Zealand (see Kott 1971) and for *Pyura tunica* Kott, 1969 from the Antarctic. This condition demonstrates the versatility of the ascidian test which in this specimen responds to the substrate by growing out to entangle sand grains as there is no firm substrate onto which it can directly be fixed.

Ctenicella antipoda n.sp.

Type Locality: Off Yankalilla Bay, at 12 to 20 m (2 specimens); in *Amphibolis* community with limestone outcropping occasionally. *Holotype*: South Australian Museum (reg. no. E877). *Further Record*: Tipara Reef.

FIGS. 67, 68

Description: Specimens are up to 10 cm long, slightly dorso-ventrally flattened. Externally they are very irregular and covered with nodules which also protect the sessile apertures on the dorsal or upper surface. The test is up to 1.5 cm thick, gelatinous but entirely impregnated with sand so that it is hard and rigid. It is sometimes produced into a ridge surrounding the siphons. There are hard brown papillae around the sessile apertures but there are no spines lining the siphons.

The body musculature is strong on the upper half of the body with longitudinal bands radiating from the siphons and inner circular bands around the siphons and at their base. However, on the lower half of the body the musculature is almost entirely absent and is represented by two vertical rows of very short parallel bands.

There are 15 large compound branchial tentacles with primary, secondary, and minute tertiary branches alternating with rudimentary tentacles. The dorsal tubercle is at the base of the tentacles anterior to the V of the peritubercular area. The opening is a double spiral slit turned to the left. The dorsal lamina is very short and has close-set slender, pointed languets.

The branchial sac has 6 high, overlapping folds on each side of the body, widely spread at their base. Longitudinal vessels are arranged as follows:

DL 3(26)3(33)5(28)4(26)3(24)2(15)3 E

There are about 12 stigmata in each mesh. They are rectangular, and crossed by parastigmatic vessels. The meshes are wider than long and there is no sign of irregularity in the stigmata which do not coil nor form infundibula.

The gut forms a narrow, closed and deeply curved loop with branched liver lobules extending along the inside of the gut loop for its whole length. The liver is spongy with short rounded finger-like papillae projecting from its surface, and supporting tissue between the liver lobules.

The intestine is filled with mud. The anal border has about 30 or more rounded lobes. On the right side of the body there is a long curved hypertrophical heart in the position occupied by the kidney in Molgulidae. There is a single gonad on each side of the body parallel to and lying against the long conspicuous heart on the right, and on the left extending parallel to the descending line of the primary gut loop. The left gonad descends into the secondary gut loop where its short ducts turn dorsally toward the atrial aperture. The ovary is central and tubular, while the especially small pyriform testis lobes extend into folds in its wall, giving the appearance of being embedded in the ovary. In one of the specimens from Tipara reef the gonads are immature and groups of very minute testis lobes are arranged around the upper and outer surface of both sides of the ovary. Vasa efferentia from each group of follicles join together to open into the vas deferens along the median surface of the ovary.

Remarks: *Ctenicella* Lacaze Duthiers (*Type Species*: *Ctenicella appendiculata* (Heller), from the Mediterranean), has few known species, although a number of *Molgula* spp.

have been erroneously ascribed to it. The genus is characterised by the presence of dorsal languets, straight stigmata, a kidney on the right, and the left gonad outside the primary gut loop. In addition to the type species which is distinguished by its long recurved siphons, *Ctenicella undulata* Tokioka, 1949, from Japan, has a posterior stalk and a folded stomach.

Hartmeyeria Ritter was also thought to be intermediate between Pyuridae and Molgulidae, with pyurid branchial sac, siphonal spines, a smooth dorsal lamina and the left gonad partly in the gut loop (as in certain species of *Microcosmus*). Monniot (1969) has shown, however, that what was thought to be a kidney, is in fact an hypertrophied heart and that *Hartmeyeria* is without doubt a pyurid genus related to *Microcosmus* and with a liver similar to that of *Halocynthia* with longitudinal plications proximally and branched tubules distally. *Hartmeyeria* differs from the present species in its smooth dorsal lamina and siphonal spines, and in the position of its left gonad which crosses into the gut loop. It is probable that the kidney, which has been described for *Ctenicella undulata* and *C. appendiculata* is, in fact, an hypertrophical heart, as described for *Hartmeyeria* and as demonstrated for the present species.

The identity of *Ctenicella undulata* Tokioka is puzzling as it has dorsal languets and the gonads on the left and right respectively in the usual position for the genus, outside the gut loop and adjacent to what has been described as an excretory organ. However, the stomach appears to have proximal glandular folds and distal arborescent lobes as described for *Hartmeyeria* and *Halocynthia* and it has a *Hartmeyeria* type of stalk. Therefore, both *Ctenicella* and *Hartmeyeria* appear to be genera of the Pyuridae, distinguished from *Pyura*, *Halocynthia* and *Microcosmus* by an hypertrophied heart. They appear to be distinguished from one another only by the absence of siphonal spines, the presence of dorsal languets and by the position of the gonad outside the primary gut loop in *Ctenicella* spp. The relationships of these pyurid genera are shown in the following Table.

TABLE 1

Comparison of Characteristics of the Genera of the Family Pyuridae.

	Pyura	*Halocynthia*	*Ctenicella*	*Hartmeyeria*	*Microcosmus*
Siphonal spines	present	present	none	present	present
Dorsal lamina	languets	languets	languets	smooth	smooth
Liver tissue	arborescent lobes	long folds and arborescent lobes	arborescent lobes (1 species with long folds and arborescent lobes)	long folds and arborescent lobes	arborescent lobes
Gonads	in primary gut loop	cross gut loop	outside gut loop	cross gut loop	cross gut loop

Family MOLGULIDAE

Molgula mollis Herdman, 1899: 54. Kott, 1952: 298; 1964: 144.

Molgula sydneyensis Herdman, 1899: 55. *Molgula janis* Kott, 1952: 295. Millar, 1966: 374.

New Record: Carickalinga Head. *Previous Records*: N.S.W. (Port Jackson, Sydney)—Herdman 1899; (Twofold Bay)—Kott 1952. Qld. (Gladstone to Moreton Bay)—Kott 1964.

Description: Small, rounded, laterally flattened specimen of 0.6 cm diameter. The apertures are present anteriorly in a depressed, sand-free area of test, surrounded by sandy protuberances and hairs from the thin test.

The dorsal tubercle is oval with a longitudinal, more or less S-shaped slit. The neural gland is conspicuous beneath the tubercle.

The branchial sac has 7 folds on each side of the body with only 2 internal longitudinal vessels along the top of each fold. Stigmata coil to form infundibula projecting into the folds and subdividing into two in the summit of the fold. Between the folds there are some interstitial stigmatal coils but no primary infundibula. The spirals of the primary coils are interrupted in their median longitudinal and transverse planes and their arrangement, especially at the base of the spiral between the folds, is obscured.

The gonads are flask-shaped and the testis follicles form a circle around the proximal end of the ovary, with a connective from the centre of this circle as previously described (Millar 1966).

Remarks: The species is characterised by the small number of longitudinal vessels on one side of the branchial folds. There is some variation in the development of the hollow extensions of the test which Kott (1952) had thought distinguished *M. fanis*. It is clear, however, that the species is synonymous with *M. mollis*.

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Appendix I—Station List

A. ROUGH COAST SUBFORMATION

WEST ISLAND; on granite usually on vertical faces or in caves.

1. Region A: rough (Shepherd & Womersley 1970); depth indicated for each species.
   Podoclavella cylindrica 25 m
   Leptoclinides rufus 16 m
   Botrylloides magnicoecus 22–25 m
   Botrylloides leachi 16–25 m
   Botrylloides nigrum 12–20 m
   Oculinaria australis 12–25 m
   Cnemidocarpa etheridgii 25 m
   Polycarpa pedunculata 16–25 m
   Pyura australis 12–20 m
   Microcosmus nickolisi 22 m
   Herdmania momus 16–22 m

2. Region B: moderately rough (Shepherd & Womersley 1970); depth 15 m.
   Synoicum cerebriformis
   Polycitor giganteum
   Botrylloides leachi

3. Region D: sheltered (Shepherd & Womersley 1970); depth 2–5 m; 27.xi.66.
   Podoclavella cylindrica
   Cystodytes dellechiajei
   Synoicium papilliferum
   Didemnum candidum
   Didemnum moseleyi
   Trididemnum spiculatum
   Didemnum sp.
   Leptoclinides rufus
   Botrylloides nigrum

WIGHT ISLAND: rough coast, strong surge; on vertical granite faces; depth 10 m; 28.xi.66.
   Podoclavella cylindrica

Sycozoa cerebriformis
Atapozoa fantasiana
Polycitor giganteum
Eudistoma renieri
Didemnum candidum
Leptoclinides rufus
Phallusia depressiuscula
Ascidia sydneyensis
Botrylloides leachi
Botrylloides nigrum
Oculinaria australis
Cnemidocarpa etheridgii
Polycarpa pedunculata
Microcosmus nichollsi
Herdmania momus

KING BEACH, Encounter Bay: under boulder on intertidal reef.
Corella eumyota

NORA CRELINA BAY, near Robe: on roof of cave; strong surge; depth 10 m; 11.i.67.
Eudistoma sp.
Pseudodistoma vercum

24 KM NORTH-WEST OF ROBE, South Australia: on aeolianite; slight surge; attached to red algae; depth 40 m.; 20.xi.68.
Pyura australis
Herdmania momus

B. SHELTERED COAST SUBFORMATION

OFF HALLETT COVE, on reef: rocky bottom; depth 8 m; 26.xii.66.
Podoclavella cylindrica
Distaplia viridis
Sycozoa cerebriformis
Polycitor giganteum
Aplidium pliciferum
Leptoclinides rufus
Erhinoclinum verrilli
Rhodosoma turcicum
Corella eumyota
Phallusia depressiuscula
Ascidia thompsoni
Ascidia sydneyensis
Polycarpa pedunculata
Microcosmus nichollsi

INSIDE PORT NOARLUNGA REEF: moderate surge; in caves or on vertical faces; depth 2–5 m; 20.xi.66.
Podoclavella cylindrica
Distaplia viridis
Ritterella herdmania
Synoicium papilliferum
Leptoclinides rufus (sometimes investing *Pyura irregularis* and *Microcosmus stolonifera*)
Ascidia sydneyensis
Botrylloides leachi
Stolonica australis
Polycarpa pedunculata
Pyura irregularis
Microcosmus stolonifera

ALDINGA REEF AT "DROP-OFF": rocky bottom; slight surge; depth 10–25 m; 12.xii.66.
Podoclavella cylindrica
Polycitor giganteum
Didemnum lambitum
Didemnum patulum
Polycarpa papillata
Polycarpa pedunculata
Pyura irregularis
Pyura spinifera
Halocynthia hispida
Herdmania momus
Microcosmus nichollsi

CARICKALINGA HEAD: in caves and on vertical rock faces; moderate surge; depth 5–6 m; 18.ii.67.
Clavelina baudinensis
Distaplia viridis
Sycozoa cerebriformis
Didemnum moseleyi
Ascidia thompsoni
Botrylloides nigrum
Polycarpa pedunculata
Pyura irregularis
Herdmania momus
Halocynthia hispida
Microcosmus nichollsi
Molgula mollis

RAPID HEAD: on vertical faces and under ledges; slight to moderate surge; depth 10 m; 25.iv.66.
Clavelina baudinensis
Polysyncraton orbiculum
Leptoclinides rufus
Botrylloides nigrum
Polycarpa pedunculata
Halocynthia hispida

OFFSHORE BENTHIC LOCATIONS

GOOSE I., Spencer Gulf: on rocky bottom; depth 3–5 m; 1.x.66.
Didemnum moseleyi
Herdmania momus

TIPARA REEF, Spencer Gulf:
1. on travertine vertical faces and under ledges; depth 6 m; 24.v.69.
Podoclavella moluccensis
Stolonica australis (aggregates)
Polycarpa pedunculata
Pyura irregularis
Herdmania momus
Microcosmus squamiger

2. on surface of rocks; slow current; depth 6m; 24.v.69.
Leptoclinides reticulatus
Phallusia depressiuscula
Ascidia sydneyensis
Stolonica carnosa
Polycarpa papillata
Polycarpa pedunculata
Pyura australis
Pyura irregularis
Halocynthia hispida
Microcosmus stolonifera
Microcosmus squamiger
Ctenicella antipoda

3. epizoic on *Amphiholis antarctica*; moderate current, 2 m/sec.; depth 12 m; 19.v.71.
Botrylloides leachi
Pyura australis
Herdmania momus

OFF BEACH HUT, 1 km off Port Vincent: on travertine; no wave action; slight current; depth 4 m; 24.ii.69.
Ascidia sydneyensis
Pyura irregularis
Halocynthia hispida
Microcosmus nichollsi
Microcosmus helleri

ORONTES BANK, off Port Vincent: 20 m; 26.iii.66.
Sycozoa cerebriformis

TAPLEY SHOAL, St. Vincent Gulf: depth indicated for each species; Feb. 1969.

1. Sluggish current, sandy bottom.
Phallusia depressiuscula 16 m
Ascidia sydneyensis 12 m
Polycarpa pedunculata 16 m
Cnemidocarpa etheridgii 12 m
Pyura scoresbiensis 16 m
Halocynthia hispida 12 m, 16 m
Microcosmus hilleri 12 m

2. Moderate current (to 1m/sec); travertine bottom covered by shallow sand; depth indicated for each species.
Aplidium colelloides 18 m
Polycarpa clavata 20 m
Polycarpa pedunculata 18 m, 20m, 22 m
Pyura australis 20 m
Halocynthia hispida
Pyura scoresbiensis 22 m

3. Mostly sand with some travertine outcrops; depth 23 m.
Sycozoa cerebriformis (on rock)
Aplidium colelloides
Polycarpa clavata
Pyura vittata

4. Strong current (to 2m/sec); sheet travertine; depth 24 m.
Polycitor giganteum
Aplidium pliciferum
Polycarpa pedunculata
Pyura australis

UPPER ST. VINCENT GULF: on sandy bottom in *Posidonia australis* community; moderate current (to 1 m/sec.); depth 10–11 m; 4.i.67.
Leptoclinides kingi
Pyura spinifera
Pyura irregularis
Halocynthia hispida
and growing on razor shell *Pinna dolobrata*:
Sycozoa cerebriformis
Aplidium rubricollum
Ascidia gemmata
Polycarpa pedunculata
Herdmania momus

OFF PORT GAWLER, St. Vincent Gulf: growing on *Pinna* and on *Cellepora* spp; slow current; depth 18–20 m; 11.ii.67.
Sycozoa cerebriformis
Leptoclinides rufus
Phallusia depressiuscula
Ascidia gemmata
Botrylloides nigrum
Polycarpa papillata
Polycarpa pedunculata

OFF OUTER HARBOUR, St. Vincent Gulf: on *Pinna*; slow current; depth 8 m; 2.xii.68.
Halocynthia hispida

OFF SEMAPHORE, St. Vincent Gulf: in sparse *Posidonia* community, silty bottom; slow current; depth 31 m; 27.i.69.
Polycarpa pedunculata
Pyura scoresbiensis
Microcosmus squamiger

OFF SEMAPHORE, St. Vincent Gulf: silty bottom; slow current; depth 24 m; 28.xii.68.
Polycarpa pedunculata

OFF GRANGE, St. Vincent Gulf: rocky bottom; slow current; depth 18 m; 7.xii.68.
Phallusia depressiuscula
Polycarpa pedunculata

OFF GRANGE, St. Vincent Gulf: in *Posidonia* community on shell; depth 6 m; 7.xii.68.
Pyura irregularis

OFF WEST BEACH (about 3 km), St. Vincent Gulf: on rocky bottom; depth 10 m; 8.vi.68.
Ascidia thompsoni
Botrylloides magnicaecus
Polycarpa pedunculata
Cnemidocarpa etheridgii
Halocynthia hispida
Pyura australis
Pyura irregularis (aggregates)
Microcosmus squamiger
Microcosmus nichollsi

OFF WEST BEACH (about 7 km), St. Vincent Gulf: in *Posidonia* community, slow current; depth 12–20 m, 27.xii.66.
Eudistoma pyriforme
Phallusia depressiuscula
Botrylloides nigrum
Polycarpa pedunculata
Pyura australis
Herdmania momus
Halocynthia hispida

OFF WEST BEACH (about 9 km), St. Vincent Gulf: on silty bottom; slow current; depth 20–25 m; 27.xii.66.
Phallusia depressiuscula

OFF BROADWAY OR GLENELG (several stations), St. Vincent Gulf: on sandy bottom; slow current; depths indicated for each species; 10.xi.68.
Sycozoa tenuicaulis (on scallop shell; 22 m)
Polycarpa pedunculata 6, 16 m
Pyura australis 12 m
Halocynthia hispida 6 m

OFF GLENELG (5 km), St. Vincent Gulf: rocky bottom; slow current; depth 13 m; 13.v.67.
Ascidia gemmata
Polycarpa papillata
Polycarpa pedunculata
Herdmania momus

OFF GLENELG (1.5 km), St. Vincent Gulf: on *Posidonia* roots; depth 6 m; 30.v.70.
Polycarpa pedunculata
Pyura irregularis
Halocynthia hispida
Microcosmus squamiger

Off Glenelg (18 km), St. Vincent Gulf: depth 35 m; 4.ix.69.
Herdmania momus

Off Seacliff, St. Vincent Gulf: in *Posidonia* community, on sandy bottom, fair sediment, slow current; depth 16 m; 21.i.69.
Ascidia aclara

Off Seacliff, St. Vincent Gulf: on *Amphiholis antarctica*; slow current; depth 9 m; 28.ix.68.
Botrylloides nigrum—with sponge

Off Hallett Cove (3–5 km), St. Vincent Gulf: on silty bottom; slow current; depth 15–22 m; 27.xii.66.
Phallusia depressiuscula

Botryllus schlosseri
Polycarpa pedunculata
Pyura australis
Pyura spinifera

Off Port Stanvac (6.4 km), St. Vincent Gulf: on steel wreckage ("The Barges"); slow current; depth 30 m; 26.iii.66.
Phallusia depressiuscula
Halocynthia hispida

Off Yankalilla Bay, St. Vincent Gulf: in *Amphiholis* community, sandy bottom; slight surge; depth as indicated: 18.ii.67.
Pyura australis 20 m
Halocynthia hispida 20 m
Ctenicella antipoda 15 m

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NEW FORM SPECIES OF POLLEN FROM SOUTHERN AUSTRALIAN EARLY TERTIARY SEDIMENTS

BY WAYNE K. HARRIS

Summary

Sixteen new form species of dispersed pollen grains; *Sparganiaceaepollenites barungensis, Amosopollis dilwynesis, "Triorites" psilatus, Tricolporites valvatus, Triporopollenites gemmatus, Ericipites crassiexinus, Sapotaceoidaepollenites rotundus, Proteacidites confragosus, P. tripartitus, P. kopiensis, P. tortuosus, P. clintonesis, P. fromensis, P. varius, P. wilkatanaensis, and P. concretus* and one new form genus, *Gambierina,* are described from early Tertiary sediments from southern Australia.

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Sixteen new form species of dispersed pollen grains: *Sparganiaceaepollenites barungensis, Arnaudapollis dilwynensis, "Triorites" psilatus, Tricolporites valvatus, Triporopollenites gemmatus, Ericipites crassiexinus, Sapotaceoidaepollenites rotundus, Proteacidites confragosus, P. tripartitus, P. kopiensis, P. tortuosus, P. clintonensis, P. fromensis, P. varius, P. wilkatanaensis,* and *P. concretus* and one new form genus, *Gambierina*, are described from early Tertiary sediments from southern Australia.

Introduction

This paper describes several new species and a new genus, *Gambierina*, that were mentioned as manuscript names by Harris (1971) in an account of the palynology of Tertiary sediments in the Otway Basin. These forms were considered to have some biostratigraphic significance.

Previous taxonomic studies of Tertiary angiosperm pollen from Australia are limited to the works of Cookson (1947, 1950, 1953, 1954, 1957 & 1959), Cookson & Pike (1954) and Harris (1965a). Dettmann & Playford (1968) described four new angiosperm pollen species from Upper Cretaceous sediments from eastern Australia and some of these probably extend into the early Tertiary.

The preparation technique is that outlined by Harris (1965a) and the descriptive terminology is largely adapted from Erdtman's glossary (1952). Dimensions are based on fifteen or more specimens. Biostratigraphic data are based in part on unpublished studies by the author and on Harris (1971) and McGowran, Lindsay & Harris (1971). Sample data are presented in the appendix.

All co-ordinates are from the Leitz Orthoplan (715494) microscope in the Palynology Laboratory of the Geological Survey of South Australia and Holotypes (catalogue numbers prefixed Py) are deposited in the Geological Survey Palaeontological collection.

Systematic Palynology

Genus SPARGANIACEAEPOLLENITES Thiergart 1937

Type species: *Sparganiaceaepollenites polyganalis* Thiergart 1937: 307.

Sparganiaceaepollenites barungensis sp. nov.

FIGS. 1–3

Pollen monoporate, sphaeroidal to slightly bilateral. Pore circular (3–4 μm diam.) with incrassate margin 1–1.5 μm wide. Exine 2 μm thick, sexine as thick as nexine, reticulate. Reticulum undifferentiated over the grain, lumina 1–1.5 μm diam. *Dimensions:* Equatorial diam. 18 (22) 25 μm.

Holotype: Preparation and slide number—ST325/15, 42.1: 110.8. Py 195. Figs. 1, 2.
Type locality: Hd. Baringa Bore 4 at 65.5 m. Clinton Formation, ?Lower Miocene.
Distribution: This species first occurs in the Upper Eocene and continues through to the Upper Tertiary.

Comparison and affinity: The pollen figured by Couper (1960, pl. 9, figs. 21, 22) as *Typha* sp. appears to be very similar to *S. barungensis*. *S. barungensis* differs from *Aglaoreidia* Erdtman in not having a differentiated reticulum. *"Monoporites" subreticulata* Cookson has a wider rim to the pore. The species here described appeared under this generic name in Harris (1971) and McGowran, Lindsay & Harris (1971). *S. magnoides* Krutzsch (1970)

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approaches *S. barungensis* in size but has a wider meshed reticulum. *S. barungensis* is very similar to pollen of *Typha* and *Sparganium*.

Genus AMOSOPOLLIS Cookson & Balme 1962

Type species: *Amosopollis cruciformis* Cookson & Balme 1962: 97.

Amosopollis dilwynensis sp. nov.

FIGS. 4, 5

Synonymy: Amosopollis cruciformis sensu Harris 1965a: 97, Pl. 29, fig. 26.

Pollen grains in rhomboidal tetrads. Individual grains prolate to sub-prolate. Exine 2 μm thick, psilate to scabrate and finely granulate, except near the margins of the aperture where grana 1–1.5 μm diam. are present. Aperture is a long gaping sulcus extending the full length of the grain. Margins of sulcus not ragged. *Dimensions:* (10 specimens) Overall diam. of tetrad 50 (60) 68 μm. Individual grains 22 (34) 40 μm diam.

Holotype: Preparation and slide number—ST209/2, 39.3; 100.7. Py 015. Figs. 4, 5.

Type locality: Dilwyn Bay, Victoria, Pebble Point Formation, Paleocene.

Distribution: A. dilwynensis is a rare species but has been observed in Paleocene sediments from the Murray and Otway Basins, and a similar form has been reported (Harris 1965b) from Queensland in sediments of similar age.

Comparison and affinity: A. dilwynensis is in general larger than the genotype but can also be distinguished by the psilate-scabrate sculpture and more importantly by the straight margins of the sulcus.

Genus TRIORITES Cookson ex Couper 1953

Type species (by subsequent designation of Couper 1953, p. 60): *Triorites magnificus* Cookson 1950.

"Triorites" psilatus sp. nov.

FIGS. 6, 7

Pollen radiosymmetric, isopolar, oblate, triorate. Amb sub-triangular, sides straight to slightly convex. Ora sunken, 2–4 μm wide, circular. Exine 2μm except around apertures where it thickens to 3 or 4 μm. Exine psilate. *Dimensions:* Equatorial diam. 24 (32) 40 μm.

Holotype: Preparation and slide number—S564/1, 32.8; 100.6. Py 411. Fig. 6.

Type locality: Polda No. 1 Bore at 55.1 m. Poelpena Formation, Middle Eocene.

Distribution: This species is a very common form throughout the Lower Tertiary in southern Australia. It first appears in the Princetown Member and ranges through to the Lower Miocene. The upper limit has not been determined.

Comparison and affinity: "*T.*" *psilatus* is comparable and may be conspecific with "*T.*" *scabratus* Couper. The ornament on the latter however is scabrate. This species would more appropriately be placed in a new genus (see section on *Triorites* below).

Genus TRICOLPORITES Cookson 1947

Type species: *Tricolporites sphaerica* Cookson 1947: 195; genus monotypic when proposed.

Tricolporites valvatus sp. nov.

FIGS. 8, 9

Pollen radiosymmetric, prolate tricolporate. Amb in equatorial view ellipsoidal. Apertures compound, colpi reaching to within 3 or 4 μm of the poles, margins strongly invaginated to about 8 μm. Equatorial aperture orate, 5–8 μm diam. Exine 2–3 μm thick unornamented. *Dimensions:* Polar diam. 45 (52) 55 μm, equatorial diam. 30 (35) 39μm.

Holotype: Preparation and slide number—ST241/12, 35.1; 98.1. Py 176. Fig. 9.

Type locality: Lake Torrens Bore 3A at 247.8 m. "Wilkatana Formation", Middle Eocene.

Distribution: Common in the "Wilkatana Formation" but less common in other Middle Eocene (*Proteacidites confragosus* Zonule) assemblages.

Comparison and affinity: The strongly invaginated colpi and psilate exine make this a very distinctive species. Its natural affinities are unknown.

Genus ERICIPITES Wodehouse 1933

Type species: *Ericipites longistulcatus* Wodehouse 1933: 517.

Ericipites crassiexinus sp. nov.

FIGS. 15, 16

Pollen united in tetrads. Individual grains indistinctly tricolporate, tetrahedral in shape

and strongly united in the tetrad. Exine 2.5–3.5 μm thick, sexine as thick as nexine psilate. Apertures complex, colpi about 14 μm long and 1.5 μm wide. Pores indistinct and difficult to detect, 2 μm diam. *Dimensions:* Overall diam. 35 (42) 53 μm. Individual grains 24 (30) 35 μm diam.

Holotype: Preparation and slide number—S660/1, 52.9: 96.9. Py 415. Fig. 15.

Type locality: Bore, Hd. Cummins at 35.7–43.3 m. Wanilla Formation, Middle Eocene.

Distribution: Often a very common form in middle and upper Eocene sediments.

Comparison and affinity: The psilate nature of the exine and the larger size of this species distinguishes it from *E. scabratus* Harris. Pollen of this type characterise the Order Ericales.

Genus TRIPOROPOLLENITES (Pflug) Thomson & Pflug 1953

Type species: *Triporopollenites coryloides* Pflug in Thoms. & Pfl. 1953: 84.

Triporopollenites gemmatus sp. nov.

FIGS. 10, 11, 13, 14

Pollen occasionally free but most commonly united in tetrads. Tetrads 34–40 μm in overall diam. Individual pollen radiosymmetric, oblate, sub-isopolar, triorate. Amb sub-triangular with straight to convex sides. Exine 4–5 μm thick (including ornament). Sexine and nexine difficult to separate but nexine appears to be thicker than sexine. Exine covered with verrucae 2–3 μm wide, sphaerical and 2 μm high. Verrucae separated from each other (by 2–3 μm) by granulate ornament. Apertures obscured by ornament, porate or orate opening 1.5–2.5 μm wide. *Dimensions:* Individual pollen, equatorial diam. 25 (29) 31 μm.

Holotype: Preparation and slide number—S547/1, 31.7: 98.4. Py 720. Fig. 11.

Type locality: Lake Cootabarlow Bore 2 at 163.4 m. Great Artesian Basin. Murnpeowie Formation, Upper Eocene.

Distribution: Appears to be restricted to Middle and middle-upper Eocene sediments from the Pirie-Torrens and Great Artesian Basins and Eyre Peninsula.

Comparison and affinity: T. gemmatus is similar to *T. bullis* Gruas-Cavagnetto (1966) from the Sparnacian of the Paris Basin but this species is more or less circular and appears to have a more strongly thickened rim to the aperture.

Genus GAMBIERINA gen. nov.

Type species: *Triorites edwardsii* Cookson & Pike (in part) 1954: 214, pl. 2, figs. 101, 105, 106.

Diagnosis: Pollen radiosymmetric, oblate, lobate, angulaperturate, triorate. Apertures sunken. Sexine imperforate tectate, thinner than nexine, the two separated by a faintly discernable baculate layer, which forms a "nick" point in the apertural region. Aperture formed by sexine larger than that of the nexine. Nexine thickens more rapidly than sexine about the apertures. Exine psilate.

Figured specimen: Fig. 12.

Remarks: The characters of the exine, the apertures and general shape distinguish this genus from *Triorites*. As Dettmann & Playford (1968, p. 86) have pointed out, the species figured by Cookson & Pike (1954, particularly figs. 104 and 105) as *T. edwardsii* is distinct in being unthickened about the apertures.

Dettmann & Playford (1968) summarised the present status of the genus *Triorites* but chose to continue using the diagnosis of Couper (1953) pending a review by the present author.

Potonié (1960) clearly indicated that the two species *T. magnificus* Cookson and *T. clavatus* Cookson were morphologically comparable and distinct from other forms allocated to the genus. However, Potonié gave no indication as to where these other forms should be placed.

It is clear that *T. magnificus* and *T. clavatus* are very closely related morphologically and perhaps phylogenetically. Indeed Cookson (1957, p. 49) goes so far as to state that "there is little or no doubt that they were produced by closely related plants. Both species have the same shape, type of ora and exine stratification, and structure. . . ." Thus these two species form a natural grouping and all other species assigned to the genus are better accomodated elsewhere. Couper's (1953) diagnosis is too broad and suggestive of a suprageneric category. Mildenhall & Harris (1971) have reached similar conclusions.

Genus SAPOTACEOIDAEPOLLENITES Pot., Thoms., & Thierg., 1950

Type species: *Sapotaceoidaepollenites* (al. *Pollenites*) *manifestus* (Potonié) 1931: 3.

Sapotaceoidaepollenites rotundus sp. nov.

FIGS. 17, 18

Pollen radiosymmetric, subsphaeroidal to sub-prolate, four and less frequently three apertures. Apertures compound. Colpi 2/3 length of polar axis, 2–3 μm wide. Equatorial aperture more or less circular, 5–6 μm diam. and slightly elongate in an equatorial direction. Apertural margin prominently rimmed and thickened. Exine 2–2.5 μm thick, nexine about as thick as sexine. Sexine psilate to finely scabrate. *Dimensions:* Polar diam. 30 (36) 39 μm, equatorial diam. 28 (33) 35 μm.

Holotype: Preparation and slide number ST241/3, 45.7: 102.8. Py 167. Fig. 17.

Type locality: Lake Torrens Bore 3A at 247.8 m. "Wilkatana Formation", Middle Eocene.

Distribution: The species first appears in the Middle Eocene and continues on into the mid-Tertiary.

Comparison and affinity: The closest resemblance of this species is with *Tricolporopollenites latizonatus* McIntyre 1968, which is most commonly 3-aperturate, has a longer polar/equatorial axis ratio and has a broad thickened zone of the exine in the equatorial region. The species is very similar to pollen of the Sapotaceae.

Genus PROTEACIDITES Cookson ex Couper 1953

Type species: *Proteacidites adenanthoides* Cookson 1950: 172, designated by Couper 1953: 42.

Remarks. The genus *Proteacidites* accomodates at present a wide variety of forms described from both the Southern and Northern Hemispheres. Some from the latter clearly do not belong in this genus but until a review of the Australian forms by the author is complete (and on present evidence the genus will be split into three or more genera) comment on these is reserved. Although the following new species show a wide variation in form with regard to aperture construction and exine stratification and ornamentation they will be described under this genus but will be further reviewed in a forthcoming paper.

Proteacidites confragosus sp. nov.

FIGS. 19–22

Pollen sub-isopolar, angulaperturate, oblate, triporate. Amb triangular with slightly convex sides. Pores simple subcircular 6–7 μm diam., obscure. Exine 4–5 μm thick. Sexine three times as thick as nexine, heavily ornamented with a dense reticulum, lumina 3–4 μm diam., polygonal and made up of single rows of distinct bacula 1–1.5 μm diam. *Dimensions:* Equatorial diam. 54 (60) 69 μm.

Holotype: Preparation and slide number—ST241/9, 41.4: 105.7. Py 173. Figs. 19, 21, 22.

Type locality: Lake Torrens Bore 3A at 247.8 m. "Wilkatana Formation", Middle Eocene.

Distribution: An index form for Middle Eocene sediments. *P. confragosus* has been recorded from the North Maslin Sands, the Renmark, Poelpena and Wanilla Formations and the Burrungule Member of the Knight Formation.

Comparison and affinity: This is a striking species and is clearly distinct from any other known in the genus.

Proteacidites tripartitus sp. nov.

FIGS. 23–25

Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular with more or less straight sides. Apertures sub-circular, simple but obscure 2–2.5 μm wide. Exine 2.5–3 μm thick. Sexine half as thick as nexine, foveolate. Lumina *ca.* 1 μm diam., slightly smaller at the poles and towards the apertures. Muri 2–3 μm wide. Nexine thickens to 5 μm at 10 μm from the apertures. Pore "canal" 7–8 μm long. *Dimensions:* Equatorial diam. 27 (30) 34 μm.

Holotype: Preparation and slide number—S650/1, 32.2: 99.8. Py 406. Figs. 24, 25

Type locality: Hd. Cummins Bore at 114–116.4 m. Wanilla Formation, Middle Eocene.

Distribution: The species first appears very high in the Princetown Member of the Dilwyn Formation but does not become common until the Middle Eocene.

Comparison and affinity: The detail of the apertures closely resembles that found in *P. latrobensis* Harris and *P. concretus* but is distinguished by the characteristic ornament.

Proteacidites kopiensis sp. nov.

FIGS. 26, 27

Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular, sides straight or nearly so. Apertures subcircular, simple, 7–8 μm diam. Exine 2 μm thick and slightly thicker in the equatorial inter-aperturate regions. Sexine about half as thick as nexine, ornamented with a reticulum. Muri 1–1.5 μm wide. Lumina 2–3 μm diam. at the equator and decreasing gradually to 1 μm towards the apertures and polar regions. *Dimensions:* Equatorial diam. 36 (40) 47 μm.

Holotype: Preparation and slide number—S560/1, 26.1; 106.9. Py 393. Fig. 26.

Type locality: Polda No. 1 Bore at 37.5 m. Poelpena Formation. Middle Eocene.

Distribution: The species is present in the uppermost section of the Princetown Member of the Dilwyn Formation and continues in all basins into the middle-upper Eocene. It does not appear to range higher than the *Triorites magnificus* Zonule.

Comparison and affinity: This species is readily distinguished from other *Proteacidites* spp. by the characteristic ornament pattern.

Proteacidites tortuosus sp. nov.

FIGS. 28, 29

Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb rounded triangular, sides convex. Pores simple 13–15 μm wide. Exine 5 μm thick. Nexine thicker than sexine. Sexine ornamented with scattered verrucae, 2 μm wide and up to 6 μm long, rounded in optical section and 2 μm high. Areas between these elements psilate. *Dimensions:* Equatorial diam. 53 (55) 58 μm.

Holotype: Preparation and slide number—S563/2, 32.2; 99.8. Py 409. Figs. 28, 29.

Type locality: Polda No. 1 Bore at 55.1 m. Poelpena Formation, Middle Eocene.

Distribution: This species has been recorded from Middle Eocene sediments on Eyre Peninsula, Poelpena and Wanilla Formations.

Comparison and affinity: The large distinctive verrucae, thick exine and rounded sub-triangular shape separate this species from other species described here. *P. tortuosus* differs from *P. tuberculatus* Cookson in being smaller. The verrucae are not arranged in a reticuloid pattern and are not confined to a spherical shape.

Proteacidites clintonensis sp. nov.

FIGS. 30-34

Pollen sub-isopolar, oblate angulaperturate, triporate. Amb more or less triangular with concave sides. Pores circular 20–35 μm in diam. Exine 3 μm thick, sexine slightly thinner than nexine. Capita of bacula coalesce to form groups up to 7 μm wide and show an LO pattern. Elements rounded in optical section. Nexine in region of pores, alternately thick and thin. The sexine is readily lost by corrosion. *Dimensions:* Equatorial diam. 62 (75) 98 μm.

Holotype: Preparation and slide number—S705/1, 31.3; 105.2. Py 405. Figs. 32–34.

Type locality: Poyntz Bore, Hd. Ettrick at 94.5 m. Renmark Beds, middle-upper Eocene.

Distribution: The species is almost ubiquitous in Eocene sediments and is particularly common in the *Triorites magnificus* Zonule. It ranges from Middle Eocene to at least Lower Miocene.

Comparison and affinity: This species is similar to *P. rectomarginus* Cookson but has much larger apertures and strongly concave sides. Figure 30 more closely resembles *P. rectomarginus* with its finer ornament, larger size and straighter sides. It is possible that the two forms intergrade. Cookson's figure (1950, fig. 27) of *P. rectomarginus* appears to show some thickening of the nexine about the apertures. The species is distinguished from *P. incurvatus* by the nature of the sculpture and the characteristic aperture. The exine does not thin markedly near the apertures as it does in *P. incurvatus*.

Proteacidites fromensis sp. nov.

FIGS. 35–38

Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular, sides strongly concave. Pores simple, circular, 5 μm in diam. Exine 2.5–3 μm thick. Sexine slightly thinner than nexine in the inter-angles and thins towards the angles, evenly granulate to scabrate. Nexine thickest in the inter-angles. *Dimensions:* Equatorial diam. 61 (65) 70 μm.

Holotype: Preparation and slide number—S17/2, 35.1; 101.4. Py 408. Figs. 35–37.

Type locality: Lake Eyre Bore 20 at 73.2 m. Murnpeowie Formation, Paleocene.

Distribution: P. fromensis is restricted to and characteristic of Palaeocene sediments and is most common in the Murray and Great Artesian Basins.

Comparison and affinity: The strongly concave sides of the amb, size, and the scabrate ornament separate this species from others in the genus. It differs from *P. granoratus* Couper in that the ornament does not become coarser around the apertural region.

Proteacidites varius sp. nov.

FIGS. 39–42

Pollen small, sub-isopolar, peroblate, angulaperturate. Amb triangular with straight or slightly concave sides. Apertural pores, three, 2.5 μm diam. Exine 2–2.5 μm thick. Sexine much thinner than nexine and thins markedly near the apertures. Nexine thins toward the apertures with loss of ?endonexine elements near the aperture. Ornament 0.5 μm high, consisting of fused groups of bacula *ca.* 1 μm diam. Groups becoming smaller to absent near apertures. *Dimensions:* Equatorial diam. 20 (25) 37 μm.

Holotype: Preparation and slide number—S705/1, 37.2: 111.0. Py 399; Figs. 39, 40.

Type locality: Poyntz Bore, Hd. Ettrick at 94.5 m. Renmark Beds, Upper Eocene.

Distribution: A common species in middle and upper Eocene assemblages in the Murnpeowie and Poelpena Formations in particular.

Comparison and affinity: The nature of the ornament distinguishes the species from *P. reticulatus* Cookson and *P. symphyonemoides* Cookson. The characteristic nexine structure (see particularly Fig. 41) is distinctive. The relationship of this species to *P. obscurus* Cookson is not clear. Her figured specimens (Cookson 1952, figs. 30, 31) have lost most of the sexine. The species described here shows thinning of the exine about the apertures rather than slight thickening and is not "lanceolate-shaped" as described for *P. obscurus*.

Proteacidites wilkatanaensis sp. nov.

FIGS. 43–47

Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular with straight to concave sides slightly bulging about 10 μm from apertures. Apertures circular 4–6 μm diam. Exine 4 μm thick, thinning rapidly near the apertures. Nexine about 3 times as thick as sexine, thinning and apparently losing the basal layer near the apertures. Sexine consists of a thin baculate layer and an ectosexinous layer formed of united baculate elements giving a low rugulate ornament. Rugulae 1–3 μm long, less than 1 μm wide. *Dimensions:* Equatorial diam. 51 (55) 61 μm.

Holotype. Preparation and slide number—S2273/4, 44.1: 106.7. Py 720. Figs. 43, 44.

Type locality: Bore near Ediacara at 280.4–283.5 m. "Wilkatana" Formation, middle-upper Eocene.

Distribution: The species is commonly observed in middle-upper Eocene sediments in most basins.

Comparison and affinity: The species differs from *P. incurvatus* Cookson and *P. clintonensis* in not being puncti-tegillate. The ornament is similar to that of *P. varius* but the species is much larger and does not show the characteristic structure of the nexine around the apertures.

Proteacidites concretus sp. nov.

FIGS. 48, 49

Pollen sub-isopolar, oblate, angulaperturate, triporate. Amb triangular with straight sides. Apertures circular 1.5 μm diam. Exine 2 μm thick but thickens in the region of the aperture to 4 μm and forms a pore "canal" 5 μm long. Exine faintly and evenly scabrate to finely spinulate. LO pattern distinct. *Dimensions:* Equatorial diam. 25 (28) 32 μm.

Holotype: Preparation and slide number—S360/2, 35.8: 105.5. Py 404. Fig. 48.

Type locality: Kopi Anomaly KR9 at 61 m. Peolpena Formation, Middle Eocene.

Distribution: A common species in most Eocene sediments.

Comparison and affinity: This species is most closely similar to *P. latrobensis* Harris, particularly in the nature of the aperture. It differs, however, from this species by the nature of the ornament. (*P. latrobensis* has a scrobiculate pattern.)

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APPENDIX

SAMPLE DATA

Bore name (or outcrop)	Depth in metres (feet in parenthesis)	Formation	Basin	Locality	Type of Sample	Sample No.
Nullabor No. 6	105-122 (344-400)	Pidinga	Eucla	Lat. 31°09′00″S Long. 131°12′30″E	Percussion sludge	S623
Polda No. 1	37.5 (123)	Poelpena	Polda	Lat. 33°33′00″S Long. 135°20′00″E	Core	S560
Polda No. 1	51.8 (170)	Poelpena	Polda	Lat. 33°33′00″S Long. 135°20′00″E	Core	S562
Polda No. 1	55.1 (181)	Poelpena	Polda	Lat. 33°33′00″S Long. 135°20′00″E	Core	S563
Polda No. 1	57.9 (190)	Poelpena	Polda	Lat. 33°33′00″S Long. 135°20′00″E	Core	S564
Kopi Anomaly K.R.9	61 (200)	Poelpena	Unnamed	Lat. 33°24′10″S Long. 135°44′45″E	Core	S360
Hd. Cummins (W.Con.Res. adj. Sec. 16)	35.7-43.3 (117-142)	Wanilla	Cummins	Lat. 34°15′10″S Long. 135°40′45″E	Percussion sludge	S660
Hd. Cummins (W.Con.Res. adj. Sec. 16)	114-116.4 (374-382)	Wanilla	Cummins	Lat. 34°15′10″S Long. 135°40′45″E	Percussion sludge	S650
Cummins school residence	32-39 (115-128)	Wanilla	Cummins	Lat. 34°15′50″S Long. 135°43′20″E	Percussion sludge	S741
Lake Torrens Bore 3A	247.8 (813)	"Wilkatana"	Piric-Torrens	Lat. 31°14′00″S Long. 138°01′45″E	Core	S241
Near Ediacara	280.4-283.5 (920-930)	"Wilkatana"	Piric-Torrens	Lat. 30°48′34″S Long. 138°07′30″E	Cuttings	S2273
Hd. Barunga Bore 4	65.5 (215)	Clinton	St. Vincent	Lat. 33°45′55″S Long. 138°13′35″E	Core	S325
Lake Cootabarlow Bore 2	163.4 (536)	Murteowie	Great Artesian	Lat. 30°16′30″S Long. 140°08′30″E	Core	S547
E. A. Rudd Bore 5	116.1 (381)	Murteowie	Great Artesian	Lat. 31°13′00″S Long. 139°52′50″E	Core	S1986
Lake Eyre Bore 20	73.2 (240)	Murteowie	Great Artesian	Lat. 28°48′00″S Long. 137°30′20″E	Core	S17
Poyntz Bore, Hd. Ettrick	94.5 (310)	Renmark Beds	Murray	Lat. 35°00′30″S Long. 139°31′45″E	Percussion sludge	S705
S.E. side of Dilwyn Bay	1.8 m above base of formation	Pebble Point	Otway	Lat. 38°44′00″S Long. 143°10′30″E	Outcrop	S208
S.E. side of Dilwyn Bay	1.2 m above base of formation	Pebble Point	Otway	Lat. 38°44′00″S Long. 143°10′30″E	Outcrop	S209

Note: Unless otherwise specified the figures are X500 in normal transmitted light. NDIC refers to Nomarski Differential Interference Contrast.

Figs. 1–12

Figs. 1–3. *Sparganiaceaepollenites barungensis* sp. nov., X 1250. Figs. 1, 2.—ST 325/15, 42.4: 110.3. Fig. 1.—High focus. Fig. 2.—Mid focus. Fig. 3.—S 325/3, 39.7: 96.8. Pore in N.W. quadrant.

Figs. 4, 5. *Amosopollis dilwynensis* sp. nov. Py 015, 38.7: 100.1. Fig. 5, X 1250. Notice the granulate margin of the sulcus.

Figs. 6, 7. *"Triorites" psilatus* sp. nov. X 1250. Fig. 6.—S564/1, 32.8: 100.6. Fig. 7.—S562/1, 37.7: 104.9.

Figs. 8, 9. *Tricolporites valvatus* sp. nov. Fig. 8.—ST 241/12, 39.0: 98.2. Fig. 9.—Py 176, 35.1: 98.1, X 1250, NDIC.

Figs. 10, 11. *Triporopollenites gemmatus* sp. nov. Fig. 10.—S650/1, 43.4: 104.5, single grain. Fig. 11.—S547/1, 31.7: 98.4, tetrad.

Fig. 12. *Gambierina edwardsii* (Cookson & Pike) Harris comb. nov. ST 208/2, 32.1: 103.7.

Figs. 13–25

Figs. 13, 14. *T. gemmatus* sp. nov. Fig. 13.—S547/1, 31.7: 98.4, X 1250 high focus. Fig. 14.—S741/2, 38.6: 106.8.

Figs. 15, 16. *Ericipites crassiexinus* sp. nov. Fig. 15.—S660/1, 52.9: 96.9. Fig. 16.—S560/1, 19.2: 107.2.

Figs. 17, 18. *Sapotaceoidaepollenites rotundus* sp. nov. Fig. 17.—Py 167, 45.7: 102.8, X 1250, NDIC. Fig. 18.—S564/1, 29.5: 106.4.

Figs. 19–22. *Proteacidites confragosus* sp. nov. Figs. 19, 21, 22.—ST 241/9, 41.4: 105.7. Fig. 21, 22, X 1250. Fig. 9 focused on ornament, fig. 10 focused on apertural region. Fig. 20.—ST 241/4, 35.6: 104.7.

Figs. 23–25. *Proteacidites tripartitus* sp. nov. X 1250. Fig. 23.—S560/1, 27.7: 100.8, NDIC. Figs. 24, 25.—S650/1, 32.2: 99.8, sectional and high focus respectively.

Figs. 26–37

Figs. 26, 27. *Proteacidites kopiensis* sp. nov. Fig. 26.—S560/1, 26.1: 106.9, X 1250, NDIC. Fig. 27.—S623/1, 16.6: 109.3, NDIC.

Figs. 28, 29. *Proteacidites tortuosus* sp. nov. S563/2, 32.2: 99.8. Median and high focus respectively.

Figs. 30-34. *Proteacidites clintonensis* sp. nov. Figs. 30, 31.—S741/2, 47.8: 96.3. Fig. 31, X 1250, high focus on polar region. Figs. 32–34.—S705/1, 31.3: 105.2. Fig. 33, X 1250, high focus on polar region; fig. 34, focus on apertural region.

Figs. 35–37. *Proteacidites fromensis* sp. nov. S17/2, 35.1: 101.4. Figs. 36, 37, X 1250. Fig. 36, high focus on polar region; fig. 37, median focus on interapertural region.

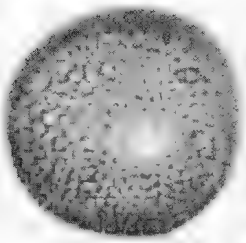
Figs. 38–49

Fig. 38. *Proteacidites fromensis* sp. nov. S1986/2, 27.0: 99.3.

Figs. 39–42. *Proteacidites varius* sp. nov. X 1250. Figs. 39, 40.—S705/1, 37.2: 111.0. High and mid focus respectively. Fig. 41.—S547/1, 22.7: 96.0. Fig. 42.—S705/1, 98.8: 44.3.

Figs. 43–47. *Proteacidites wilkatanaensis* sp. nov. Figs. 43, 44.—S2273/4, 44.1: 106.7. Mid and high focus respectively. Fig. 45.—S705/2, 22.8: 105.9. Figs. 46, 47.—S2273/3, 33.2: 107.1. High and mid focus respectively.

Figs. 48, 49. *Proteacidites concretus* sp. nov. X 1250. Fig. 48.—S360/2, 35.8: 105.5. Fig. 49.—S705/3, 26.9: 105.5.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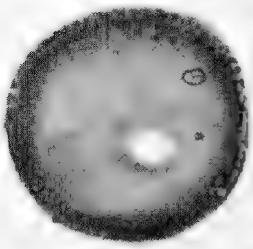
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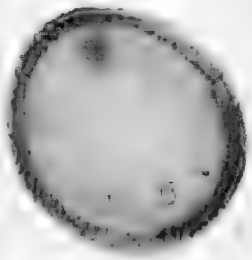
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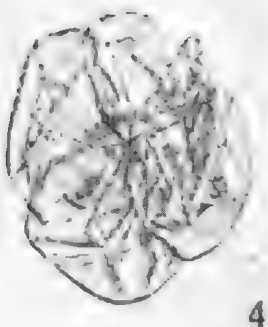
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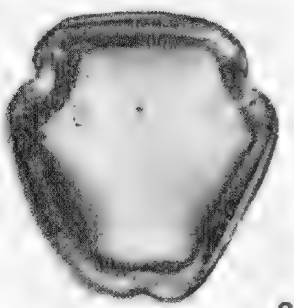
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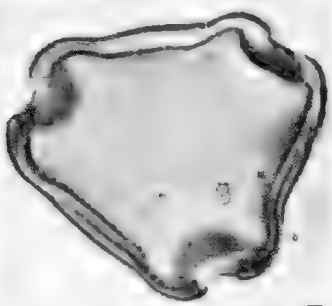
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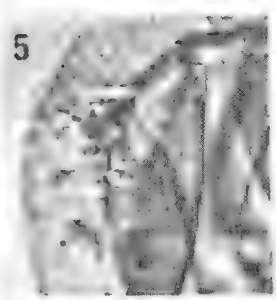
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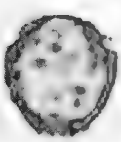
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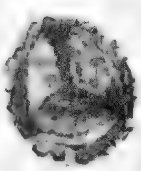
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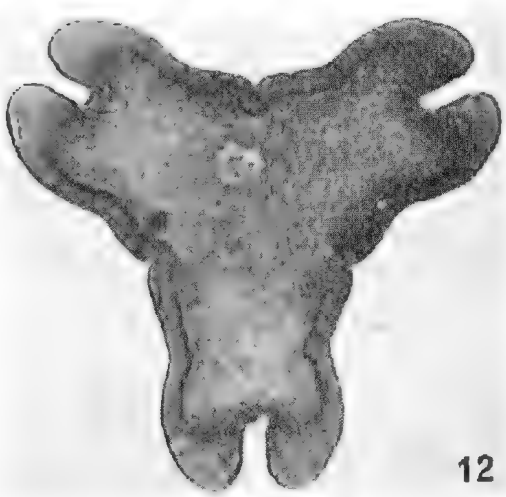
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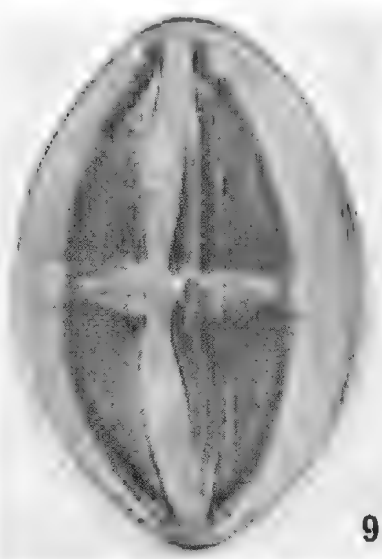
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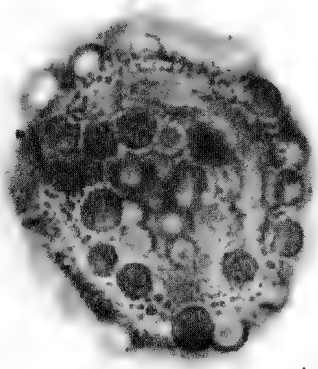

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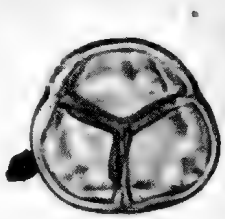

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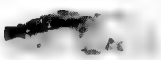

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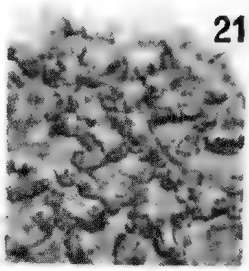

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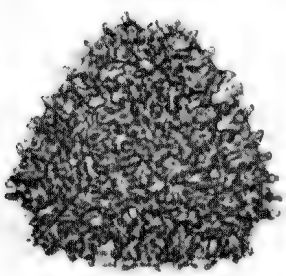

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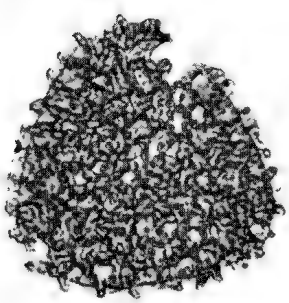

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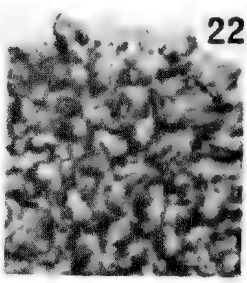

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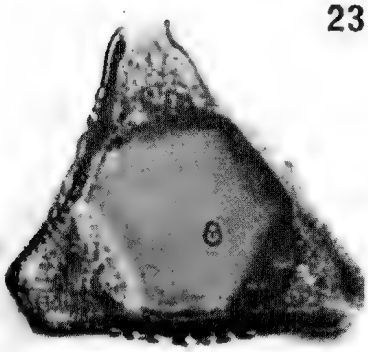

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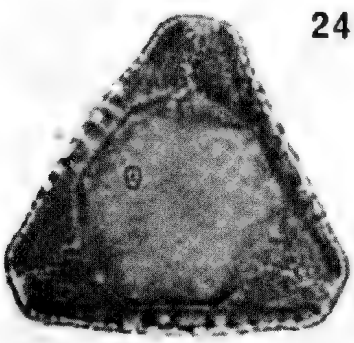

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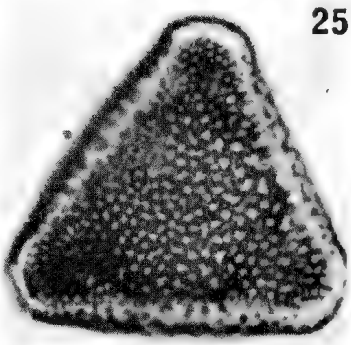

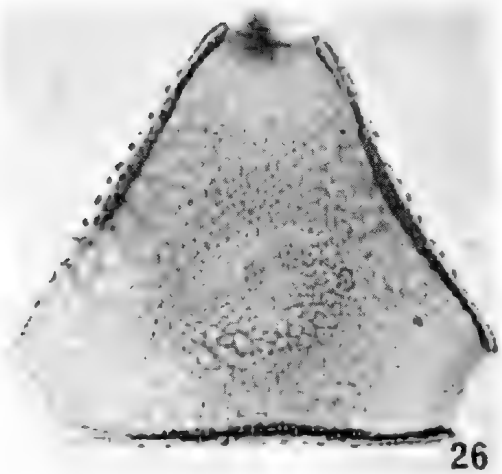
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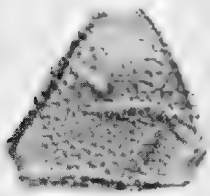
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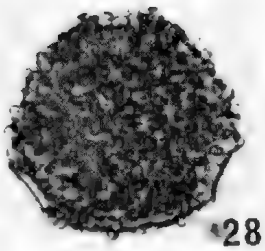
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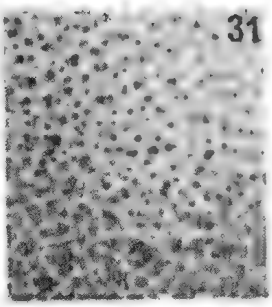
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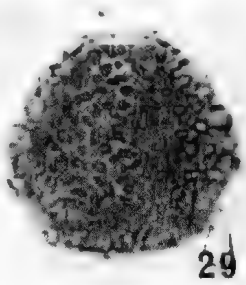
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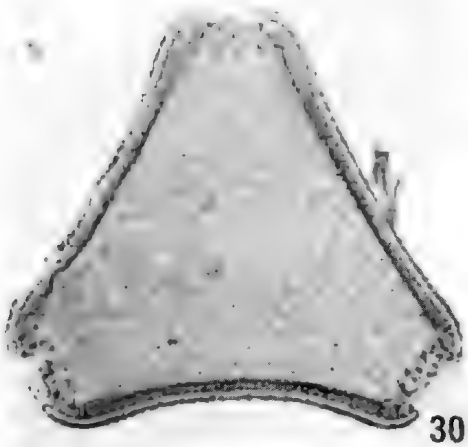
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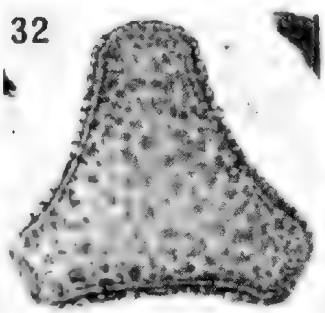
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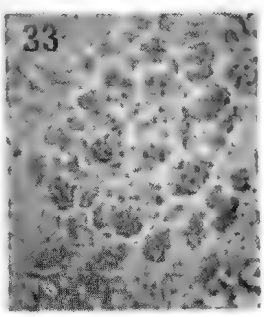
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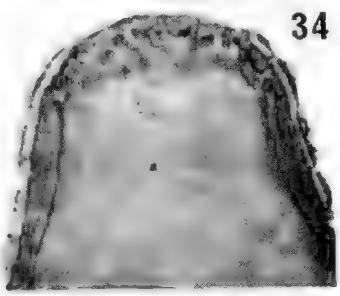
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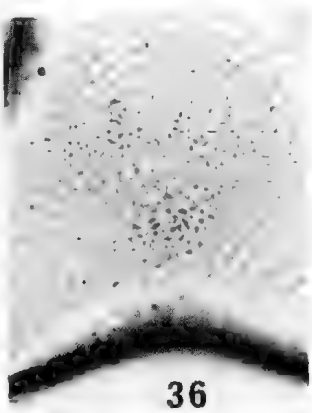
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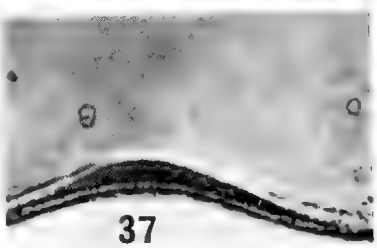
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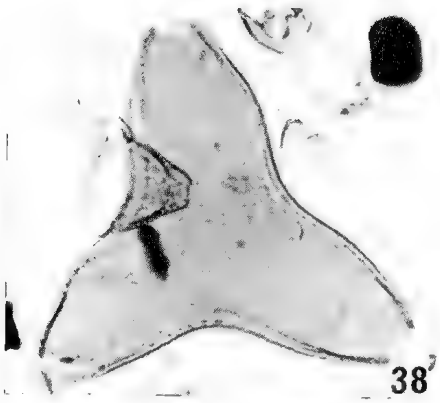
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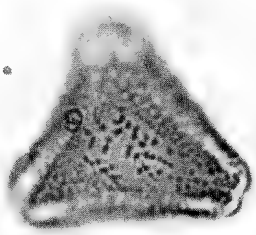
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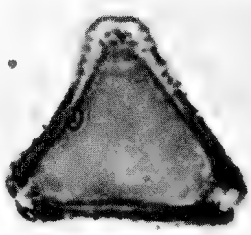
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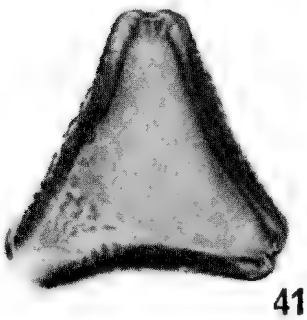
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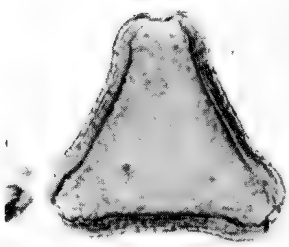
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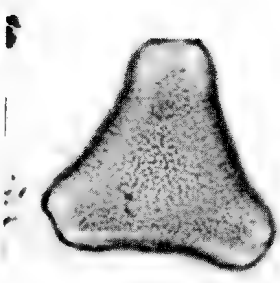
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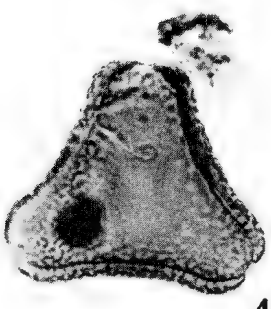
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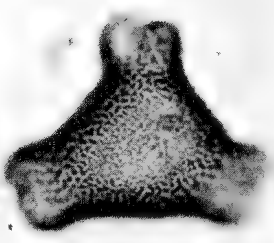
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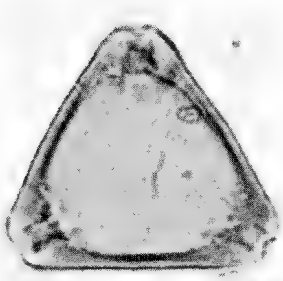
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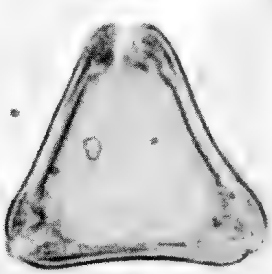
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BY W. V. PREISS

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Introduction

Stromatolites are laminated structures formed in sediments, mostly carbonates, by the trapping and precipitation of sediment by mats of algae and bacteria. They are known throughout the sedimentary record, and are particularly abundant in otherwise unfossiliferous Precambrian sequences. This observed abundance and the diversity of forms have made stromatolites potentially useful as index fossils, provided that taxa can be defined which have stratigraphically restricted time-ranges. A group of Russian stromatolite specialists has been engaged in the systematic description and classification of stromatolites for the past fifteen years and their results stimulated this study of South Australian stromatolites in an attempt to apply biostratigraphic methods to the problems of the age and correlation of the Precambrian sequence in the Adelaide Geosyncline.

This paper is based on the systematics section of a thesis submitted for the degree of Ph.D., University of Adelaide. It is necessary here to briefly discuss the taxonomy of stromatolites and particularly to formalize several new taxa needed for subsequent discussions of biostratigraphy and palaeoecology. This paper, the first of three, will include an outline of previous studies, consideration of some taxonomic principles and problems, and descriptions of four new forms and one indeterminate form. The other parts will comprise descriptions of further forms and a discussion of the stratigraphic distribution of stromatolites. Stromatolite forms will be described in alphabetical order.

Background

This history of the early study of stromatolites was comprehensively reviewed by Maslov (1960). Although most researchers prior to 1914 sought an animal origin for these structures, for example Hall's *Cryptozoon* (1883) and Steinmann's *Gymnosolen* (1911), Walcott's (1914) discovery of filamentous microfossils in Precambrian stromatolites from the Belt Series of Montana paved the way for the understanding of stromatolite formation by algae.

Later workers clarified the role played by the algae. In particular, Black (1933) established that the algal mats of the Bahamas are polyspecific and that the mucilaginous filaments of the blue-green algae present trap detrital grains. Pia (1926) recognized the rock-building properties of modern blue-green algae. Algal filaments were also found by Bradley (1929) to occur in stromatolites of the Eocene Green River Formation of Wyoming.

In Australia, Mawson (1925) recognized stromatolites in the Flinders Ranges, and started a collection which was partly used in this study. During the 1930's fossil stromatolites were described by numerous authors, the most important being Young (1933a, 1933b, 1935), Fenton & Fenton (1931, 1933, 1936, 1937, 1939), Johnson (1937, 1940) and Maslov (1937a, 1937b, 1938, 1939a, 1939b). The work of others were reviewed by Maslov

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(1960). Most of these authors tacitly accepted the validity of a formal binomial nomenclature for stromatolites.

Cloud (1942) was the first to question the validity of such a classification, arguing that stromatolites are built by associations of algal species. Similarly, Johnson (1966) has more recently rejected the use of this nomenclature, and suggested rather that only actual algal species should be named, if they are present. Nevertheless, Rezak (1957) found it useful to retain a binomial nomenclature and used the defined taxa successfully for intrabasinal correlation.

Since the controversy regarding the classification of stromatolites arose, at least three schools of thought have evolved. Firstly, a small group of Russian students (e.g. Vologdin 1962), like Johnson, considered that only actual algal remains can be validly named. But algae are very rarely preserved in Precambian stromatolites, and most of the micro-structures referred by Vologdin to fossil algae are very doubtfully of organic origin.

A second group rejects the concept of biological control over stromatolite morphology, and uses purely descriptive classifications to aid environmental interpretations. For example, Maslov (1960) used "generic" names such as *Collenia*, *Conophyton* and *Glebulella*, but he modified these by a series of descriptive Latin adjectives. Logan, Rezak & Ginsburg (1964) used symbols and formulae to describe various features of stromatolites, which they showed to be influenced by the local environment. Both Maslov's multinomial nomenclature and the variable descriptive formulae of Logan *et al.* tend to be cumbersome, and cannot in themselves describe all the useful characters of stromatolites. Some of the simpler formulae are, however, very useful in routine field descriptions. Hofmann (1969a) found difficulty in applying a binomial nomenclature to the stromatolites of the Gunflint Iron Formation, and later (Hofmann 1969b) discussed the significance of various characters of stromatolites, concluding that different morphologies are more likely to be environmentally than biologically controlled. Hoffman (1967, 1969) gave an outstanding example of the use of stromatolites in palaeocurrent determination

The third school is a Russian group which describes and classifies stromatolites on the basis of morphology and microstructure, and uses them for biostratigraphy. Their first results were reported by Keller *et al.* (1960). Despite differences of emphasis today between different workers, all use a binomial nomenclature with the form taxa "group" (analogous to genus) and "form" (analogous to species). They have found that the time ranges of the defined taxa are restricted, and this allowed them to subdivide and correlate Late Precambrian sections throughout much of the USSR. The biostratigraphy was supported by numerous radiometric datings, both K–Ar determinations on glauconites and K–Ar, Rb–Sr and U–Th–Pb determinations on intrusives. The subdivision is as follows:

Cambrian	
	570 ± 10 m.y.
Vendian	
	680 ± 20 m.y
Late Riphean	
	950 ± 50 m.y.
Middle Riphean	
	1,350 ± 50 m.y.
Early Riphean	
	1,600 ± 50 m.y.

The approach of this group was applied to Australian stromatolites, and it was found that many of the Russian taxa do occur here, in a similar order of succession (Glaessner, Preiss & Walter 1969; Preiss 1971). The resulting correlations with the dated Russian sequences were in agreement with most of the radiometric evidence available for the Australian Precambrian.

The successful use of stromatolites in biostratigraphy implies that their morphology is at least partly controlled by genetic characters of algae which evolve in time. The concept of biological control is supported by some studies of modern algal mats (Eardley 1938; Hommeril & Rioult 1965; Monty 1967). Each of these authors has shown the partial dependence of mat type on the predominating algal species present. This in turn affects the microstructure and lamina shape of the stromatolite, and indirectly, the gross morphology. Thus, deciding which characters are genetically determined and which are directly shaped by local environmental factors becomes the major difficulty in classifying stromatolites.

The Russian work of recent years has shown that it is mainly the columnar stromatolites which are of value in biostratigraphy. Only Komar (1966) has given a detailed account of laterally linked stromatolites but their usefulness has not been confirmed to the extent of that of columnar forms. In this study, atten-

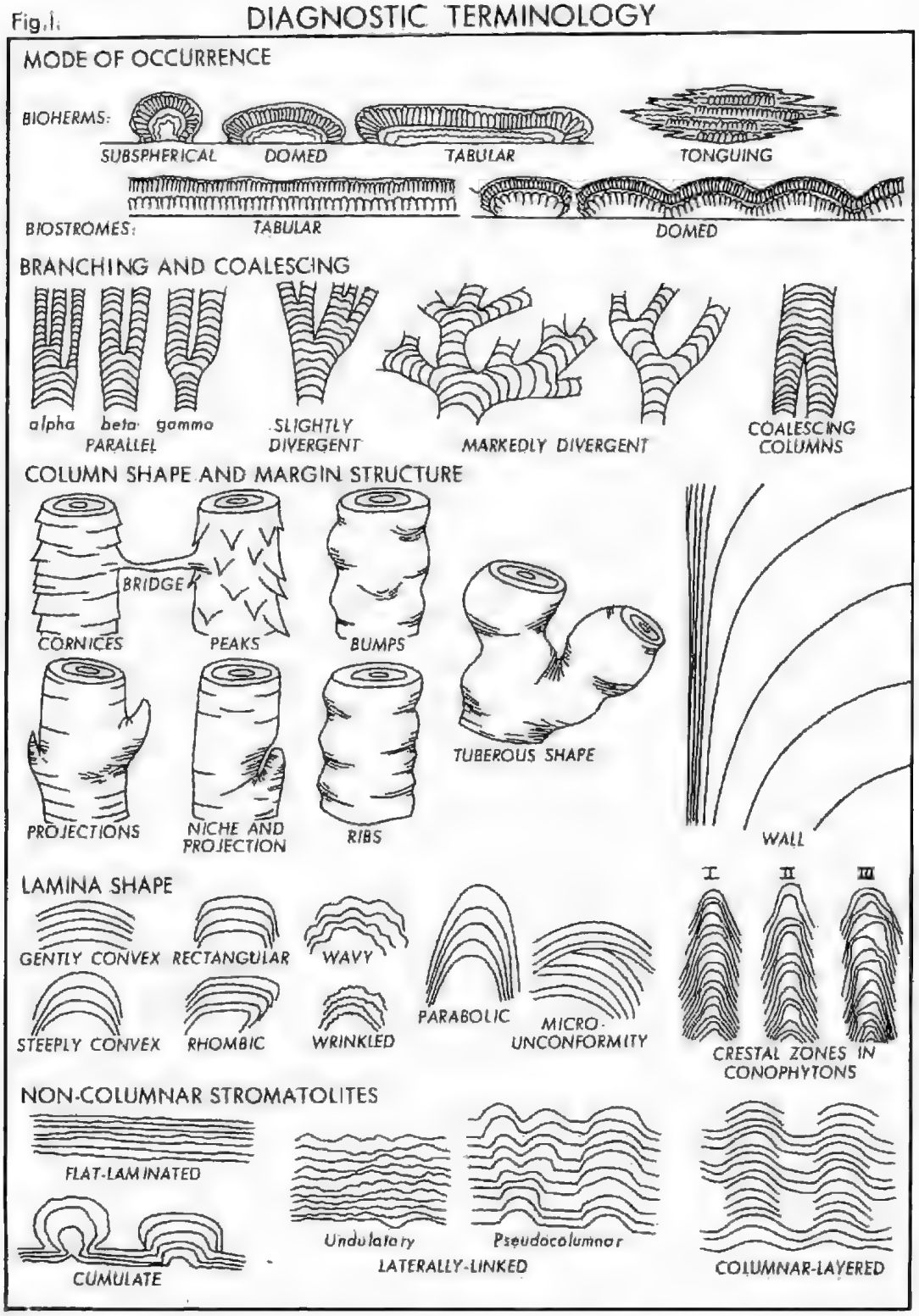

Fig. 1. Diagnostic terminology found useful in the description of stromatolites. The diagrams illustrate features discussed in the Appendix.

tion was also concentrated on columnar forms since these have the most characters allowing them to be classified. Therefore the binomial nomenclature has been applied only to these.

The terms used here to describe stromatolite characters, are largely based on translations of Russian terms, with minor alterations and additions. Most of the new terms introduced by Hofmann (1969b) are unnecessary from the point of view of this study. The diagnostic terminology proposed by Glaessner *et al.* (1969, Fig. 1) has been expanded (Fig. 1), and the terms used in the descriptions are defined in the glossary, Appendix I.

Taxonomy

In general the methods of stromatolite study and classification used by the Russians, Krylov (1963, 1967), Semikhatov (1962), Nuzhnov (1967) and Komar (1966) have been applied here, including binomial nomenclature. Although many of the group names have been accepted in palaeobotanical literature as genera, e.g. *Baicalia*, *Conophyton* and *Gymnosolen* by Andrews (1970), it is considered that retention of the terms *group* and *form* emphasizes the distinction between stromatolites as organo-sedimentary structures and actual fragmentary plant remains to which the terms *form genus* and *form species* may be applicable. While similar groups of characters are studied for each stromatolite, the relative taxonomic significance attached to any particular character may vary from taxon to taxon, depending on its diagnostic value. Mostly, *groups* are defined on the basis of gross morphology, column shape, branching and margin structure. Lamina shape and microstructure are frequently useful in the distinction of *forms*. But sometimes these features are diagnostic at group level—*Conophyton*, for example, is diagnosed by its lamina shape, and is characterized by particularly distinct lamination. *Baicalia* tends to be characterized by banded lamination, except where altered by diagenesis. Although the presence of a wall is a diagnostic difference between some groups, Walter (1970) [1] has described single stromatolites which are unwalled in their lower parts and walled at the top, in which case other features are diagnostic. No similar situation is known from South Australia.

It is considered unnecessary to use categories higher than the group, as Raaben (1964, 1969a, 1969b) has done. Her higher taxa are somewhat arbitrary and several alternative ones could be proposed, but all are equally questionable. On the other hand, the *variety* as a subdivision of the form is useful in cases where finer subdivisions can be made, and is therefore retained for *Conophyton garganicum*.

It could be argued that a single name would be sufficient to characterize a particular stromatolite, but the value of a binomial nomenclature is that it indicates real similarities and differences between various forms. Thus groups contain one or more forms which all share a number of characters considered diagnostic for that group. Forms are distinguished within a group whenever there are sufficient gross or microstructural differences. But the essential comparison between closely related forms would be lost without a binomial nomenclature.

The chief difficulty in the taxonomy of stromatolites is the isolation of discrete character combinations, where intergradation is common. Thus, subjective choice may be required in some cases. Where the morphology remains uniform throughout a particular occurrence, a single name can easily be applied, but if there is variation within the occurrence, the definition must be broadened. Whether or not the morphology of a stromatolite from another occurrence falls within this range of variation is difficult to decide. Conversely, if a significantly different morphology occurs as a discrete portion of an occurrence, is this to be classified separately? Examples of stromatolites with a broad range of variation are *Tungussia elina* and *Linella munyallina*. Both of these show a spectrum of intergrading branching types and column shapes, even within single outcrops, so that the range of variation between specimens of different areas lies within the range of variation in one locality, and these are therefore included in the one form.

It has been found that many characters overlap, and distinctions must be made even at group level on the most commonly occurring expression, i.e. the mode, of each character. This is especially true of branching. *Boxonia* is characterized by α-parallel and some β-parallel branching, while γ-parallel is rare. In *Gymnosolen* γ-parallel predominates, but not to the total exclusion of the other types. Similarly, there is overlap between the branching styles of *Baicalia* (the forms of which show a tremen-

[1] Unpublished Ph.D. thesis, University of Adelaide.

dötis variation of branching, as shown by Krylov 1967) and that of *Tungussia*. But while *Baicalia* has predominantly slightly to moderately divergent branching, in *Tungussia* markedly divergent branching predominates.

Although it is often easy to recognize groups on the basis of even limited reconstructions and longitudinal sections, the identification of forms is more difficult and subjective. Forms are distinguished on minor features of column morphology, lamina shape, or microstructure. Microstructure is the most difficult character to use, partly because different types intergrade to some extent and partly because it is so easily altered by diagenesis. The distinctive lamination of *Conophyton* is somewhat exceptional, and is amenable to statistical analysis. Although Raaben (1969a) has attempted similar studies on *Inzeria* and Semikhatov, Komar & Serebryakov (1970) have measured the sizes of clots and pellets in *Boxonia*, it is uncertain whether or not the structures measured are primary.

The laminae of most South Australian columnar branching stromatolites are too diffuse and variable to allow a detailed statistical study, although the well-preserved representatives of the banded microstructure of *Baicalia burra* might be amenable.

Stromatolites can be classified only on the basis of combinations of characters, and, as Walter (1970, unpublished) has also concluded, the classificatory significance of characters must vary to some extent from taxon to taxon. The classification has been found empirically to be useful in that the resulting taxa are temporally restricted. The question arises as to the fundamental meaning of these taxa, and why they are so restricted. Several possibilities exist:

(1) Each form is built by a particular association of algal species, and forms change as the content of the associations changes.

(2) Each form is built by a dominant algal species, in association with other species that have little effect on stromatolite morphology.

(3) The environment, and not the algal composition, entirely controls the stromatolite morphology.

If (3) were true, we should expect a temporal restriction of forms only if the environment has systematically evolved in time. It is difficult to see how local factors such as current activity or sediment accumulation which could conceivably control stromatolite morphology, can exhibit continent-wide, if not world-wide, unidirectional change. On these grounds, this possibility must at present be rejected. If (1) were true, we could expect the morphology to change gradually as the overall algal composition changes, one species replacing another in the association. On the other hand, if one species controls the morphology, a rapid change would be expected. At present, it is not possible to tell which of (1) and (2) is correct and possibly both apply; the first possibility may explain the intergradations sometimes observed between taxa, when classification becomes difficult.

Although Hofmann (1969b) regarded *Conophyton* as apart from other stromatolites, recent work has shown that conophytons possibly intergrade with columnar branching forms such as *Baicalia* (Shapovalova 1968). Similarly Bertrand (1968) described intergradations of *Conophyton* and branched forms. While the taxonomic significance of these changing morphologies and their relationship to environmental factors has not been fully determined, it is clear that *Conophyton* is not fundamentally different from other stromatolites.

It is concluded that stromatolites must be defined on combinations of characters, the significance of each of which may vary in different taxa. The fact that some taxa have much broader ranges of variation than others results from the necessity of grouping intergrading morphologies present in single stromatolite occurrences.

Methods

Stromatolites were studied both in the field and in the laboratory, but field observations were often limited by outcrop conditions and lichen cover on rock surfaces. Where possible, the mode of occurrence, column shape and arrangement and branching were observed in order to gain an impression of the total variability.

The variable nature of stromatolites necessitates sampling of sufficient material to determine the modal expressions of characters present. Depending on the size of columns, large specimens weighing from 4-70 kg were collected, and the relative position and orientation were noted. Ideally, bioherm centres and margins were both sampled.

The diagnostic gross features of columnar stromatolites can only be determined from a

three-dimensional view of the structure. This is achieved by the method of "graphical reconstruction" described by Krylov (1963). A series of 10 to 15 serial longitudinal slabs 2 to 6 mm wide were cut on an oil-cooled 60 cm diamond saw with a saw cut about 2 mm wide. The columns were outlined in pencil on the slabs and traced on to a block diagram framework on tracing paper, each longitudinal section being parallel to the front face of the block. The reconstructions were retraced with shading to show surface morphology and finally redrafted by stippling.

Lamina shape, margin structure and microstructure were studied in large, longitudinal, thin sections, up to 20 cm long. Their thickness varies with the nature of the rock, but in general they must be thicker than petrological sections to preserve the distinctness of the structures. Carbonates were mostly identified by staining with Alizarin Red S, but were frequently checked by X-ray diffraction powder photographs.

Systematics

For each group from which forms are described, a diagnosis, a list of the known constituent forms and the stratigraphic and geographic distributions are presented. Forms are diagnosed only if described here for the first time. Descriptions are given under the headings *mode of occurrence, column shape and arrangement, branching, margin structure, lamina shape* and *microstructure*. The interspace sediments and the nature of secondary alteration are also described since they provide important clues to the depositional environment and diagenetic history.

The distribution of forms refers to both their geographic distributions and to the rock-stratigraphic units (Thomson *et al.* 1964) in which they occur. Reference is made for each locality and stratigraphic unit to the relevant geological sheet (either 1:63,360 or 1:250,000 map sheets, Geological Atlas of South Australia).

It was found convenient (Preiss 1971) to subdivide the Adelaidean into two time units: the Early Adelaidean, represented by all sediments up to the pre-tillite unconformity, and the Late Adelaidean, represented by sediments from the base of the lower tillite to the base of the Cambrian. This subdivision reflects both a climatic change and a major change in stromatolite assemblages. Ages of stromatolites will be referred to as Early or Late Adelaidean, but the probable correlations with the subdivisions of the Riphean will be noted in each case.

Type specimens are kept in the Department of Geology and Mineralogy, University of Adelaide, catalogued under numbers prefixed by S.

Group ACACIELLA Walter

Walter has supplied the group name *Acaciella* and the following diagnosis,

"*Type Form: Acaciella australica* (*Cryptozoon australicum* Howchin 1914).

Diagnosis: Nearly straight, parallel or radially arranged sub-cylindrical columns with α-, β- and rarely γ-parallel and very slightly divergent multiple branching. On column margins are numerous low bumps and occasional small cornices and peaks; small areas of wall occur infrequently. Laminae dominantly are rectangular, rhombic or gently domed and are not markedly wavy or wrinkled; the microstructure is streaky."

Content: *Acaciella australica* Walter, *A. angepena* f. nov. and *A. augusta* f. nov.

Age and Distribution: Adelaidean to Early Cambrian; Loves Creek Member of the Bitter Springs Formation, Central Aust.; the Lower Cambrian of S. Aust.; the Wundowie Limestone and Brighton Limestone equivalent, Umberatana Group, S. Aust. and as erratics in the lower (Sturtian) glacials, S. Aust.

Acaciella angepena f. nov.

FIGS. 2, 10, 11a

Material: Forty-seven specimens from nine localities.

Holotype: S460 (Figs. 2a, 10c). Lower Cambrian, 1 km south of Angepena H.S., Northern Flinders Ranges.

Name: After the type locality.

Diagnosis: *Acaciella* with vertical or radially arranged columns or pseudocolumns, which may branch upwards from either flat-laminated or small cumulate stromatolites. Columns may branch upwards into minute, irregular columns. Bridging is extremely common. Microstructure is regularly banded, with thin continuous laminae. Vermiform microstructure may be developed.

Description

Mode of occurrence: Cambrian stromatolites were studied in outcrop only in the Angepena area, where lenticular stromatolite beds consist of closely spaced ellipsoidal and domed bioherms 3 to 50 m wide. These overlie flaggy,

laminated, dark grey limestones with irregular erosional contacts. Cumulate or pseudocolumnar stromatolite individuals commence growth upon the erosional highs, and pass up into radially arranged or parallel short columns with very numerous bridges. At bioherm margins, columns and pseudocolumns become horizontal, and laminae are deflexed parallel to the overhanging sides of the bioherm, so that here growth actually proceeded downwards (Fig. 10a & b, showing longitudinal sections of a bioherm margin). Where adjacent bioherms become contiguous, they are overlain by a domed biostromal layer of columnar, pseudocolumnar and columnar-layered stromatolites, similar to those of the bioherm. At the edge of a stromatolite bed, the terminal bioherm has an abrupt vertical margin and the laminae bend downwards only slightly. The surrounding sediment of dark lime mud accumulated synchronously with stromatolite growth, and occasional algal laminae are intercalated with it: the bioherm probably never had more than 10 cm of relief over the surrounding sediment surface. Also, there is evidence of contemporaneous compaction of the lime mud the bioherm rests upon (Fig. 10c): the lower layers of the surrounding muds are depressed, while the upper ones simply abut against and cover the bioherm.

Column Shape and Arrangement: Column shape is highly variable in single bioherms, mainly due to different degrees of coalescing and bridging. The structures vary from laterally linked pseudocolumns with some discrete small cumuli (Fig. 10d) to frequently bridged and coalescing columns (Fig. 11a), to discrete, parallel subcylindrical columns (Figs. 2d, f, g; 10f). The latter chiefly make up Mawson's (1925) collection from Italowie Gorge. In all specimens where columns are reasonably discrete, they are smooth to slightly bumpy, sometimes with pointed terminations (Fig. 2b, j), while others branch into minute columns 1 to 3 mm wide. Columns are commonly less than 1 cm diam., but broad, cumulate columns up to 10 cm diam. have been observed. Transverse sections of columns are round, rounded polygonal or lobate (Fig. 2d, f, g). Columns may be vertical or radially arranged, especially on the margins of contiguous bioherms. Dolomitization of interspaces frequently obscures the original margins of the minute columns so that their shape cannot be accurately determined.

Branching: Branching is most commonly α- or β-parallel, occasionally γ-parallel. Columns frequently branch into narrower columns which do not regain the former diameter. Some branches are in the form of thin pointed projections (Fig. 2j). At bioherm margins, branching may remain parallel (Fig. 10c) or become radial (Fig. 10b), but here the stromatolites are largely pseudocolumnar.

Margin Structure: Column margins are rarely preserved intact. Commonly they are corroded by dolomite rhombs, if the interspaces are dolomitized; otherwise very fine stylolites may be developed. Bridging is extremely common in all specimens except those from Mawson's collection from Italowie Gorge, in which the columns are mostly discrete. These also have the smoothest margins, with only slight, occasional humps and ribs. Columns are always unwalled, the laminae thinning only slightly near the column margin. Laminae may slightly overhang the margin, but long peaks and cornices are absent.

Lamina Shape: Fig. 8a illustrates common lamina shapes; most are gently convex. Of 101 lamina measured, 69% have height to diameter ratios (h/d) beneath 0.2 and 0.4; only 7% have ratios greater than 0.6 (Fig. 9a). Laminae are smoothly domed, without sharp changes in shape from lamina to lamina. A few of Mawson's specimens from Italowie have wavy laminae, of wavelength 3 to 10 mm, amplitude 1 to 3 mm (Fig. 10f).

Microstructure: Microstructure in all specimens is regularly, thinly banded, with continuous laminae of uniform thickness across a column width. In most specimens there is little contrast between dark and light laminae, except in the amount of organic pigment. Some specimens, especially from Angepena, have irregularly tubular, sinuous, anastomosing, vermiform sparry patches, 0.05 to 0.1 mm thick and up to 0.6 mm long, crossing the dark laminae. Dark laminae, varying in thickness from 0.03 to 0.07 mm, consist of xenotopic calcite of grain size varying from 0.003 to 0.01 mm, stained with grey organic pigment, but in some specimens, subhedral dolomite rhombs of grain size 0.01 to 0.02 mm are interspersed. Minor subangular quartz silt may be present. Individual laminae are continuous, and of constant thickness across the column width, but may be markedly wavy. In specimens with vermiform microstructure, dark laminae are generally thicker, up to 0.3 mm, but remnants of finer lamination are often preserved. The boundaries of the sparry patches are often irregular and their orientation varies from perpendicular to

gently inclined to the lamination, but is commonly at a high angle to it. The vermiform microstructure may be consistently developed preferentially on one side of a column. Transverse sections of the tubules are round to elongated, irregularly oriented and anastomosing. The tubules may be interpreted as algal borings in the fine, lime mud laminae, but not the whole sediment was affected, since homogeneous and bored laminae occur side by side. This fact also makes it unlikely that they are casts of actual algal filaments. The distribution of borings on one side of columns may be environmentally determined. Bathurst (1966, p. 20) illustrated a sequence of events involved in boring by algae; if the process were stopped at stage (2), and the borings infilled with sparry calcite, a structure similar to the vermiform microstructure of *A. angepena* would result. Light laminae are 0.03 to 0.1 mm thick, frequently indistinct, but continuous across a column width. They are especially poorly differentiated in specimens with vermiform microstructure, where the tubules may pass across the light-dark lamina boundaries. Light laminae consist of xenotopic calcite, often with interlocking crystals 0.015 to 0.03 mm in diameter. Subhedral to euhedral 0.01 mm dolomite rhombs are scattered throughout the light laminae in some specimens.

Interspaces: Interspaces are filled either with altered micrite or fine sandy and silty micrite. Specimens from Italowie (Mawson's collection) have very narrow interspaces filled with sparse, angular quartz silt, supported by a micrite matrix (Fig. 10f), sometimes extensively dolomitized, with inequigranular hypidiotopic dolomite ranging in grain size from 0.005 to 0.1 mm. Extremely finely disseminated haematite may be present in interspaces. Stromatolites from Angepena also have sandy interspaces, but these are more frequently interrupted by bridging laminae. Subangular to subrounded quartz grains vary in diameter from 0.08 to 0.5 mm, and may be partially or wholly replaced by calcite. Ooids and small intraclasts occur very rarely.

Secondary Alteration: Dolomitization is common in all specimens, and is probably of late diagenetic origin. Within columns, rhombs postdate the vermiform microstructure and have also formed in the micrite of interspaces, and in places, interspaces may be totally dolomitized. Here sparry calcite occurs as irregular patches between dolomite rhombs perhaps filling a secondary porosity. The grain size and density of dolomite rhombs decrease markedly across the column margins; perhaps interspaces were originally more porous, to cause the preferential dolomitization (in Fig. 10e note the dark calcite columns and the white, dolomitic interspaces). Stylolites may follow column margins, or may be grossly cross-cutting. Haematite dispersed through carbonate is probably secondary. In Italowie specimens, it is concentrated in interspaces which pass into fine stylolites. Minute irregular calcite veins cut the whole rock, apparently predating the major dolomitization. Large patches of coarse sparry calcite are bounded by markedly lobate fine stylolites, suggesting their origin as solution cavities.

Comparisons

In gross morphology (mode of occurrence, column shape, branching and margin structure) the stromatolites from Italowie are similar to *Acaciella* Walter. Columns are less discrete in other areas, due to frequent bridging and coalescing, but their columnar portions are similar to those of Italowie specimens. Microstructures are uniform, except for the local vermiform structure interpreted as algal boring. *Madiganites mawsoni* Walter, from the Middle Cambrian Jay Creek Limestone of the Amadeus Basin, also has vermiform microstructure, but here the tubules are more consistently developed, and are complexly intertwined, the intervening micritic areas being reduced to clots. The gross form of *Madiganites mawsoni* is similar to some *Acaciella angepena* in having numerous irregular frequently bridged columns and pseudocolumns; however, it lacks the subcylindrical, parallel branching, discrete columns found at Italowie. *Acaciella angepena* resembles *Vetella uschhasica* Krylov in having evenly banded lamination and wide columns branching into narrow columns, but has ragged column margins and lacks the wall of *V. uschhasica*. *Illicta composita* Sidorov is similar in also possessing vermiform microstructure, but is distinguished by its very smooth, walled, columns. At this stage it is difficult to be certain of the content of the form *Acaciella angepena*. Despite some variation of column shape (specimens from Italowie have predominantly subcylindrical, discrete columns, while those from Angepena have numerous bridges and less regular column margins), all the specimens studied are included in the one form, since these column morphologies intergrade and the microstructures remain constant. The stromatolites are assigned to the group *Acaciella* on

Fig.2

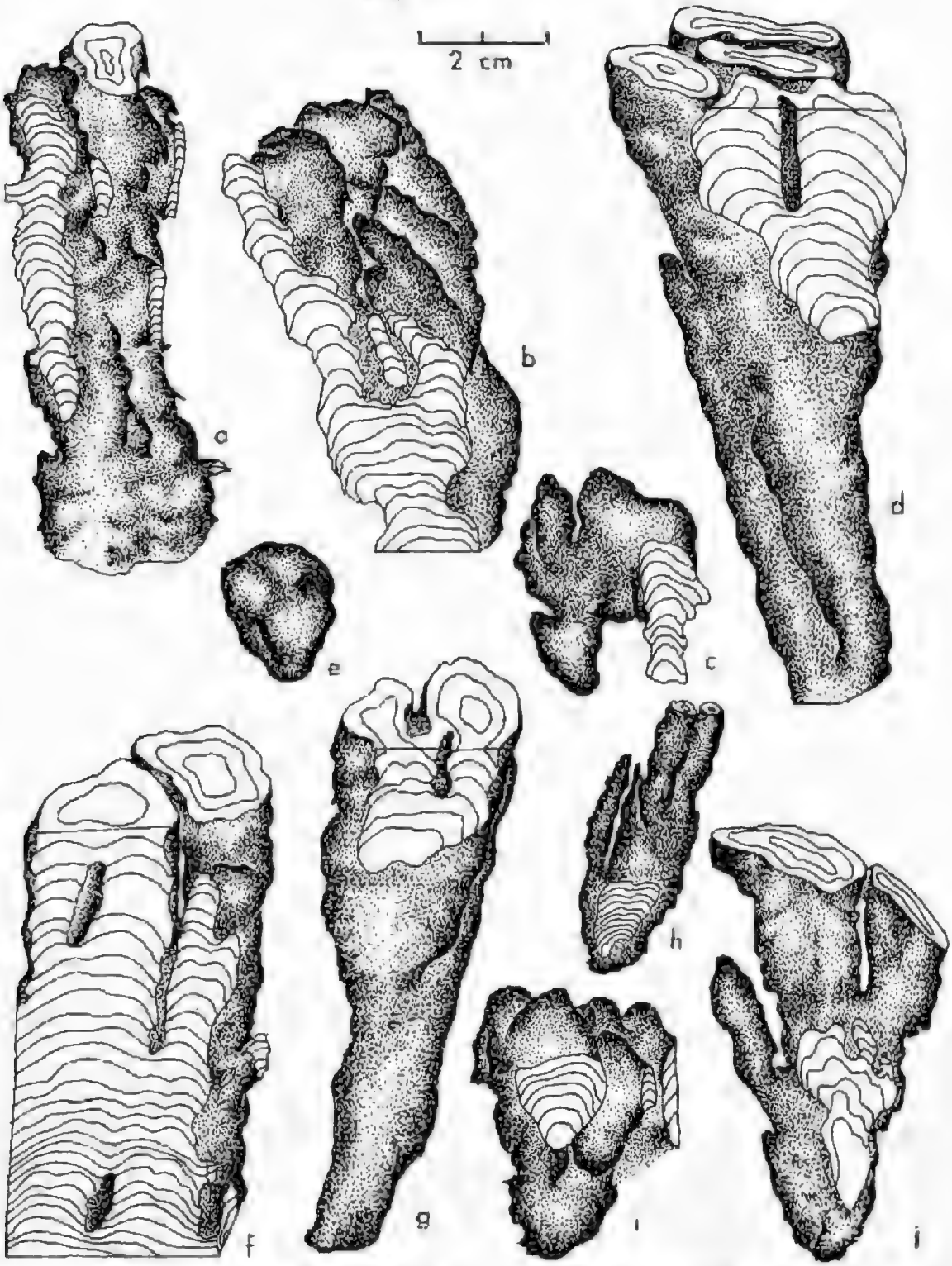

Fig. 2. *Araciella angepena*, from Lower Cambrian limestones, Flinders Ranges. (a)—Holotype, S460, 1 km S. of Angepena H.S.; (b)—S458, 1 km S. of Angepena H.S.; (c), (e) & (i)—S459, 1 km S. of Angepena H.S.; (d) & (g)—S8, 4.8 km W. of Italowie Gorge (collected by Sir Douglas Mawson); (f)—S44, 4.8 km W. of Italowie Gorge (collected by Sir Douglas Mawson); (h)—Probable *A. angepena*, near Old Wirrealpa (collected by Mr. P. G. Haslett); (j)—Possible *A. angepena*, 4.8 km W. of Italowie Gorge.

the basis of gross morphology. They are differentiated from other forms of the group by their thin, continuously banded microstructures and by frequent development of bridges and pseudocolumns. The very narrow, minute columns into which broader columns branch are absent in other forms.

A ferruginous specimen from Old Wirrealpa is problematical. Its dark laminae are strongly haematitic, the haematite being in part distributed into minute dendrites. The small columns branch from basal cumuli, the interspaces being filled with recrystallized biomicrite (hyolithids, sponge spicules, archaeocyathan and brachiopod fragments may be recognized). Although the gross morphology resembles that of *Acaciella angepena* (Fig. 2h), the extremely regular lamination is atypical of stromatolites, and the possibility of an inorganic origin for the structure cannot be excluded.

Distribution: Widespread in the dark limestones of the Lower Cambrian at Angepena, Old Wirrealpa, near Point Well, at Mern Merna, Beltana Hill, Chace Range, near Narina H.S., Moro Springs south of Balcanoona, and 4.6 km west of Italowie Gorge; Flinders Ranges, South Australia. (COPLEY and PARACHILNA 1:250,000 map sheet areas.)

Age: Early Cambrian.

Acaciella augusta f. nov.

FIGS. 3a-m, 11d-f, 12

Material: Thirteen specimens from two localities plus eight specimens of uncertain identification from a further two localities.

Holotype: S401 (Figs 3c, e; 12c), Brighton Limestone equivalent, Depot Creek, Southern Flinders Ranges.

Name: After the city of Port Augusta, 32 km south of the type occurrence.

Diagnosis: *Acaciella* with extremely frequent coalescing and bridging of columns at all levels, and with broad and narrow columns closely associated. Column margins bear short ribs, low bumps and short cornices. Laminae are gently to moderately steeply convex or rectangular, and of distinct, regularly streaky microstructure.

Description

Mode of Occurrence: The stromatolites form lenticular and tonguing bioherms (Fig. 12a) varying in thickness from 3 m to 50 m, and extending laterally for up to nearly 2 km, intercalated at varying stratigraphic levels within the Brighton Limestone equivalent. Most commonly, growth commences on a substrate of oolid and intraclast grainstones, as laterally linked stromatolites, up to 3 m thick; these gradually develop interspaces to form broad, bridging and coalescing columns (Fig. 11d). At various levels, these columns branch into narrower columns 1 to 3 cm wide, frequently with parallel basal and slightly divergent upper branches (Fig. 12c). Occasionally, narrow columns arise directly from an undulatory or flat-laminated base (Fig. 11f). Columns repeatedly alternate with continuous undulatory or flat-laminated stromatolites, which commonly intertongue with the adjacent sediment; they apparently mark periods of reduced influx of coarse sediment. At bioherm margins, columns become slightly inclined. Rarely, there are hemispherical bioherms with columns strongly inclined at their margins.

Column Shape and Arrangement: Basal columns are up to 20 cm wide, of irregular shape, with frequent coalescing and bridging. Their margins are frequently inclined, although laminae remain subhorizontal. The narrow columns are 1 to 3 cm wide, and up to 10 cm long between branches (Figs. 3a-j; 12b-d). Transverse sections are round, rounded polygonal, elongated, or complexly lobate. At least some of the elongation is of tectonic origin. Columns are straight or gently curved, with slight swellings and constrictions (Fig. 3a-j); a few are short and narrow, and terminate their growth after a few centimetres (Fig. 3e). Coalescing is so frequent that almost all columns are interconnected; one specimen contains numerous irregular, short, frequently bridged and coalescing columns.

Branching: Branching is frequent at all levels, and generally multiple (Fig. 3a-j). Broad basal columns divide by α-parallel branching into narrower columns, which frequently branch again at intervals of less than 10 cm; this branching is usually α- or β-parallel, occasionally γ-parallel, or slightly divergent (Fig. 3c-e, g). Near points of coalescing, branching tends to be more irregular; gamma-parallel or divergently branched columns approach each other and coalesce (Fig. 3d).

Margin Structure: The lateral surfaces of all columns bear relatively low bumps, short discontinuous ribs, and a few peaks and cornices (Fig. 3a-j). In places, bridges, varying from delicate bridges only one or two laminae thick to massive, thick bridges (Fig. 3g), are very frequent; in other places, columns remain rela-

tively unaffected by bridging throughout most of their length. Columns are unwalled, and between bridges and cornices their margins are relatively smooth. Depending on the degree of convexity, laminae approach the margin at various angles.

Lamina Shape: Lamina shape varies according to column diameter; narrow columns have moderately convex, or sometimes steeply convex, laminae, h/d greater than 0.6 being rare. Broad columns have very gently convex to rectangular laminae (Fig. 8b). Of all laminae measured, 70% have h/d between 0.2 and 0.6 (Fig. 9b). Laminae are most frequently smooth, but sometimes broadly wavy, especially before branching. Laminae frequently become doubly-crested before branching (Fig. 12b-d), but the interspace so formed may be bridged over, in which case the column resumes its former growth pattern.

Microstructure: In the best preserved specimens, distinct, regular light and dark (green) laminae, and in places macrolaminae up to 4 mm thick, alternate, forming a regular streaky microstructure (Fig. 12e). *Dark laminae*, varying in thickness from 0.05 mm to 2 mm, are smooth to gently wavy, occasionally wrinkled, and have parallel upper and lower boundaries. Single laminae have relatively constant thickness across the column width, but frequently lens out. They consist chiefly of hypidiotopic to idiotopic dolomite, of grain size ranging from 0.005 to 0.02 mm. The crystals are equidimensional, commonly euhedral, and stained pale green, which gives the laminae their colour. Dolomite crystals are densely packed in the dark laminae, leaving only occasional irregular undolomitized patches, consisting of xenotopic calcite, ranging in grain size from 0.003 to 0.01 mm. *Light laminae* vary in thickness from 0.07 to 2 mm, single laminae having constant thickness. They are sparsely dolomitized, and consist of xenotopic to hypidiotopic calcite, varying from 0.01 to 0.02 mm in grain size, with scattered euhedral dolomite rhombs, 0.005 to 0.04 mm long. Laminae are frequently grouped into broad macrolaminae, up to 4 mm thick, in which very thin, lenticular, either light or dark laminae predominate. In places, laminae are slightly wrinkled, or draped over underlying irregularities; in one case laminae are domed over lenses of sparry calcite, probably open space fillings (Fig. 11e). In a few places small scour structures up to 2 mm deep are cut into the tops of dark laminae. Occasional euhedral to subhedral reddish brown limonite grains of 0.01 to 0.02 mm diameter (possible pseudomorphs after pyrite) occur in both lamina types.

Interspaces: The distance between columns varies from 1 to 10 mm. Interspaces are filled with banded limestone, layers of micrite 1 to 6 mm thick alternating with thicker intervals of partially dolomitized intramicrite. Laminae in the interspace commonly abut against the column margins, having accumulated after the growth of that part of the column (Fig. 12c). The micrite laminae, consisting of xenotopic calcite of grain size varying from 0.003 to 0.01 mm, are frequently silty, and slightly graded, generally with sharp upper boundaries, and are overlain by matrix-supported intramicrites and some oomicrites. This sediment may originally have been more porous, as it is extensively dolomitized; the dolomite is of similar texture to that in columns. All remnant calcite is recrystallized to a hypidiotopic sparry mosaic; no micrite matrix remains. Alternatively, this calcite may represent infilling of voids left by dolomitization. Intraclasts, which may be preserved as undolomitized micrite, or entirely idiotopic dolomite, are from 1 to 10 mm long, and up to 1 mm thick, and may represent eroded fragments of algal mat. Strongly recrystallized dolomitized oolites are occasionally present. Intraclasts, which commonly lie at a high angle to the bedding, may have fine grained laminae draped over them. Coarse sediment influx was periodic; columns may have had up to 2 cm of relief over the interspace sediment or a bridge, then the interspaces were filled rapidly with intraclasts and finer calcareous sediment. During periods of relative quiescence, lime mud accumulated to form thin layers. In some specimens, bridging is very frequent, so that there never was more than about a centimetre of relief.

Secondary Alteration: Little is preserved of the primary difference between the light and the dark (green) laminae, which now differ in the extent of dolomitization. The dolomite is equigranular, idiotopic, and probably secondary, although a detrital origin cannot be ruled out. If the dolomite originated by replacement of calcite, the preferential dolomitization of dark laminae may indicate that they were originally more porous. Small irregular patches of coarsely crystalline sparry calcite within both columns and interspaces post-date dolomitization, and are associated with fine calcite veins. Stylolites are very rare, being restricted to a few which are concordant with the lamination or

column margins. The green staining of dolomite crystals oxidizes under subaerial weathering to form finely disseminated limonite, which may be concentrated along column margins or stylolites. Columns are commonly slightly flattened parallel to an axial plane cleavage, which is better developed south of Depot Creek and at Mundallio Creek. The cleavage is an irregular fracture which passes around, not through, stromatolite columns and is commonly expressed as stylolites in the carbonate rocks. A specimen from Mundallio Creek contains light laminae with prominent radiating structures; these consist of dolomite crystals aligned in rows almost perpendicular to the lamination (Fig. 12d), and may represent a dolomitized, earlier acicular texture. In specimens from the Wundowie Limestone (Wundowie Bore and Copley), column margins have been almost completely removed by stylolites, leading to uncertainty of identification (Fig. 3k, l & m).

Comparisons

The predominantly parallel branching (α-parallel at base, then β- or rarely γ-parallel) and almost total absence of a wall, identify the stromatolites as *Acaciella*.

Acaciella augusta is distinguished from *A. australica* by the rarity of discrete, broad, basal columns, by its mode of occurrence (lenticular and tonguing bioherms instead of tabular and domed biostromes), by its extremely frequent coalescing and bridging, and by its very distinct microstructure. The mode of occurrence and microstructure also distinguish it from *A. angepena*. *A. augusta* has many wavy, sometimes lenticular laminae, and prominent macrolaminae, the dark laminae being preferentially dolomitized. *A. augusta* is very similar in gross morphology to *Eucapsiphora paradisa* Cloud & Semikhatov, from the Paradise Creek Formation near Mt. Isa, N.W. Queensland. *E. paradisa* is difficult to distinguish on the basis of the published description, but apparently has a patchy wall.

Specimens of poorly preserved stromatolites from the Wundowie Limestone near Copley and Wundowie Bore, originally tentatively identified as *Linella munyallina* (Preiss unpubl.) are better assigned to *Acaciella augusta* on the basis of column shape, branching and microstructure. Where column margins are not removed by stylolites, they are unwalled.

Distribution: Brighton Limestone, Depot Creek and Mundallio Creek, Southern Flinders Ranges, and possibly the Wundowie Limestone near Copley and Wundowie Bore, Northern Flinders Ranges (PORT AUGUSTA and COPLEY 1:250,000 map sheet areas).

Age: Late Adelaidean, correlated with the Late Riphean of the USSR.

Acaciella form indet.

FIGS. 3n-q; 11b, c)

Material: Two specimens from one locality.

Description

Mode of Occurrence: Both stromatolite specimens are erratic boulders in the lower (Sturtian) glacials; their provenance is unknown.

Column Shape and Arrangement: One specimen (S509), consists of pseudocolumns and frequently bridged columns, oriented subparallel to slightly radiating, and passing laterally into flat-laminated stromatolites (Fig. 11c). The other specimen (S539) consists of rather smooth, erect, parallel, cylindrical, discrete columns, 1-5 cm wide. Transverse sections are round or rounded polygonal (Fig. 3n-p).

Branching: Branching is commonly α- or β-parallel; columns either retain their width or widen gradually before branching. Axes of branching columns may be very slightly divergent (Fig. 11b). Specimen S539 shows only dichotomous branching, but S509 has some multiple, α-parallel branching.

Margin Structure: S539 has a rather smooth margin structure, with low bumps and a few very short peaks and overhanging laminae (Fig. 3n-p). There is no wall; laminae simply terminate, without appreciable thinning, at the column margins. Bridges are extremely frequent in S509, but otherwise column margins are similar to S539. Few columns in S509 are entirely discrete.

Lamina Shape: All laminae are gently convex (Fig. 8e), h/d never exceeding 0.5, and 84% of laminae measured have h/d between 0.2 and 0.4 (Fig. 9e). Laminae are smoothly curved, rarely rectangular, and without wrinkles or sharp flexures. Occasionally laminae are slightly wavy, and before branching always develop multiple crests (Fig. 11b, c). Laminae are not normally deflexed at the column margins.

Microstructure: Microstructure consists of very smooth or broadly wavy, light and dark, dolomitic, striated to banded, laminae. There is little contrast between laminae. *Dark laminae* are 0.05 to 0.5 mm thick, and commonly pinch and swell slightly across the column, and in places they are lenticular, but otherwise, they have smooth, parallel boundaries. They consist

Fig. 3

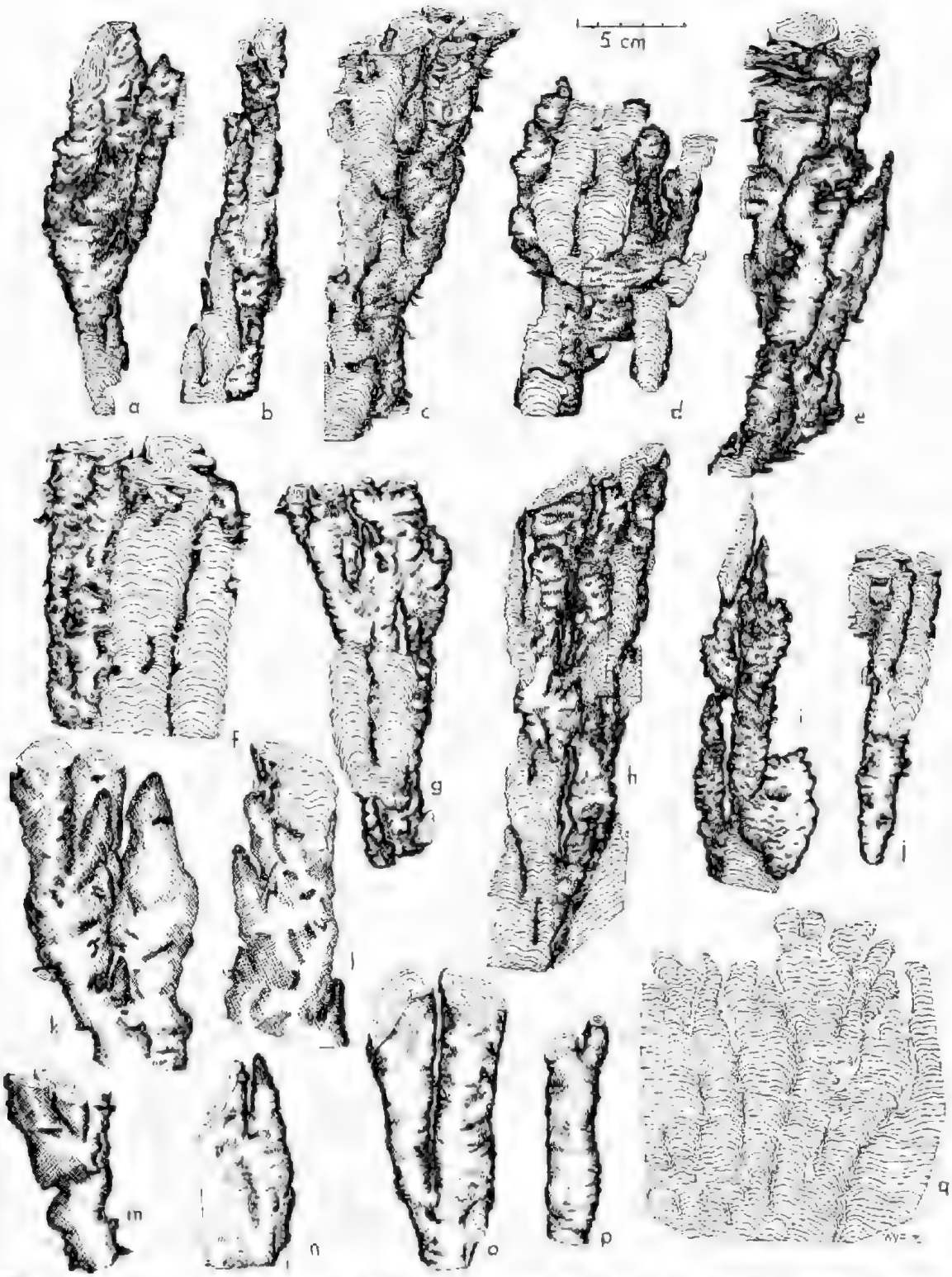

Fig. 3. (a)-(j): *Aracicella augusta*, Brighton Limestone equivalent, Umberatana Group, Flinders Ranges. (a), (b), (d) & (i)—S404, Depot Creek, Southern Flinders Ranges; (c) & (e)—Holotype, S401, Depot Creek; (f) S538, Mundallio Creek, Southern Flinders Ranges; (g) & (h)—S396, Depot Creek; (j)—S537, Depot Creek; (k), (l) & (m)—Possible *A. augusta*, Wundowie Limestone Member, Wundowie Bore, Northern Flinders Ranges; (n), (o) & (p)—S539, *Aracicella* f. indet. from an erratic in the Sturtian glacials, N.E. of the Enorama Diapir; (q)—S509, *Aracicella* f. indet., from the same locality. Sketch traced from a thin section.

of pale grey stained hypidiotopic dolomite of grain size varying from 0.003 to 0.015 mm. *Light laminae* vary in thickness from 0.05 to 1.0 mm, generally with little change across a column, thinning only slightly towards column margins. They consist of hypidiotopic to idiotopic transparent, unstained dolomite of grain size varying from 0.015 to 0.06 mm. Very characteristic of S539 is the presence of very fine, limonite-rich solution surfaces, concordant with the laminae. Although these are probably stylolites, surfaces with little or no wrinkling, which follow the fine-scale structure of laminae exactly, are especially common (Fig. 11b). In places these are only about 0.5 mm apart, and light laminae may be separated by them, without intervening dark laminae.

Interspaces: Interspace sediment is completely dolomitized, consisting of equigranular, idiotopic dolomite of grain size ranging from 0.01 to 0.05 mm. There is little contrast between columns and interspaces, but small amounts of subangular quartz silt are present in the interspaces. Fragments of slightly darker stained dolomite, of similar texture to the matrix, probably represent original intraclasts. The nature of the matrix cannot be determined, but the sparsity of intraclasts suggests that these were mud supported. Intraclasts are better preserved in S509.

Secondary Alteration: Dolomitization of the stromatolites and interspaces is clearly secondary, as indicated by the general idiotopic, equigranular texture, and poor preservation of the finest structures. Stylolites are of at least two generations; the earliest stylolites are almost perfectly concordant, without lobes or wrinkles; these possibly predate the dolomite euhedra, which in places cut into them, and certainly predate a relatively coarse grained dolomite vein (grain size up to 0.1 mm). The vein is itself cut by more pronounced, slightly discordant stylolites. Occasionaly cross-cutting stylolites cut interspaces and columns, some following column margins. Dolomitization almost certainly predates the erosion and deposition of the clasts into the glacial sediments.

Comparisons

The straight, chiefly α- to β-parallel branching unwalled columns allow assignment to the group *Acaciella*. They are clearly distinguished from *Acaciella augusta* by the discrete, rather smooth, more cylindrical columns; although bridging and coalescing occur in S509, this specimen is considered to represent the basal part of the stromatolite bed. The distinct, subcylindrical columns with relatively smooth margins and gently convex laminae are similar to *A. australica* Walter, but the specimens are inadequate for identification.

Distribution: As clasts in the lower (Sturtian) glacials, on the flanks of Enorama Diapir, 6.4 km North of Oraparinna H.S., Central Flinders Ranges (PARACHILNA 1:250,000 map sheet area).

Age: Probably Adelaidean, but not younger than the Sturtian glacials

Group BAICALIA Krylov

Baicalia Krylov 1963: 64. Semikhatov 1962: 198. Komar 1966: 82. Krylov 1967: 25. Nuzhnov 1967: 135. Cloud & Semikhatov 1969: 1035.

Type Form: *Baicalia baicalica* (Maslov) Krylov, from the Uluntuy Suite of the Pribaikalye [based on *Collenia baicalica* Maslov 1937a: 287].

Diagnosis: Tuberous, bumpy; swelling and constricting, parallel to markedly divergent branching columns, generally without wall, with frequent overhanging laminae. Lamination is distinctly banded.

Content: *B. baicalica* (Maslov) Krylov, *B. kirgisica* Krylov, *B. rara* Semikhatov, *B. unca* Semikhatov, *B. prima* Semikhatov, *B. ampla* Semikhatov, *B. ingilensis* Nuzhnov, *B. maica* Nuzhnov, *B. aimica* Nuzhnov, *B. minuta* Komar, *B. capricornia* Walter and *B. burra* f. nov.

Age: Middle Riphean to early Late Riphean.

Baicalia burra f. nov.

FIGS. 4, 5, 6, 13, 14, 15a-c

Baicalia spp. Glaessner, Preiss & Walter 1969:1056.

Material: Thirty-three specimens from ten localities.

Holotype: S222 (Figs. 13a & d), Skillogalee Dolomite 3.2 km west of Yatina, Southern Flinders Ranges.

Name: From the Burra Group in which the stromatolites occur.

Diagnosis: *Baicalia* with moderately frequent, slightly to markedly divergent branching, irregular, coalescing columns with highly variable lamina shape and continuous, distinctly banded microstructure.

Description

Mode of Occurrence: Two modes of occurrences have been noted: biostromal and biohermal, the latter occurring only at one locality

(Yatina). Biostromes vary in thickness from 0.3 to 2 m, the stromatolites being evenly distributed throughout their extent; they have been followed for 100 m or more, without lensing, before the outcrop disappears under soil cover. Biostromes are frequently interbedded in green shales (e.g. Myrtle Springs, Willouran Ranges), platy dolomites (e.g. Arkaroola, Worumba) or massive dolomites (e.g. Burra). The bioherms at Yatina are restricted to two thin beds; they are small lenticular stromatolitic mounds, approximately 20 to 30 cm thick and up to 1 m wide (Fig. 13a), interbedded with and surrounded laterally by platy and shaly dark grey dolomites. The overlying sediment is draped over the mounds, showing that the stromatolites had at least 10 cm relief over the surrounding surface. Columns arise from substrates in several ways: (1) Flat-laminated stromatolite passes gradually up into undulatory and pseudocolumnar stromatolites, then into discrete, vertical to inclined columns, often with steeply domed laminae (e.g. Burra, West Mount Hut); (2) Columns arise directly from eroded surfaces of laminated or intraclastic dolomites (e.g. Yatina, Fig. 4a); (3) Columns arise from flat-laminated stromatolite *via* broad cumuli (e.g. West Mount Hut). The degrees of discreteness of columns varies greatly; in some beds, columns are almost immediately bridged over by laterally linked stromatolites, but usually columns remain discrete for 20 to 30 cm. In some areas new sets of columns may arise from pseudocolumns. The upper surfaces of biostromes vary from flat (e.g. in the Willouran Ranges, Burra) to broadly undulating (e.g. Worumba).

Column Shape and Arrangement: Columns are tuberous, varying from subcylindrical to irregular, with round, oval and irregular cross sections (Figs. 4, 5, 6). Elongated or flattened columns are variously oriented. The diameter of columns varies from 1 to 10 cm, most commonly 3-5 cm, with rapid swellings and constrictions. Columns are 2-15 cm high between branches. Some but not all columns are constricted at the point of branching (Figs. 4c, f; 5c, d). The orientation of columns varies greatly from vertical to inclined, and is sometimes sub-horizontal for short distances (Figs. 4c, 5j). Column axes vary from straight to strongly curved. In some specimens, the uppermost columns swell markedly upwards and become bridged over by laterally linked stromatolites. Adjoining columns coalesce very frequently, even in the discrete portions, but specimens from Burra show the least coalescing and bridging. In the Willouran Ranges, column growth is frequently interrupted by penecontemporaneous erosion; columns may grow over broken-off fragments of earlier columns, contributing to the irregularity of the structure.

Branching: The most common form of branching is moderately divergent (Fig. 4a, i, 6f) though some sub-parallel branching (Fig. 4e, g, m) and some very markedly divergent branching occurs (Figs. 4a, 5d & j). In some specimens several branches arise from nearly one point (Fig. 4a). Branching is moderately frequent, the length of column between branches commonly being only a few centimetres; but at any one point of branching it is usually dichotomous or less often trichotomous. In some specimens branches arise at a high angle to the main columns, and then turn sharply upwards. Some columns arise from the side of a main column (Fig. 14d). Great variation is seen even in single outcrops.

Margin Structure: The lateral surface varies from smooth to very irregular, laminae approaching the column margins at various angles. Some specimens have very patchy walls, while the intervening unwalled areas are smooth or only slightly fringed with small peaks and cornices, for example those from Burra (Fig. 14d), Yatina (Fig. 4a), River Broughton (Fig. 5c), Arkaroola (Fig. 5d, e). Willouran Ranges specimens contain both smooth and highly irregular edges, with large overhanging peaks composed of one or more laminae (Fig. 6b & c). Frequently large swellings are composed of numerous laminae overhanging a constricted portion of a column (Fig. 4c). Bridges between columns are especially common near the tops and bottoms of biostromes (Fig. 6e).

Lamina Shape: The lamina shape is most commonly gently convex, but varies in single specimens from very gently convex to nearly conical; many laminae are steeply convex. Microunconformities are especially prominent in specimens from the Willouran Ranges, but occur to some extent in all areas. In places, branching commences upon a partly eroded column surface (Fig. 15b). Fig. 8d illustrates the more commonly occurring lamina shapes; 92% of lamina have h/d between 0.1 and 0.6, the mode being h/d between 0.3 and 0.4 (28%) (Fig. 9d). Generally, the widest columns have the most gently convex laminae, while strongly elongated columns have laminae gently convex in the section parallel to the long

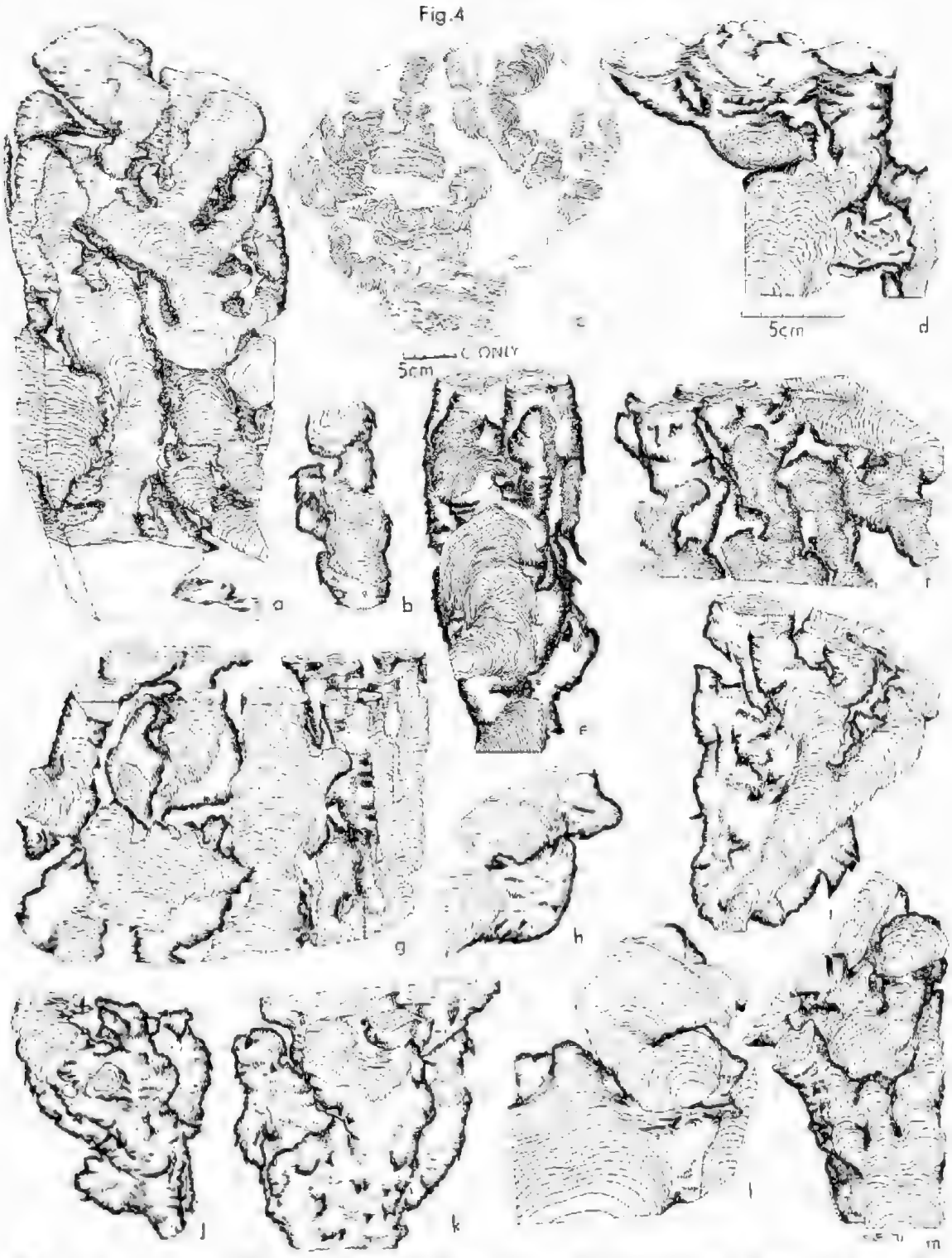

Fig. 4. *Baicalia burra*. Skillogalee Dolomite, Burra Group, Southern Flinders Ranges: (a) & (c)—Holotype, S222, 3.2 km W. of Yalina; (b)—S218, same locality; (d) S151, 13 km S.W. of Worumba H.S.; (e) & (f) S151, same locality; (g), (i) & (j)—S221, Dutton's Trough H.S., 14 km S. of Burra; (h) & (l)—S314, same locality; (k)—S534, same locality; (m)—float specimen, River Broughton, W. of Spalding.

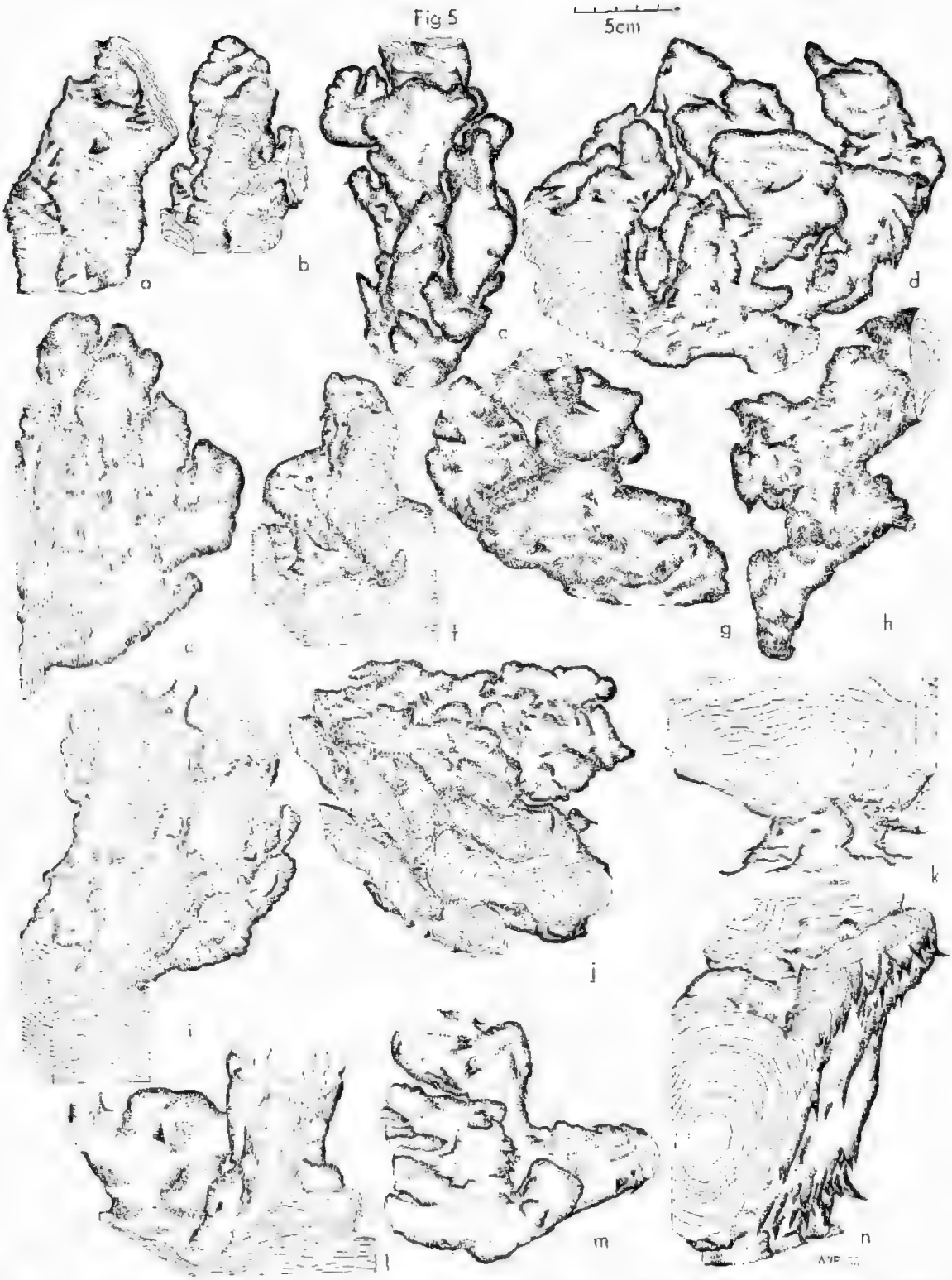

Fig. 5. *Baculia burra*, Skillogalee Dolomite, Burra Group: (a)—S533, Dutton's Trough H.S., 14 km S. of Burra; (b)—S534, same locality; (c)—S383, River Broughton, W. of Spalding; (d)—S456, 6.4 km S. of Arkaroola; (e)—S457, same locality; (f)—S491, 2.4 km E. of Myrtle Springs H.S. (upper member of Skillogalee Dolomite); (g)—S489, same locality; (h)—S490, same locality; (i)—S488, 1.6 km E. of Myrtle Springs H.S. (lower member of Skillogalee Dolomite); (j)—S487, same locality; (k)—S319, the Avondale Mine, Lyndhurst (collected by Mr. P. J. Binks); (l)—S302, West Mount Hut, Willouran Ranges; (m)—S99, same locality (collected by Mr. C. R. Dalgarno); (n)—S97, near Chintapanna Well, Willouran Ranges (collected by Mr. C. R. Dalgarno).

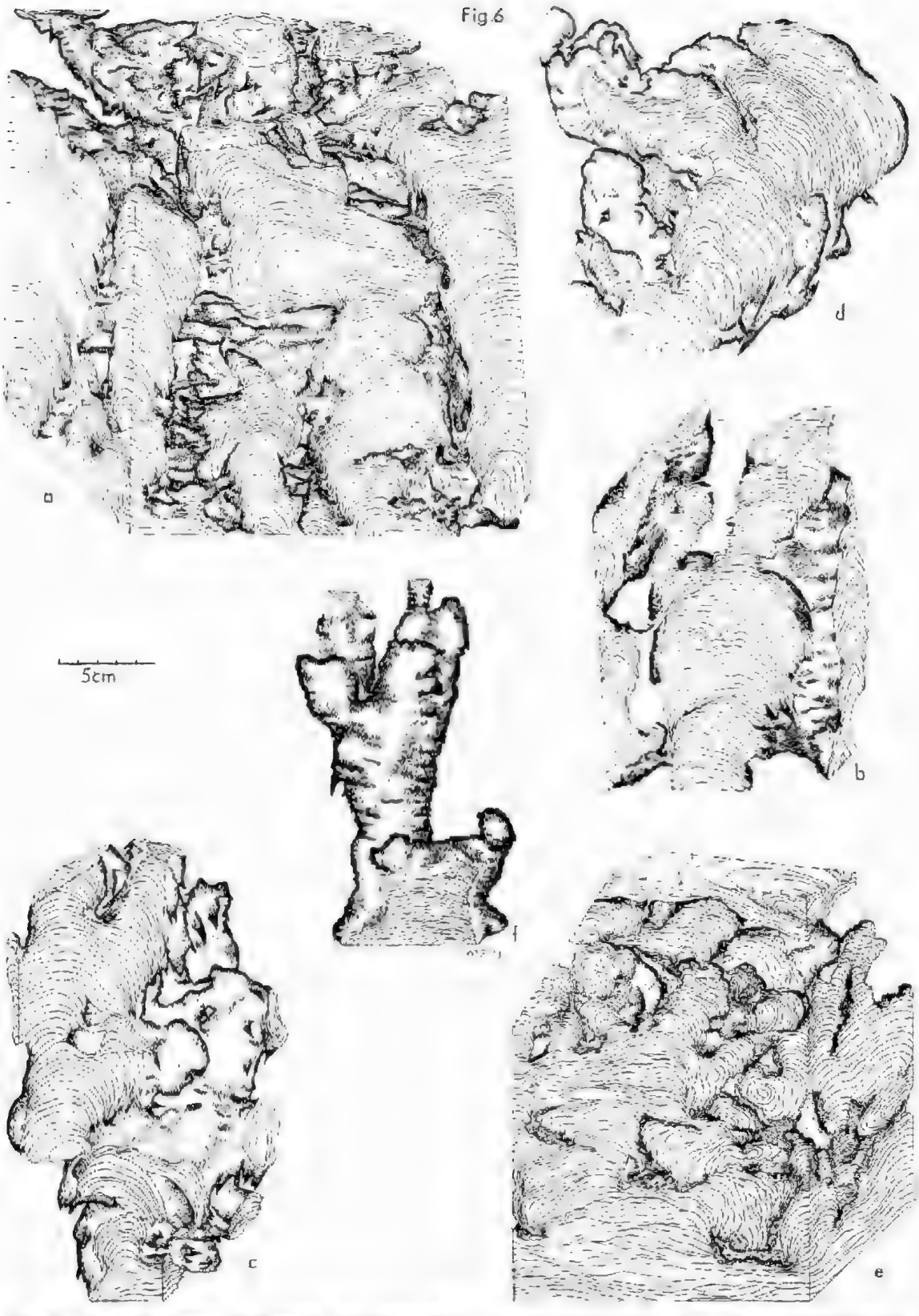

Fig. 6. *Baicalia burra*, Skillogalee Dolomite, Burra Group, north-western part of the Adelaide Geosyncline: (a), (b) & (f)—S96, Chintapanna Well, Willouran Ranges (collected by Mr. C. R. Dalgarno); (c)—S98, West Mount Hut, Willouran Ranges (collected by Mr C. R. Dalgarno); (d)—S496, 4.8 km W. of Copley; (e)—S301, West Mount Hut, Willouran Ranges.

axis, and steeply convex at right angles to it. Rarely do laminae turn over sharply and thin at the column margins, to form a wall. Generally, where a patchy wall is present, it is formed by the edges of steeply convex or parabolic laminae (Fig. 14c). Frequently, laminae develop two crests, anticipating branching immediately above (Fig. 4a, m). On a smaller scale, lamina shape varies from smooth and regularly curved to slightly wavy, with discontinuous curvature and sharp crests. Both types occur in single specimens (Fig. 14).

Microstructure: The microstructures and textures observed in the different areas vary considerably depending on the degree of recrystallization. In the best preserved specimens, the layering comprises alternating relatively thick, continuous, very distinct, light and dark laminae, giving a banded appearance. Some are single homogeneous thick layers, while others are macrolaminae consisting of several very thin light-dark lamination pairs. Most commonly single laminae traverse the whole column width, except where cut by microunconformities. Ooids or other detrital grains may be included in the laminae. Upper and lower boundaries of laminae are usually smooth and even, sometimes wavy or broadly wrinkled, but always more or less parallel. Exceptions occur only where erosional scour has taken place during growth. Rarely, lenticular swellings occur. *Light laminae* vary in thickness from 0.02 to 0.5 mm, very rarely to 1.0 mm. Most light laminae thin towards the column edges, but rarely lens out. In the best preserved specimens, the sparry dolomite forming them is inequigranular, xenotopic, and of grain size ranging from 0.005 to 0.06 mm. With greater recrystallization an equigranular mosaic of 0.05 to 0.2 mm grain size results (e.g. Burra). The light laminae usually have sharp and smooth upper boundaries, but sometimes grade down into grumous textured laminae, consisting of irregular and interconnected micritic patches up to 0.1 mm diam., set in xenotopic equidimensional sparry dolomite with a grain size of about 0.01 to 0.03 mm, i.e. partially recrystallized dark laminae. In some specimens (e.g. Yatina, West Mount Hut, Worumba), the light laminae contain detrital granules, including small flat intraclasts, up to 0.5 mm long, and rare ooids up to 0.3 mm in diameter. Overlying laminae are draped over the larger detrital grains. Laminae in the Copley specimen may be pelletal (Fig. 14c). *Dark laminae* occur either singly, alternating with light laminae, or in dark macrolaminae. Thin dark laminae are commonly 0.04 to 0.3 mm thick, but macrolaminae range up to 2.5 mm in thickness, generally constant across the column, or thinning slightly towards the margins. They are either continuous, or consist of a series of aligned lenses, each up to 0.2 mm long. In well preserved specimens the dark laminae have smooth, sharp, parallel boundaries; rarely, single laminae may be wrinkled, suggesting intraformational crumpling during growth. Well preserved dark laminae consist of dense, brownish-pigmented xenotopic dolomite, of equidimensional grains 0.003 to 0.01 mm diam., but vertical and lateral gradations from unaltered to grumous textures are common. Where dark laminae are grouped into macrolaminae, they alternate with very thin, discontinuous light laminae, and frequently fuse to form solid, thick dark laminae.

Interspaces: A few specimens have interspaces filled predominantly with bedded dolomite mud (e.g. Burra), but generally the sediment is unbedded intrasparite or oosparite, less commonly intramicrite. Frequently, intraclasts are derived from the erosion of stromatolitic columns; in places, a large fragment torn from a column has acted as a base for new growth. Intraclasts are flat to gently curved tabular dolomite pebbles up to 3 cm long, 1 to 2 mm thick, and only slightly rounded. Many are fragile and could have survived very little transport. They contain the typical internal laminations of the associated stromatolites, and are probably derived directly from them. Occasional flat pebbles stand vertically, but generally they lie flat or imbricated. Ooids vary in shape from round to oval, 0.2–1.0 mm diam., and consist of one dark-rimmed sparry layer coating a micritic core, or less commonly, several sparry layers. Most commonly, allochems are closely packed and cemented by a clear, sparry dolomite cement. Some specimens contain significant amounts of dolomite mud, variously recrystallized, forming a matrix between allochems; in these cases the sediment is poorly laminated.

Secondary Alteration: Secondary alteration has extensively modified the textures and often the microstructures of stromatolites from many areas. The following four stages of alteration may be recognized:

(1) *Penecontemporaneous*. The fact that dolomite consistently constitutes the whole rock to the exclusion of calcite, while still preserving fine structures, suggests very early dolomitiza-

tion, during the growth of the stromatolites. It is also possible that penecontemporaneously dolomitized lime muds were reworked and trapped in the algal mats. During growth, erosion by strong currents scoured the living surfaces of columns, creating micro-unconformities. In some specimens (e.g. West Mount Hut), laminae may be separated by lenticular vughs, later filled with sparry dolomite (Fig. 12c). These voids were probably formed by arching up of laminae, perhaps due to lateral expansion in growth of the algal mats building the stromatolites, or to partial desiccation.

(2) *Early Diagenetic*. Black chert very commonly replaces portions of stromatolites and interspace sediments. Sometimes dark laminae are preferentially silicified, perhaps during growth, but more commonly, silicification postdates the growth of the columns (e.g. one side of a column may be replaced). In places, silicified laminae are broken by minute dolomite filled cracks.

(3) *Late Diagenetic*. Dark laminae and macrolaminae may be recrystallized to grumous textures, consisting of patches of dark, dense micritic dolomite (remnants of the original carbonate) varying greatly in size from 0.005 to 0.1 mm, set in a matrix of xenotopic sparry dolomite, of equidimensional grains ranging in size from 0.01 to 0.03 mm. Light laminae are commonly slightly recrystallized and sparry, consisting of hypidiotopic to idiotopic, equidimensional dolomite grains of similar size to those of the sparry matrix of the grumous textures. Coarsely recrystallized laminae also occur, in places cutting across the fine structure of primary laminae and corroding their boundaries. They consist of idiotopic transparent dolomite of grain size up to 0.1 mm.

(4) *Tectonic*. The only specimens affected by tectonic deformation are from the Burra region. Here columns are slightly flattened and laminae are crenulated along a slight tectonic foliation. These are also the most highly metamorphosed, displaying the greatest degree of recrystallization. Tensional joints filled with coarsely crystalline dolomite are common in most areas.

Comparisons

The stromatolites are assigned to the group *Baicalia* on the basis of their tuberous, swelling and constricting, humpy, variously oriented columns, general absence of wall, numerous overhanging peaks and short cornices, and generally divergent branching. Some specimens have horizontal colomns for short distances resembling *Tungussia*, but are distinguished by the absence of the multiple horizontal branching characteristic of *Tungussia*, and by their generally more ragged column margins. *Baicalia burra* is distinguished from *B. prima* Semikhatov, *B. aimica* Nuzhnov, and *B. capricornia* Walter, by its frequently divergent branching and general complexity of columns, and from *B. minuta* Komar by its larger size and more complex structure. Some specimens resemble *B. baicalia* (Maslov) Krylov, but most have more inclined and irregular columns. *B. lacera*, *B. rara*, *B. ampla* and *B. unca* Semikhatov are not adequately illustrated for reliable comparison, and the illustrated microstructures are badly altered; single specimens of *B. burra* may show microstructures similar to *B. unca*, *B. lacera*, and especially the pelletal laminae of *B. rara*. Some specimens have long overhanging peaks and thus resemble *B. ingilensis* Nuzhnov, but are distinguished by more frequent and divergent branching. *B. burra* most closely resembles *B. rara* Semikhatov and *B. maica* Nuzhnov; it is distinguished from *B. rara* in that neither pelletal laminae nor knee-shaped bends in columns are consistently developed, and from *B. maica* by its more irregular and coalescing columns, and its more continuous laminae.

Distribution: Widespread in the Skillogalee Dolomite, Burra Group: Dutton's Trough H.S., 16 km south of Burra; Scrubby Range, 27 km south of Burra; 3 km west of Yatina; River Broughton, 8 km west of Spalding; 11 km south-west of Worumba; 11 km south of Arkaroola; 3 km west of Copley; 3 km east of Myrtle Springs H.S. near Leigh Creek; West Mount Hut, 27 km west of Witchelina H.S. and Chintapanna Well, about 16 km west of Witchelina H.S. Possible *B. burra* occurs also in the Skillogalee Dolomite, Depot Creek, but these have not been studied in detail. Specimens from possible River Wakefield Group, Carrieton (Fig. 15c) are inadequate for identification, but are possibly to be included (BURRA, ORROROO, PARACHILNA, COPLEY, ANDAMOOKA and CURDIMURKA 1:250,000 map sheet areas).

Age: Early Adelaidean, correlated with the youngest Middle Riphean of the USSR.

Group BOXONIA Korolyuk

Boxonia Korolyuk 1960:139. Komar 1966: 79. Cloud & Semikhatov 1969:1036. Glaessner, Preiss & Walter 1969:1056

Type Form: *Boxonia gracilis* Korolyuk, from the Bokson Suite, Eastern Sayan.

Diagnosis: Straight, subcylindrical columns with moderately frequent α- to β-parallel branching and smooth, walled margin structure.

Content: *B. gracilis* Korolyuk, *B. lissa* Komar, *B. krasivica* Golovanov, *B. allahjunica* Komar & Semikhatov, *B. ingilica* Komar & Semikhatov, *B. bianca* Raaben and *B. pertaknurra* Walter. Raaben (1969a) places *B. grumulosa* Komar into partial synonymy with *B. gracilis* Korolyuk. *B. diverata* Sidorov has only a patchy wall and may therefore be excluded.

The South Australian form is *Boxonia melrosa*.

Age: Late Riphean and Vendian.

Boxonia melrosa f. nov.

FIGS. 7a–h, 15d–f

Material: Four specimens from one locality.

Holotype: S503 (Figs. 7b, c & d; 15e), 1.6 km west of Melrose township, Southern Flinders Ranges.

Name: After the type locality.

Diagnosis: *Boxonia* with long, narrow, closely spaced columns, α- and β-parallel branching, without very broad basal columns, with occasional rounded projections, and with indistinctly banded, moderately convex, laminae lacking pelletal microstructure.

Description

Mode of Occurrence: The stromatolites are relatively poorly exposed in a faulted area, so that relationships are not clear. At least two bioherms occur, preserved as grey or pale buff dolomite. The beds are overturned, dipping south at about 40°. The narrow, parallel columns arise directly from laterally linked stromatolites, partly pseudocolumnar, the base of which is not exposed. The overlying columnar portion is approximately 6 m thick and consists of vertical columns near the centre of the bioherm, and inclined columns at the margins, where they pass laterally into pseudocolumnar stromatolites. Columns are overlain by wavy laminated stromatolites, which cover the whole bioherm. Bioherms are of cumulate shape, broadly domed, up to 60 m long, and are surrounded by flat-bedded dolomite.

Column Shape and Arrangement: Columns are straight, erect, subcylindrical, smooth to gently bumpy, with circular or slightly lobate, rounded polygonal cross-sections, 1–5 cm diam. (Fig. 7a–h). The diameter of a single column generally remains constant throughout its length. Columns may reach a length of up to 20 cm between branches, but some columns are only a few centimetres high, occasionally in the form of rounded projections.

Branching: Branching varies from α- to β-parallel; γ-parallel branching is rare (Fig. 7h). Commonly a 3–5 cm column divides into two or three narrower, parallel, very closely spaced columns, 1–2 cm diam. (Fig. 7c,d,f). Occasionally, two narrow columns may coalesce (Fig. 7c). Not all branches develop into long columns; some terminate their growth only a few centimetres above branching (Fig. 7d).

Margin Structure: The lateral surface is even, smooth or with low, broad bumps, up to several centimetres wide, with a relief of 1–5 mm. Peaks and cornices are entirely absent, but very rarely bridges up to 1 cm thick occur between adjacent columns. A multi-laminate wall is almost ubiquitous. At the margins of columns laminae are poorly preserved, but in places up to 10 laminae may be seen to comprise the wall. Single laminae generally extend for a distance of 1–2 cm down the column margin (Figs. 15d–f).

Lamina Shape: Laminae are most commonly moderately convex, hemispherical, in places approaching rectangular (Fig. 8e). Frequently they are slightly asymmetrical, especially in inclined columns. Before branching, laminae usually develop two crests. The degree of convexity, h/d, is moderately constant, even in columns of differing widths. Of laminae measured, 91% have h/d between 0.3 and 0.7, the mode (39%) being 0.5–0.6 (Fig. 9e). The shape of crests varies from tightly arcuate to gently rounded (Fig. 8e). Most laminae are broadly wavy (wavelength up to 8 mm, amplitude 1–2 mm) but not wrinkled.

Microstructure: Microstructure is poorly preserved in both pale and dark specimens; laminae are broadly continuous, with smooth, parallel upper and lower boundaries, but may be broken into a series of clots and lenses by recrystallization, and even where their continuity is preserved, they are extensively embayed by recrystallized carbonate. Microstructure is indistinctly banded with alernating darker and lighter laminae. *Light laminae* vary in thickness from 0.08–0.4 mm, but usually thin towards column margins. Continuity is usually retained across a column, although the finest laminae frequently lose their identity by

recrystallization. The laminae consist of transparent, slightly inequigranular (of grain size 0.01–0.04 mm) equidimensional dolomite of polygonal, hypidotopic texture. Within this occur irregular 0.05–0.1 mm segregations of darker, greyish pigment, with no relation to grain boundaries. These are apparently remnants of pigment left by partial recrystallization, as they may grade into more or less continuous laminae. Distinct round to oval pellets (as in Russian *Boxonia*) are absent. *Dark laminae* are less continuous, and often diffuse. Their thickness varies from 0.08–0.3 mm; towards the margins they frequently thin or lens out completely, and do not take part in the formation of the wall. (The layering in the wall is

Fig.7

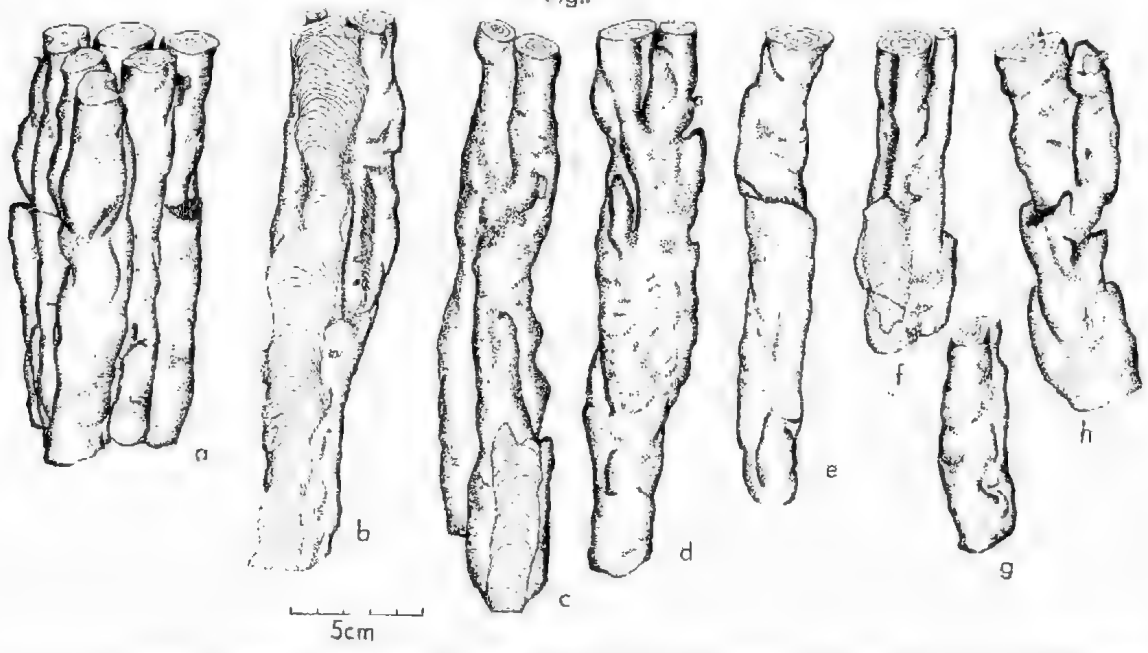

Fig. 7. *Boxonia melrosa*, Brighton Limestone equivalent, Umberatana Group, 1.6 km W. of Melrose: (a), (e), (g) & (h)—S502; (b), (c) & (d)—Holotype, S503; (f)—S504.

Fig.8

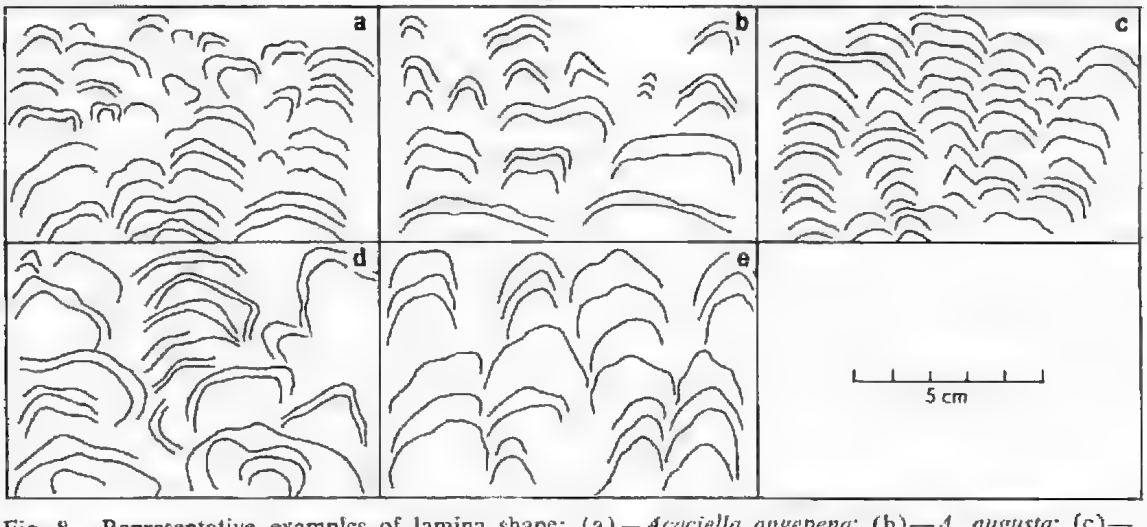

Fig. 8. Representative examples of lamina shape: (a)—*Acaciella angepena*; (b)—*A. augusta*; (c)—*Acaciella* f. indet.; (d)—*Baicalia burra*; (e)—*Boxonia melrosa*.

extremely indistinct). In places, they lens out also within the central part of a column. Dark laminae are composed of equidimensional, xenotopic, equigranular dolomite (of grain size ranging from 0.003–0.01 mm), and in places, are disrupted into a series of irregular clots and lenses separated by sparry dolomite.

Interspaces: Interspaces between columns are extremely narrow (usually less than 5 mm), and are filled with partially recrystallized dolomite mud, now largely of finely grumous texture, containing in places, round or ovoid clastic pellets, 0.2–0.7 mm diam. Much of the sediment is vaguely laminated, the laminae abutting against the walls of columns, which they postdate.

Secondary Alteration: Stromatolite columns and interspaces consist of dolomite, considered to result from the replacement of original calcium carbonate. Most fine structure has been lost; dark laminae are outlined mainly by segregations of dark pigmented dolomite, but recrystallization has partly embayed and partly obliterated the fine dark laminae. The irregular distribution of pigment is due to recrystallization. In places, coarser, sparry laminae of grain size up to 0.08 mm occur, and may contain dismembered remnants of dark laminae. Stylolites are moderately frequent, and usually discordant to the lamination. In places they follow column margins for short distances, removing the wall. Occasional thin dolomite veins follow the path of stylolites. Some stylolites are parallel to overall bedding, and displace column axes slightly (Fig. 7c).

Comparisons

The stromatolites are assigned to the group *Boxonia* on the basis of their long, smooth walled columns with moderately frequent α- and β-parallel branching. *Katavia* Krylov and *Acaciella* Walter have similar gross structure; *Katavia* is distinguished by its very prominent humps, while *Acaciella* generally lacks a wall. *Minjaria* Krylov also has parallel straight columns but is distinguished by its less frequent branching. Most other described forms of *Boxonia* have well defined pelletal microstructures; forms are largely distinguished on the basis of the size of the pellets. A specimen of *B. gracilis* sent by M. A. Semikhatov and I. N. Krylov, has pellets consisting of rounded carbonate grains with dark, fine-grained rims. These are absent in *B. melrosa*, which also has less wrinkled laminae. *B. melrosa* is distinguished from *B. ingilica* Komar & Semikhatov by its ubiquitous wall and straight columns; *B. allahjunica* Komar & Semikhatov apparently has some complex branching. *B. lissa* Komar, *B. gracilis* Korolyuk, *B. grumulosa* Komar, *B. bianca* Raaben and *B. krasivica* Golovanov

Fig.9

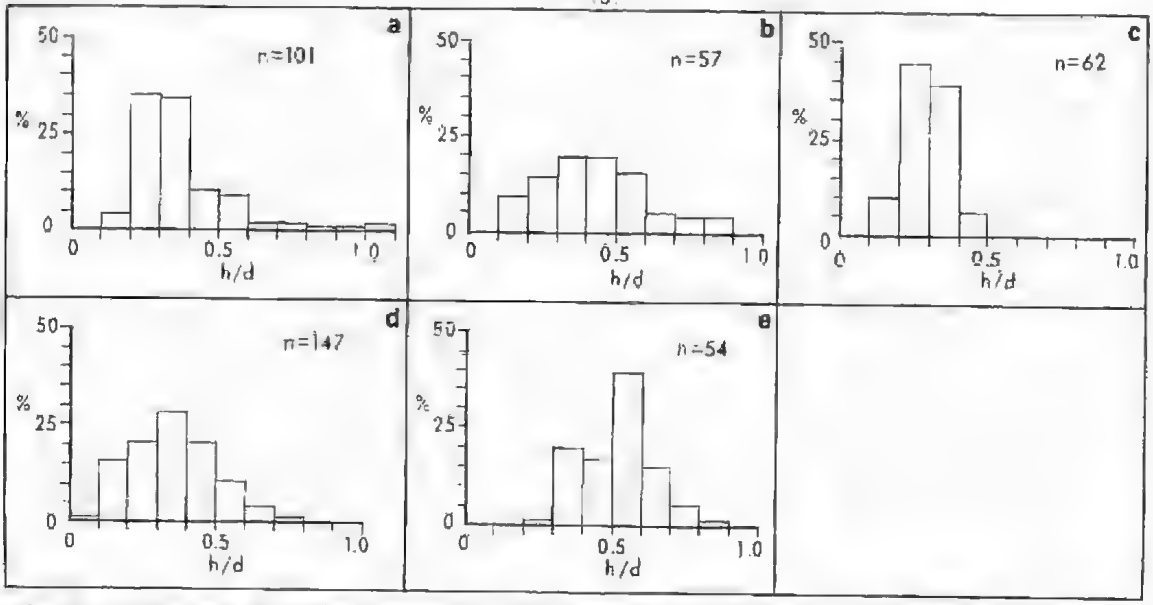

Fig. 9. Histograms of lamina convexities. The convexity of a lamina is the ratio of the height of that lamina to its diameter (h/d). Histograms are plotted for each stromatolite form at intervals of 0.1; *n* is the number of measurements made for each form: (a)—*Acaciella angepena*; (b)—*A. augusta*; (c)—*Acaciella* f. indet.; (d)—*Baicalia burra*; (e)—*Boxonia melrosa*.

may all be synonymous. *B. melrosa* is distinguished from *B. pertaknurra* Walter (in press), which also lacks a pelletal microstructure, by its more steeply convex laminae, its occasional short, projection-like columns and by the absence of well defined broad basal columns. *B. melrosa* most resembles *B. lissa*, from which it is distinguished by the absence of pelletal microstructure, and by the presence of some short, projection-like columns.

Distribution: Brighton Limestone equivalent, 1.6 km west of Melrose (ORROROO 1:250,000 map sheet area).

Age: Late Adelaidean, correlated with the Late Riphean of the USSR.

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Appendix 1.—Glossary

Axis: The centre-line of a column.

Bioherm: A circumscribed organo-sedimentary structure whose minimum width is less than or equal to one hundred times its maximum thickness, embedded in rocks of different lithology. Note: the definitions of the terms *Bioherm* and *Biostrome* are based on those given by Nelson, Brown & Brineman (1962) but since, at least in stromatolites, the two integrade, an arbitary limit must be set.

Tabular bioherms have parallel upper and lower surfaces, while *domed bioherms* have gently convex upper surfaces. *Subspherical bioherms* had the highest growth relief relative to their width.

Tonguing bioherms are bioherms which had little or no growth relief, and therefore intertongue at their margins with the surrounding sediment.

Biostrome: A stratiform organo-sedimentary structure whose minimum width is more than one hundred times its thickness. Note: in practice it is rarely possible to see the three dimensional shape of the structure in outcrop. The distinction between bioherms and biostromes must therefore be based on the dimensions visible in outcrop. If the outcrop is inadequate, the informal term "bed" is used.

Tabular biostromes have parallel lower and upper surfaces. *Domed biostromes* either may consist of juxtaposed domed bioherms or may be continuous with juxtaposed domes on their upper surfaces.

Branching: The division of a column into new, discrete columns. The columns become discrete when they are first separated by an interspace. In *parallel* branching, the *axes* of the new columns are parallel (most commonly they are also parallel to the axis of the original column). *α-parallel branching* is parallel branching in which the width of the individual remains constant. In *β-parallel branching* the original column widens gradually before branching, while in *γ-parallel branching*, it widens abruptly before branching. In *slightly divergent branching*, the axes of the new columns diverge at less than 45°, while in *markedly divergent branching* they diverge at more than 45°. *Dichotomous branching* is branching into more than two columns at approximately one level.

Bridge: A stromatolitic lamina or set of laminae linking adjacent columns.

Bump: A low, rounded protrusion on the side of a column.

Coalescing columns: Adjacent columns which join and continue growth as one column.

Column: A discrete stromatolite structure, with the dimension in the direction of growth greater than at least one of the transverse dimensions. Column shape and arrangement often vary according to the position in the bioherm.

Columnar-layered stromatolite: A stromatolite in which short columnar and laterally linked (usually pseudocolumnar) portions alternate.

Cornice: Peripheral overhanging portion of a lamina or set of laminae, elongated transversely to the column axis.

Crest: The summit of an upward-convex lamina.

Crestal line: The line jointing the crests of successive laminae.

Crestal zone: The environs of the crestal line. In *Conophyton*, the crestal zone is specifically the zone of thickening and contortion of the laminae; the width of the crestal zone is the width of the thickened and/or contorted portions of laminae. Three types of crestal zones of *Conophyton* were distinguished by Komar *et al.* (1965).

Cumulate stromatolite: A rounded protruding non-columnar stromatolite.

Domed: With approximately constant radius of curvature.

Flat-laminated stromatolite: Non-columnar stromatolite with flat continuous laminae. Aitken (1967) has proposed the term *cryptalgalaminate* for stromatolites with planar lamination.

Gently convex lamina: A lamina whose ratio of height to diameter is less than or equal to 0.5. Measurements of this ratio are best treated statistically by plotting on a histogram.

Gnarled column: A column with large bumps

Grumous: A mineral texture in which fine-grained patches are surrounded by coarser grains, interpreted to have formed by partial recrystallization.

Hypidiotopic: A mineral texture intermediate between xenotopic and idiotopic.

Idiotopic: A texture in which the mineral grains are bounded by crystal faces.

Individual: A single discrete stromatolite within which either the laminae are continuous or which comprises a group of columns arising from a single basal column.

Interspace: The space between columns, usually filled with sediment.

Lamina: The smallest unit of layering in a stromatolite.

Lanceolate: An elongate transverse section of a column, tapering at both ends.

Laterally linked stromatolite: Stromatolite with wavy laminae which are continuous between crests.

Macrolamina: A distinct set of laminae.

Microstructure: The fine-scale structure of the stromatolite lamination, in particular the distinctness, continuity, thickness and composition of the laminae.

Banded microstructure is characterized by very continuous laminae with sharp, distinct, more or less parallel boundaries. In *streaky microstructure* less distinct and continuous laminae frequently grade into one another. The darker laminae are usually more distinct.

Striated microstructure consists of primary chains of lenses, oriented parallel to the lamination (this excludes cases where originally continuous laminae are disrupted by recrystallization).

Vermiform microstructure consists of narrow, sinuous, pale coloured areas (usually of sparry carbonate) surrounded by darker, usually finer grained areas.

Micro-unconformity: Surface of lamination discordance due to penecontemporaneous erosion within a stromatolite.

Niche: A deep indentation in the side of a column.

Parabolic lamina: A lamina whose axial longitudinal section approximates a parabola.

Peak: Overhanging portion of a lamina or set of laminae with a small dimension transverse to the column.

Pellet: Ovoid to sub-ovoid micritic carbonate grain of silt or sand size, lacking internal structure

Pigment: Organic or inorganic colouring matter.

Platy column: A strongly transversely elongated column.

Projection: A small columnar or conical outgrowth from the side of a column.

Pseudocolumnar stromatolite: Laterally linked stromatolite in which successive crests are superimposed, forming column-like structures (pseudocolumns).

Rectangular lamina: Lamina which in a longitudinal section of a column is flat-topped with edges deflexed at about 90°.

Rhombic lamina: Lamina which in a longitudinal section of a column is flat-topped but has subparallel edges not perpendicular to the top.

Rib: A low, rounded protrusion which is elongated transversely to the column on which it occurs.

Selvage: An unlaminated coating on column margins. Possible explanations for this include (a) micritization by algal boring; (b) inorganic precipitation of lime; (c) a thin algal film on column margins during growth. In some forms a selvage-like structure is probably the result of differential recrystallization of a wall.

Steeply Convex lamina: A lamina whose ratio of height to diameter is greater than 0.5.

Tuberous column: A column with prominent expansions and constrictions.

Wall: Structure at the margin of a column formed by one or more laminae from within the column bending down and coating the margin for at least a short distance.

Wavy lamina: A lamina with flexures of wavelength greater than 2 mm.

Wrinkled lamina: A lamina with flexures of wavelength greater than 2 mm.

Undulatory stromatolite: Laterally linked stromatolite in which successive crests are not superimposed.

Xenotopic texture: A texture in which the mineral grains are anhedral or irregularly shaped, i.e. not bounded by crystal faces.

Fig. 10. *Acaciella angepena*, from Lower Cambrian limestones, Flinders Ranges; sections perpendicular to bedding, showing mode of occurrence and microstructures: (a)—Marginal section of a bioherm. Note that the laminae are completely recurved under the bioherm edge. The specimen is *in situ*. The ball-point pen is 16 cm long, Angepena; (b)—Etched section of S300, the recurved margin of the bioherm in (a) cut at right angles to bedding. Note that here growth partly proceeded downwards. Specimen is 15 cm wide; it was collected from the outcrop shown in (a); (c)—Lateral termination of a bioherm, which partly sank into the soft substrate during growth. The white areas are dolomitized. Width of specimen (S460) is 20 cm. Angepena; (d)—Pseudocolumns with rare interspaces. Note the domed laminae grown upon partly buried intraclasts, and the extremely continuous lamination. Thin section, Angepena (S462); (e)—Evenly laminated ferruginous structure, probably the stromatolite *A. angepena* affected by secondary ferruginization. Thin section, from near Old Wirrealpa. The dark laminae are outlined by finely disseminated hematite. (S564, collected by Mr. P. G. Haslett); (f)—Evenly laminated discrete columnar form from Balowie Gorge (Sir Douglas Mawson's specimen).

Fig. 11. (a)—*Acaciella angepena*; irregular columns from the marginal portion of a small bioherm (S458, Angepena). Note the vermiform microstructure within parts of columns, here interpreted as due to algal boring, disrupting the normally very even, continuous lamination; (b) & (c)—*Acaciella* f. indet. Both specimens are erratics from the Sturtian glacials north of the Enorama Diapir. Thin sections. Note the very numerous concordant stylolites in (b). (S539 and S509 respectively; S539 was collected by Dr. B. Daily); (d), (e) & (f) *Acaciella augusta*, Brighton Limestone equivalent, Depot Creek. Vertical sections showing mode of occurrence and microstructure: (d)—Details of transition from broad, frequently bridged basal columns to upper narrow, discrete columns. Broad columns in lower right-hand corner have inclined margins and subhorizontal laminae; (e)—Lenticular open spaces between laminae, possibly representing original gas vesicles (S163); (f)—Portion of a bioherm showing the intercalation of columnar and laterally linked stromatolites.

Fig. 12. *Acaciella augusta*, Brighton Limestone equivalent, Depot Creek, showing mode of occurrence and microstructures. (a)—Margin of a bioherm (pale coloured at right of photograph) interfingering laterally with massive oosparite (at left); (b) & (c)—S404 & S401 respectively. The gross shape and branching of columns. The interspaces are filled with interlayered micrite and intramicrite, in 0.5 to 1.0 cm bands. (c) is natural size. In (b), laminae become doubly crested before branching, but in the centre of the photograph (c) is an example of a short interspace between crests bridged by the overlying laminae: the column then resumes its former growth pattern; (d)—Recrystallized specimen from Mundallio Creek (S538), illustrating radiating recrystallized acicular textures in the lower part of the photograph.

Fig. 13. *Baicalia burra*, Skillogalee Dolomite. Sections perpendicular to bedding, showing the mode of occurrence and microstructure: (a)—Small lenticular bioherms interbedded in thinly bedded dolomites, Yatina; (b)—Portion of a biostrome interbedded in massive, fine grained dolomites, Dutton's Trough H.S. Longitudinal section of partially silicified columns. The section is parallel to the tectonic cleavage, in the plane of flattening of the columns; (c)—Irregular columns with numerous micro-unconformities and highly variable lamina shape, West Mount Hut; (d)—Moderately divergent branching columns, with some pelletal laminae. Thin section, Yatina (S222, holotype); (e)—Slightly divergent branching in regular, sub-cylindrical columns. Thin section, S533, Dutton's Trough H.S.; the specimen is taken from the biostrome shown in Fig. 13 (b).

Fig. 14. *Baicalia burra*, Skillogalee Dolomite: (a)—Tuberous and inclined columns with evenly banded microstructure and high-angle micro-unconformities. Thin section, S487, Myrtle Springs; (b) *B. burra* with minor pelletal laminae. Thin section, S150, Worumba; (c)—Subcylindrical columns with steeply domed, evenly banded laminae. Thin section, S302, West Mount Hut; (d)—Branching of narrow columns from the sides of a main wide column. Cut slab, S534, Dutton's Trough H.S. The specimen is taken from the biostrome shown in Fig. 13 (b); (e)—*B. burra* with predominantly pelletal laminae. Thin section, S496, Copley; (f)—Complex branching of columns from Arkaroola. Thin section, S457.

Fig. 15. (a)—*Baicalia burra* with finely silicified laminae. Thin section, natural size, S151, Worumba. Note the vertical tectonic dolomite veins; (b)—*B. burra*. Cut slab illustrating sub-parallel branching columns with high-angle micro-unconformities and banded lamination. S96, near Chintapanna Well, specimen collected by Mr. C. R. Dalgarno. Note the overgrown stromatolite fragment in the lower left quadrant, and the branch arising from an eroded column in the upper right; (c)—Indeterminate stromatolite, possibly *Baicalia burra*. Thin section, S322, near Carrieton; (d), (e) & (f)—*Boxonia melrosa*, Brighton Limestone equivalent, Melrose: (d)—Hand specimen illustrating longitudinal sections of columns; (e)—Thin section of holotype, S503. The lamination is indistinctly banded, and becomes diffuse in the wall zone; (f)—Thin section illustrating lamination and wall structure. S177, natural size. Note that the upper left and lower left corners of the thin section are composed of highly weathered rock.

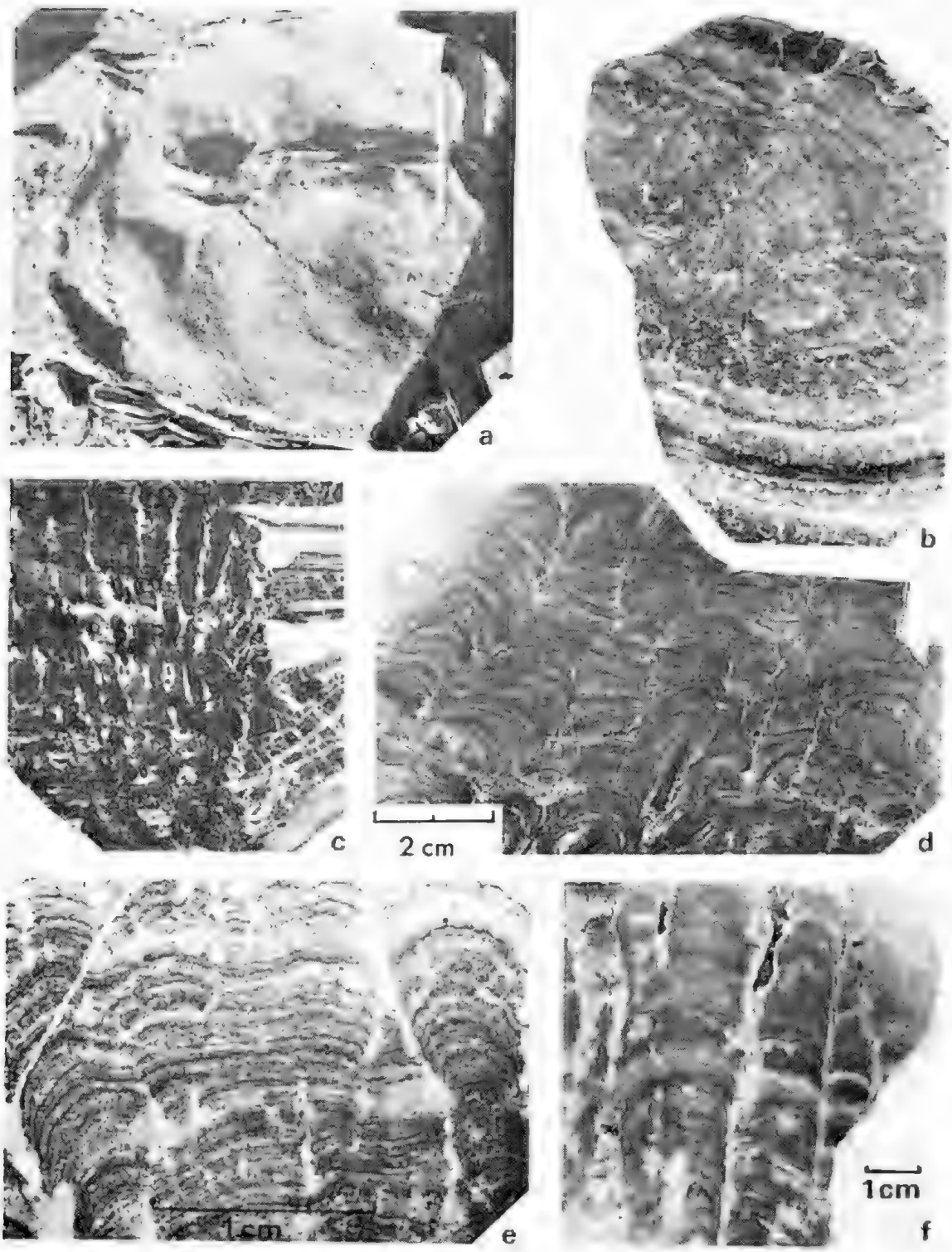

FIG. 10

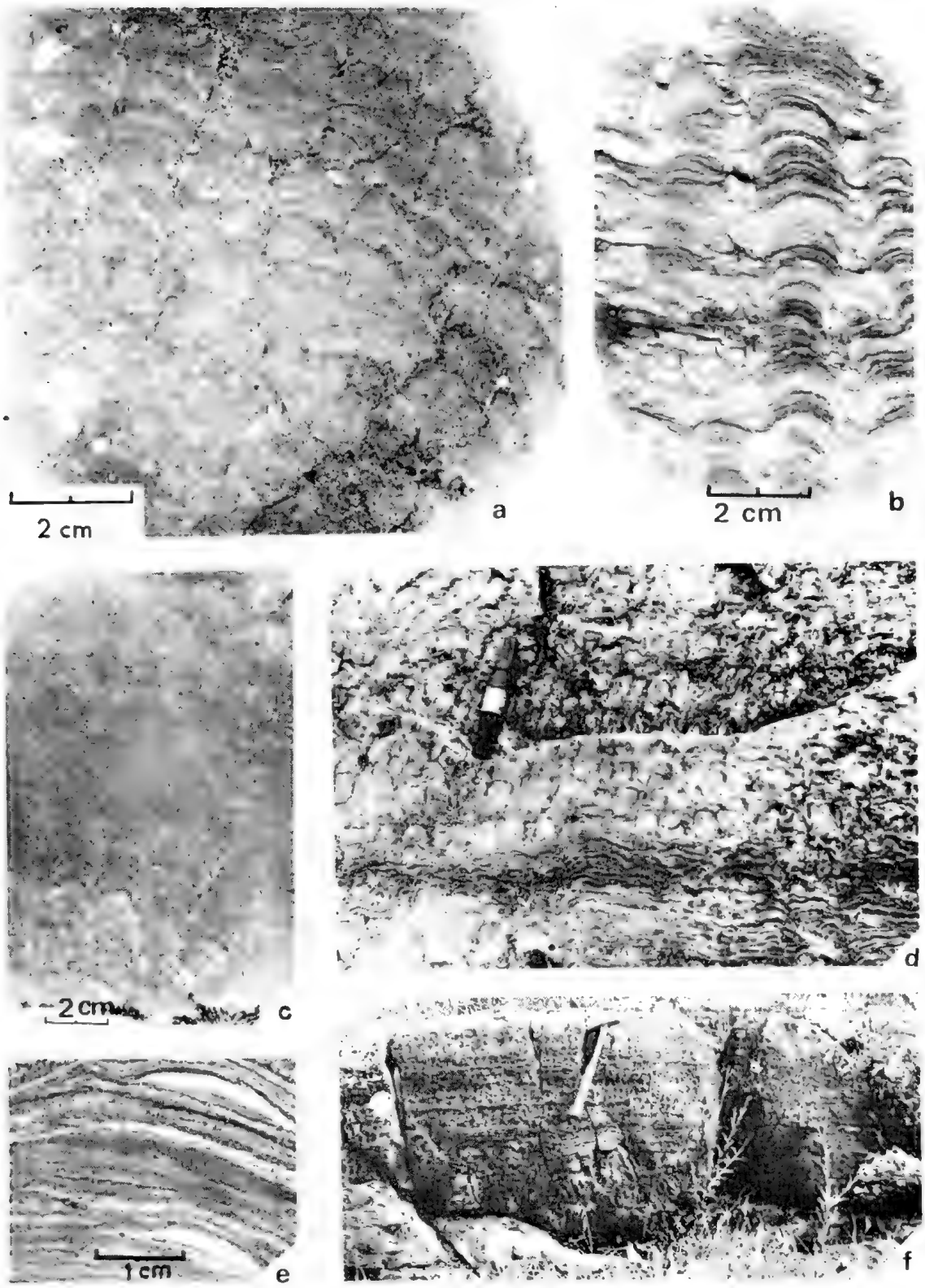

FIG. 11

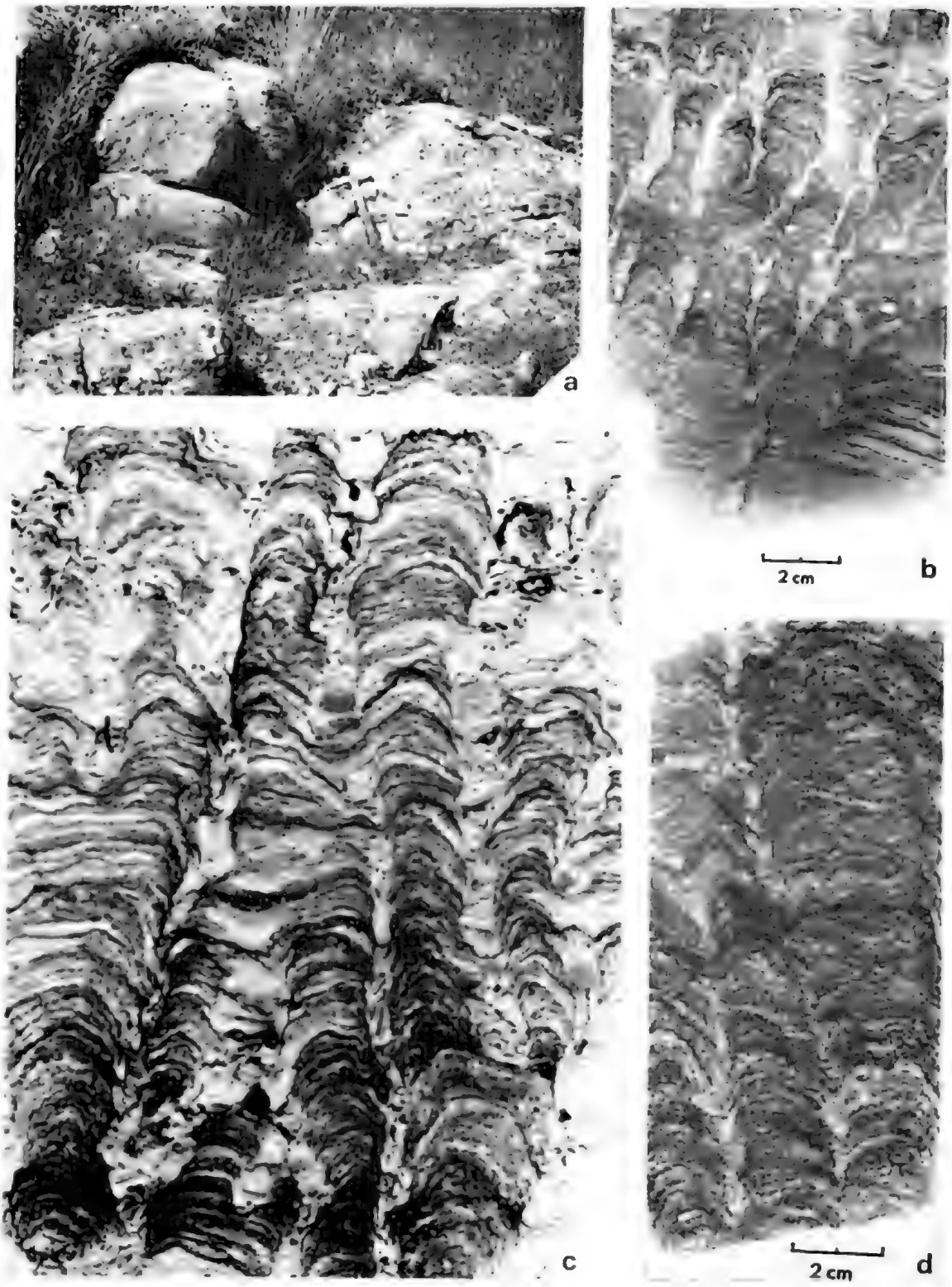

FIG. 12

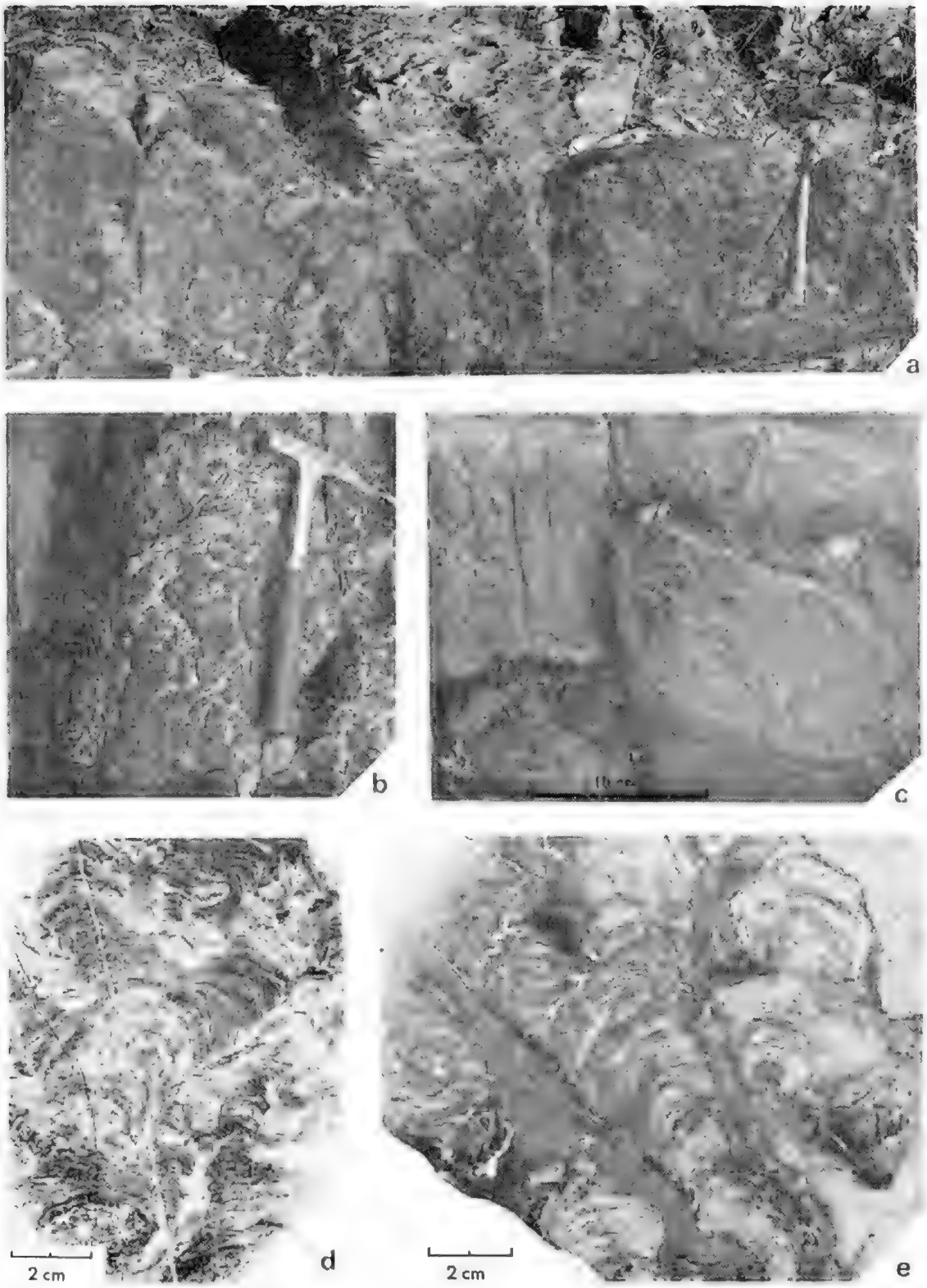

FIG. 13

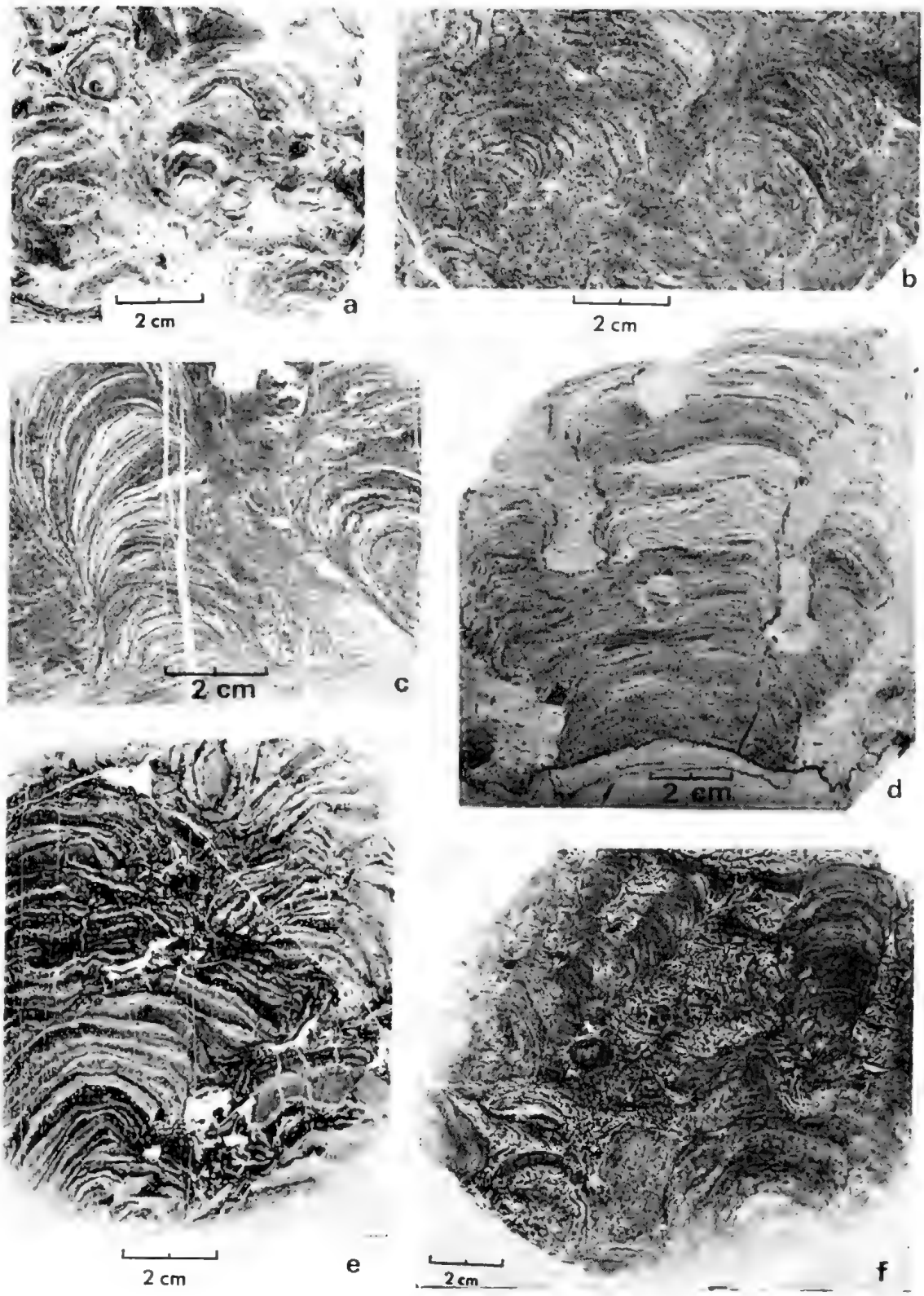

FIG. 14

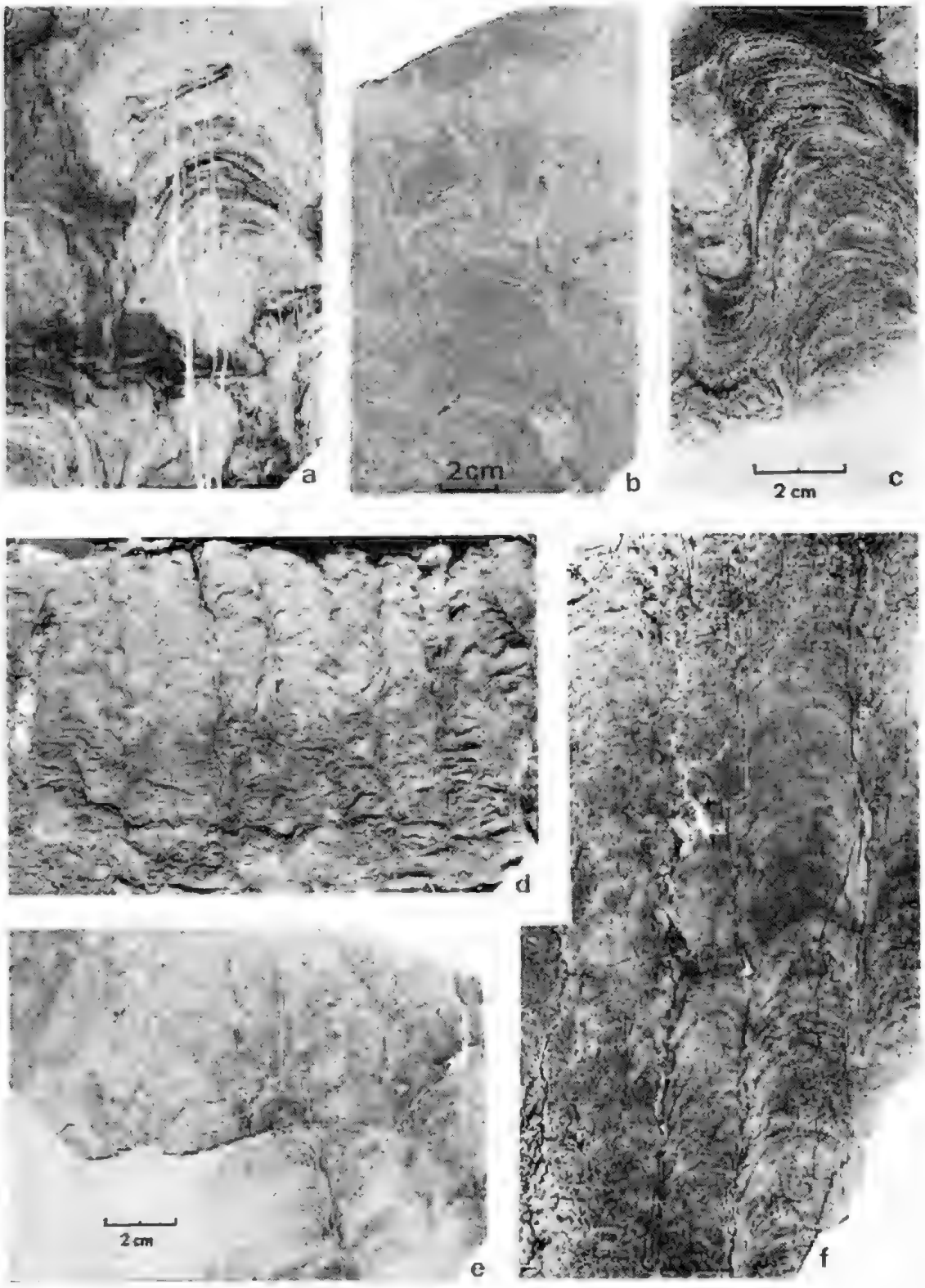

FIG. 15

THE NEMATODE GENUS MAXVACHONZA (OXYURATA: COSMOCERCIDAE) IN AUSTRALIAN REPTILES AND FROGS

BY PATRICIA M. MAWSON

Summary

The genus *Maxvachonia* Chabaud & Brygoo, 1960, previously known only from reptiles in Madagascar, is now recorded in Australia and New Guinea. New species described are M. *chabaudi* from 7 species of skinks, 1 species of gecko, and 1 species of snake (? from food); M. brygooi from 5 species of agamid lizards; and M. ewersi from a frog, *Litoria nasuta,* from New Guinea. M. *ftindersi* (Johnston & Mawson) [syn. *Aplectana flindersi* J. & *M.],* is recorded from 5 species of Australian frogs and one introduced species, *Bufo marinus.* The genus *Austrocerca* Inglis, 1968, is regarded as a synonym of *Maxvachonia.*

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Introduction

Maxvachonia dimorpha Chabaud & Brygoo (1960, p. 129) was first described from *Chamaeleon pardalis*, and later also from *C. australe* (Chabaud, G. R. Caballero, & Brygoo 1964, p. 846), in both cases from a small island, Nossi-Bé, about 20 km from the mainland of Madagascar. It has since been recorded from one chameleon and two other species of lizards (*Zonosaurus maximus* and *Mabuia gravenhorstii*) on Madagascar itself. (G. Caballero 1968, p. 192.)

Although the genus was not recognised until recently, and does not appear to be common in any host species, it is surprisingly widespread. The seventeen species of Australian lizards from which *Maxvachonia* spp. are recorded in this paper belong to the families Scincidae, Agamidae, and Gekkonidae, and they come from a wide geographical range. One collection was made from the stomach of a snake, but as this also contained some semi-digested skinks, the snake may not be a true host record.

The genus is not confined to reptiles. *Austracerca* Inglis (1968, p. 164) appears to be a synonym of *Maxvachonia*. Inglis recorded *A. flindersi* (Johnston & Mawson) (syn. *Aplectana flindersi*) from three frog species in Western Australia. It has now been recognised from five more frog species from various parts of Australia, and from a toad, *Bufo marinus*, introduced into Queensland sugar cane fields in 1934. Another species is recorded from a frog from New Guinea.

The males and females of *Maxvachonia* spp. are very different in size, but the morphology of the anterior end is similar in the two sexes. Both males and females are easily distinguished from other cosmocercoid genera, the female by the great distance of the anus from the posterior end of the body, and by the shape of the eggs, and the male by the shape of the gubernaculum, which is very large and bears two prominent projections near its proximal end.

The differentiation of species within the genus is rather more difficult. The presence or absence of lateral alae on the anterior part of the body in the female appears to be a specific character. There is a wide variation in the body length of the female within a species, although fully adult specimens from the same host animal are usually about the same size. The ratio of the body length to that of the oesophagus varies considerably, possibly due at least in part to the degree of contraction of the body in different collections. The ratio of body to tail length in the adult is more constant, and may be of specific significance. The egg size is similar in all specimens available, but there is some variation in the shape of the projection on the egg shell and of the envelope which surrounds the egg in the vagina, and these appear to have specific value.

The male worms are rare compared with the female, so that it is even harder to assess the specific value of any character. The body length and that of the oesophagus are very similar among all the specimens examined. There is some variation in the lengths of spicules and gubernaculum but even these vary almost as much between two specimens from the same host animal (in the only case where two males were found in one host) as among all the males collected in Australia.

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On these slender criteria, three species have been distinguished from Australian reptiles, one (*M. flinderi*) from Australian frogs, and one from a New Guinea frog. The general body form is similar in all species, and agrees generally with the descriptions of Chabaud & Brygoo (1960) and Chabaud *et al* (1964) and of Inglis (1968). Some additional observations and distinguishing characters are noted under the species. Measurements are given in Tables I and II. Type-specimens will be deposited in the South Australian Museum.

Maxvachonia chabaudi n.sp.

FIGS. 1–6

Hosts and localities: *Morethia lineoocellata* (Duméril & Bibron), type host; *Lerista bougainvillii* (Gray), *Ctenotus leae* (Boulenger), *Pseudonaja ? affinis* Günther, all from Eyre Peninsula, S. Aust.; *Ctenotus labillardieri* (Gray) from Pemberton, W. Aust.; *Hemiergis peronii* (Fitzinger) from Pemberton and Esperance, W. Aust.; *Sphenomorphus australis* (Gray) from Wilgarup, W. Aust.; *S. kosciuskoi* (Kinghorn) from the New England district, N.S.W.; *Egernia whitei* (Lacépède) from Penola, S. Aust.; *Phyllurus nilii* (Bory) from Kangaroo I., S. Aust.

Most of these collections consist of female worms, adult and/or juvenile (i.e. with or without embryonated eggs). There are five males, two from *Ctenotus leae*, one from *Lerista lineoocellatus* and one in each of two *H. peronii*. In these last two there were no females, and as this species of *Maxvachonia* is separated from others by characters of the female, the inclusion of the males is arbitrary.

Alae are present in both sexes. There are three lips, the inner border of each projecting as a cuticular lamella. The mouth is triangular, or triradiate. Each lip is strengthened by a chitinous bar, the three bars meeting to form a triangle around the anterior end of the buccal cavity. The short triangular buccal capsule rests against the anterior end of the oesophagus. Three well-defined teeth project from the oesophageal lining into a depression in the anterior end of the oesophagus.

Female: Lateral alae extend from the level of the nerve ring to about the mid body. The posterior end of the body ends in a more or less distinct mucro, which is rugose. The vulva, a transverse slit, lies at about the level of the isthmus of the oesophagus. The two ovaries commence shortly in front of the anus, pass backwards nearly to the posterior end of the body where each enters a short oviduct, leading to a slightly wider, sometimes almost spherical, thicker-walled section (? seminal receptacle) from which the uterus leads forward. The two uteri pass forward side by side, uniting to form the vagina at about a quarter of the body length from the anterior end, or a little in front of this.

Eggs in the anterior parts of the uteri each contain a coiled larva. The eggs are roughly spherical, slightly longer in the axis through the knob on the shell. In the vagina, where they are less crowded, they are seen to be surrounded by a spongy or reticulate material which forms a loose envelope attached to the shell by, or at, the apical knob, more or less open at the opposite pole (Fig. 5) and often trailing two ribbon-like pieces from the open end. This envelope was noted in the original description of *Maxvachonia dimorpha*.

Male: The lateral alae extend for most of the body length, from the level of mid-oesophagus to shortly in front of the anus. The posterior end of the body is strongly curved ventrally. The gubernaculum is large and heavily built, with a pair of lateral processes near the proximal end. The spicules are slender, well chitinised, and blunt-tipped. The cloacal opening is on an elevation of the body wall. The thirteen pairs of caudal papillae are arranged as shown in Fig. 6.

The species is distinguished from *M. dimorpha* chiefly because of the presence of lateral alae in the female. The females are all shorter, and the males about the same size, as those of *M. dimorpha* but the spicules and gubernaculum are larger.

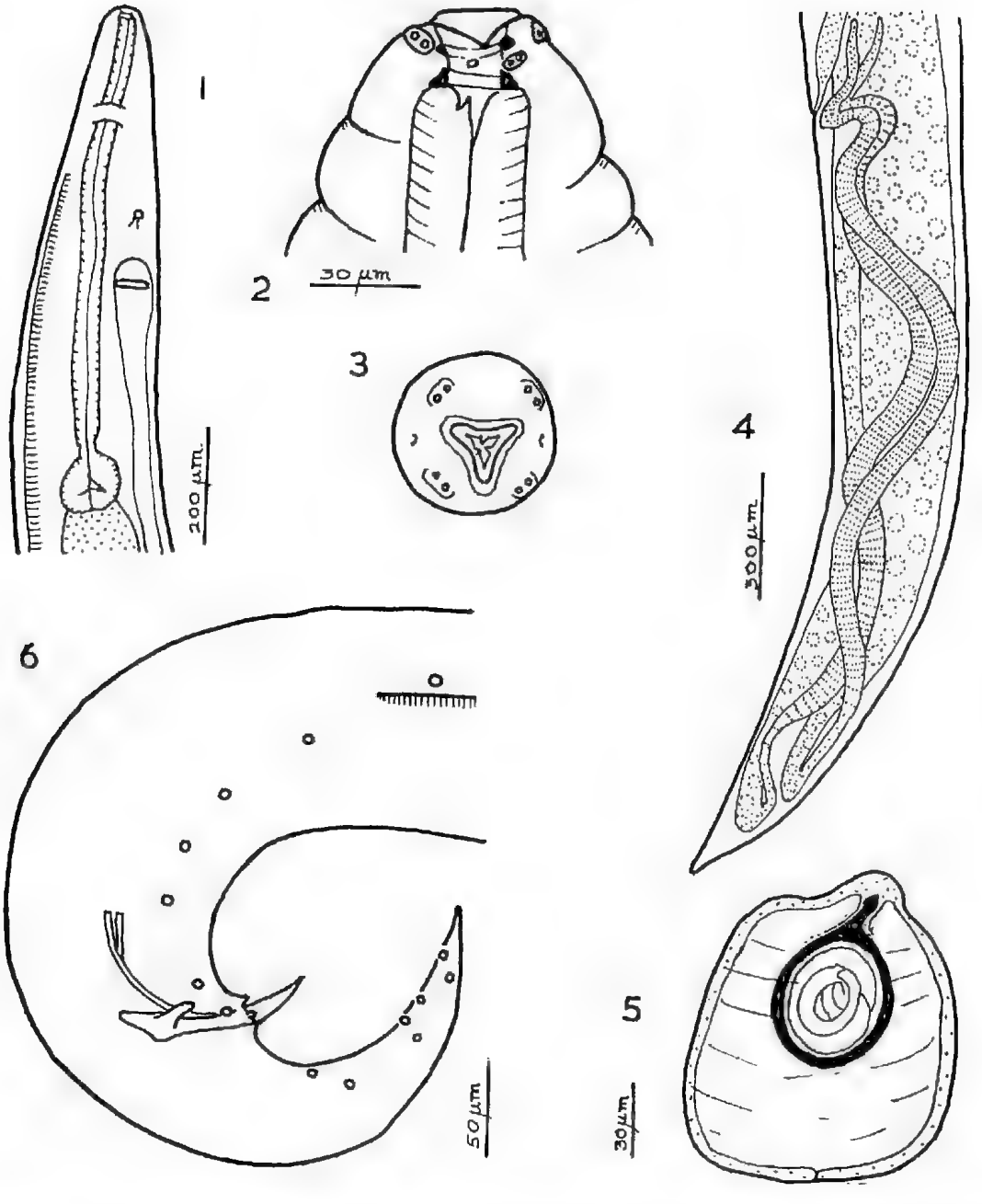
Maxvachonia brygooi n.sp.

FIGS. 7–10

Hosts and localities: *Amphibolurus decresii* (Duméril & Bibron), type host; *A. maculatus* (Gray), both from Eyre Peninsula, S. Aust.; *A. inermis* (De Vis) from Yuendumu, Northern Territory; *A. muricatus* (Shaw) and *A. barbatus* (Cuvier) from N.S.W.

Only females have been taken from these agamid lizards. All of them, however, differ from those from skinks in the absence of lateral alae. In other respects they are very similar.

Although this distinction is slight, it is constant. Notwithstanding the fact that agamids and skinks occurred in the same locality in Hincks National Park on Eyre Peninsula, *Maxvachonia* spp. from the agamids were always



Figs. 1–6. *Maxvachonia chabaudi.* Fig. 1.—Oesophageal region. Figs. 2, 3.—Lateral and *en face* views of head, to same scale. Fig. 4.—Posterior end of female. Fig. 5.—Egg. Fig. 6.—Posterior end of male.

without alae, while those from the skinks had alae. In view of this it is thought safer to regard the two groups as separate species, at least until more specimens, especially males, are found.

Maxvachonia sp.

Host and locality: *Morethia taeniopleura*, Mornington I., Gulf of Carpentaria.

Only one female was collected from this host; it is very similar to females of *M. chabaudi* but the ratios of oesophagus and tail to the body length differ markedly (Table 1).

Maxvachonia flindersi (Johnson & Mawson)

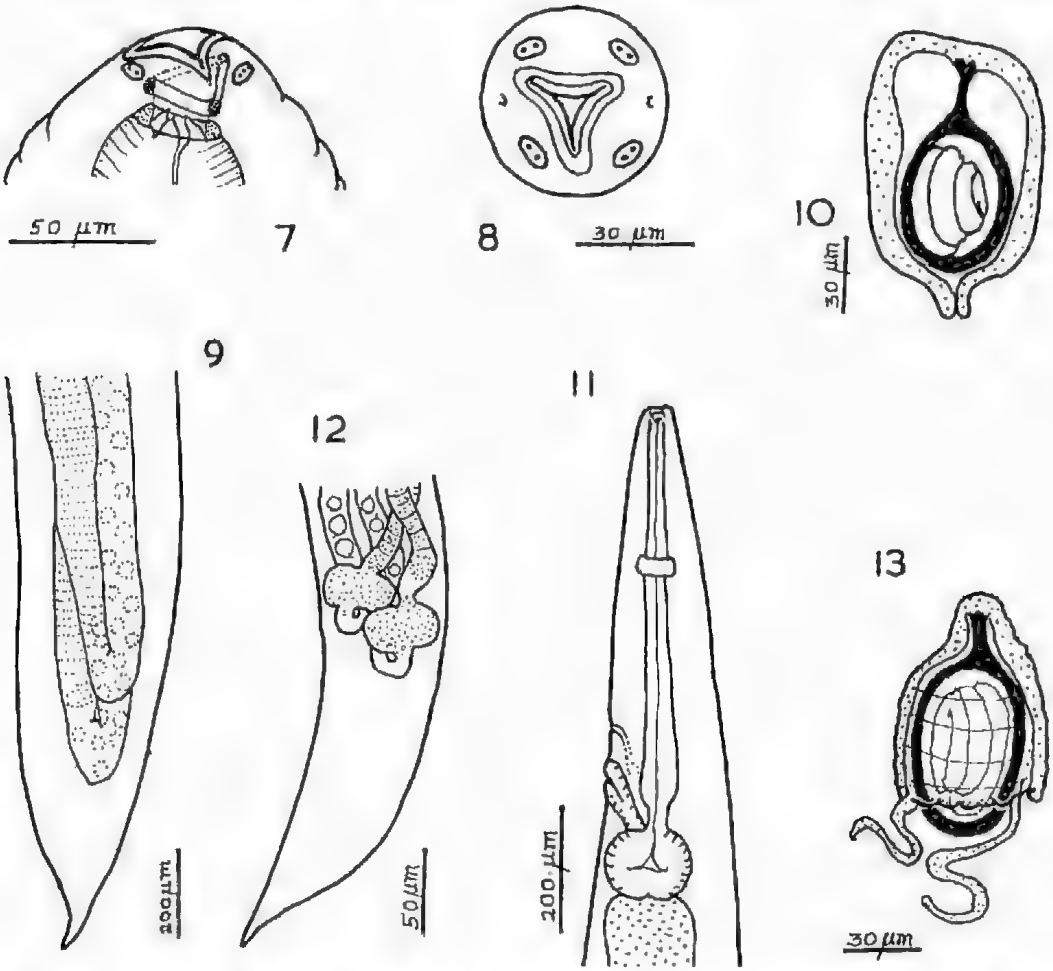
FIGS. 11–13

Aplectana flindersi Johnston & Mawson, 1941: 148, from *Litoria ewingi* (syn. *Hyla jervisensis*) from Kangaroo I., S. Aust.

Austrocerca flindersi (Johnston & Mawson) Inglis, 1968: 165, from *Litoria coeloryncha*, *Heleioporus barycragus* and *H. psammophilus*, from W. Aust.

Host and localities: *Bufo marinus* Linn. from Queensland; *Limnodynastes dorsalis* (Gray) from Adelaide, S. Aust.; *Heleioporus inornatus* Lee & Main, *Litoria moorei* Copland, *L. adelaidensis* (Gray) from near Perth, W. Aust.; *L. caerulea* (White) from Alice Springs, N.T.

All the hosts listed above are new records for *M. flindersi*. The new male specimens agree closely with the earlier descriptions, both in size and appearance, but the females are distinctly larger, even those from related hosts in Western Australia. Through the courtesy of



Figs. 7–10. *Maxvachonia brygooi*. Figs. 7, 8.—Lateral and *en face* views of head. Fig. 9.—Posterior end of female. Fig. 10.—Egg.

Figs. 11–13. *M. flindersi*. Fig. 11.—Anterior end of female. Fig. 12.—Posterior end of female. Fig. 13.—Egg.

Dr. W. G. Inglis and of the Western Australian Museum it has been possible to compare all the known specimens, and no significant difference other than size was observed. The details of the female reproductive system have now been studied, and these agree generally with the form in other species of the genus. The ovaries begin shortly in front of the anus. The eggs in the uteri are enclosed in the characteristic outer envelope, which in some specimens is very dark. The envelope is in the form of a bell attached to the knob of the shell at its apex and open at the other end; from the open end come two long ribbons of material similar to that of the envelope. In one case an egg lying just outside the body of the female was still attached by one of these ribbons, which passed into the vulva.

Maxvachonia flindersi differs from *M. dimorpha* in the presence of well developed lateral alae in the female, and from both *M. dimorpha* and *M. ewingi* (see below) in the shape of the seminal receptacle. The size of the spicules and gubernaculum vary greatly in the few male specimens known, but the gubernaculum is always distinctly longer than the spicules.

Maxvachonia ewersi n.sp.

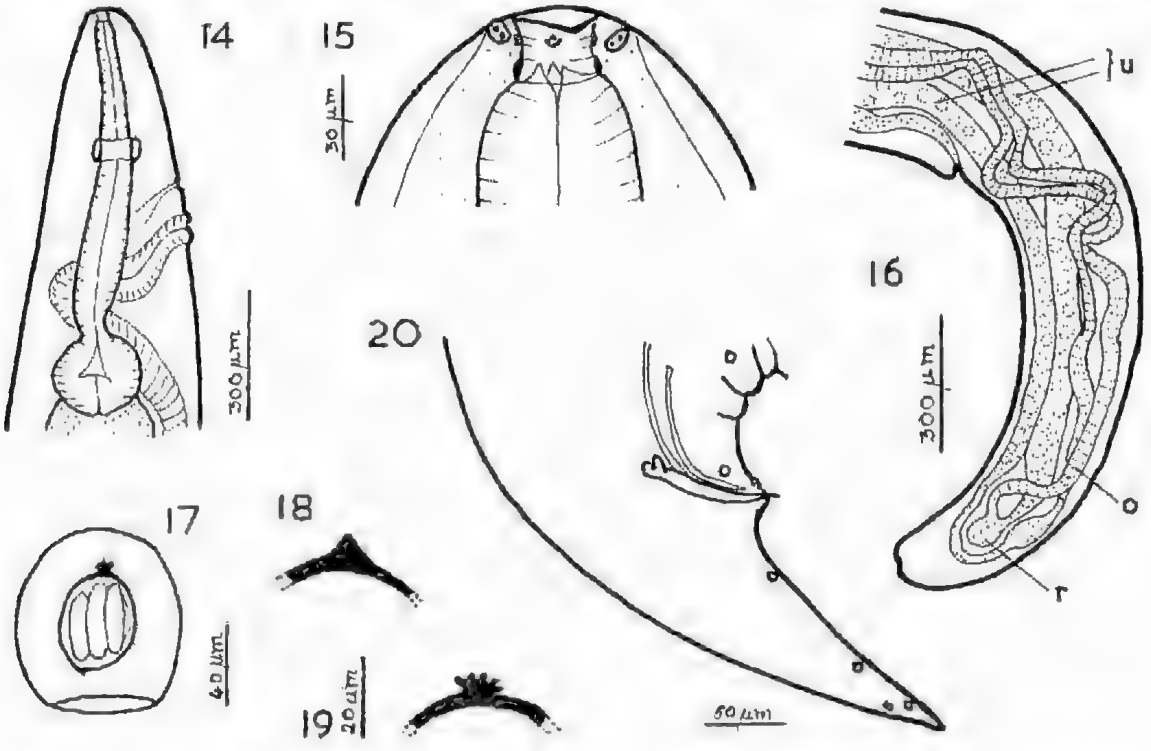
FIGS. 14–20

Host and locality: *Litoria nasuta* (Gray) from Brown River, New Guinea.

The material consists of three female and one male worms. The general body form is very similar to that of *M. flindersi* and other species of the genus; measurements are given in Table 2.

The characters distinguishing this species from *M. flindersi* are the following:

1. The oesophageal teeth are much smaller (Fig. 15).
2. The spicules are distinctly longer than the gubernaculum.
3. There are only two pairs of preanal papillae in the male. The other caudal papillae are arranged as in *M. flindersi*.
4. In the female the posterior end of the body appears rounded, because the extreme tip is slightly withdrawn forming a dimple.
5. The arrangement of the reproductive organs in the female is slightly different. The ovaries start much further forward at about



Figs. 14–20. *Maxvachonia ewersi*. Fig. 14.—Oesophageal region, female. Fig. 15.—Lateral view of head. Fig. 16.—Posterior end of female. Fig. 17.—Egg. Figs. 18, 19.—Two views of apical extension of egg shell, to same scale. Fig. 20.—Posterior end of male. o, ovary; r, seminal receptacle; u, uterus.

two-thirds the body length from the head, and the seminal receptacle is not so much wider than the uterus and oviejector.

6. The shape and size of the eggs are different. The knob on the shell is shorter, and appears conical on one axis, but broad and grooved on an axis at right angles to this; the egg itself is slightly flattened in this latter view. The coils of the larva lie in the plane of the wider diameter. The envelope surrounding the egg is thinner than in other species, although it is dark in colour, and forms a bell, attached at knob end of the egg, similar to those of *M. flindersi*, but more definite in shape (in these specimens at least). In eggs furthest from the vulva (but in the vagina) the mouth of the bell is open, but in those nearest to the vulva it is closed.

Acknowledgements

Several of the collections examined were made by Dr. John Hickman of the Zoology Department, University of Tasmania; specimens from *Litoria nasuta* were sent by Dr. W. Ewers of the University of Papua and New Guinea. To both these helpers I am most grateful. I also wish to thank Dr. W. G. Inglis, then Director of the South Australian Museum, because I would not have examined any frog material for *Maxvachonia* sp. had he not pointed out that his genus *Austrucerca* is a synonym of *Maxvachonia*.

I am also indebted to officers of the South Australian Museum, Mr. M. Tyler, Hon. Associate in Herpetology, and Dr. T. Houston, Curator of Amphibia and Reptiles, for information on the nomenclature of the hosts.

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TABLE 1

Measurements of Maxvachonia *spp. from Australian reptiles; unless otherwise stated, measurements are given in μm.*

Species	*M. chabaudi*						*M.* sp.	*M. brygoo*		
host group	Skinks				Geckos	Snake	Skink	Dragons		
locality	Type host, S. Aust.	Others, S. Aust.	W. Aust.	N.S.W.	S. Aust.	S. Aust.	Qld. Mornington I.	S. Aust.	N.S.W.	N.T.
♂ Length (mm)	2.5	2.3, 2.5	2.4, 2.7	—	—	—	—	—	—	—
Oesophagus	380	520, 500	450, 370							
L/Oes. length	6.6	5.1, 5.0	5.3, 7.3							
A—nr	145	330, 300	165, —							
—ex.p.	330	200, 200	300, 310							
Spicules	120	120, 125	120, 130							
Gubernaculum	130	160, 160	135, 150							
♀ Length (mm)	7.3–8.7	6.0–15.5	9.6–10.3	11.7–13.7	7.5–14.9	7.2–9.6	8.5	9.3–10.8	8.8–12.9	8, 11.9
Oesophagus	720–800	570-980	800–880	890–950	570–920	720–890	500	800–900	620–770	750, 1080
L/oesoph. length	10.2–11.0	9.3–16.8	11.6–12.5	13.1–14.4	12.6–17.9	10–11.8	17.0	10.3–13	13.5–16.7	10.6, 11.0
A—nr	150–180	160–280	220–270	220–270	–320–	240–300	160	250–270	210–220	—, 250
—ex.p.	270–370	300–630	410–500	450–560	400–600	400–450	240	370–	350–420	—, 550
—vulva	380–500	380–800	520–600	600–700	500–600	530–650	350	490–	500–	—, 780
Tail (mm)	1.9–2.6	1.5–4.2	2.0–2.3	2.9–3.3	1.5–3.8	2.1–2.9	0.92	2.3–2.9	2.1–3.1	1.6, 3.1
L/Tail length	3.3–4.2	3.6–4.2	4.5–5.1	3.9–4.5	4.1–4.2	3.7–4.1	9.2	3.5–4.9	3.9–4.2	5.0, 3.8

TABLE 2

Measurements of Maxvachonia *spp. from Australian frogs: unless otherwise indicated, measurements are given in μm.*

Species	*M. flindersi*						*M. ewersi*
locality	S. Aust.	W. Aust.	W. Aust	W. Aust.	N.T.	Qld. (introduced)	N.G.
host	*Limnodynastes dorsalis*	*Helelioporus inornatus*	*Litoria moorei*	*L. adelaidensis*	*L. coerulea*	*Bufo marinus*	*Litoria nasuta*
♂ Length (mm)	—	—	—	2.2	2.35	—	2.4
Oesophagus				370	380		350
L/oes. length				5.9	6.2		6.9
A—nr				190	170		
—ex.p.				230	290		
Spicule				100	150		120
Gubernaculum				120	180		100
♀ Length (mm)	8.9–11.1	6.7–9.8	8.1–9.0	11.2–11.3	6.2–9.0	8.8–11.1	11.0–16.3
Oesophagus	680–900	750–870	710–820	720–780	700–750	680–800	700–900
L/oesoph.	9.9–15	8.9–12.1	10.4–11.4	14.5–15.7	8–12.1	11.3–13.9	14.7–17.2
A—nr	230–270	230–270	250–290	220–290	200–210	200–290	250–330
—ex.p.	430–550	430–550	450–540	450–500	350–420	400–510	320–420
—vulva	570–720	540–690	600–690	580–640	470–550	530–630	450–540
Tail (mm)	1.8–2.5	1.3–2.2	1.7–1.8	2.5–2.8	1.5–2.2	1.6–2.3	2.3–3.3
L/tail	4.5–5.5	4.5–5.1	4.9–5.0	4.0–4.5	4.1–4.7	4.8–5.9	4.7–4.8

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Summary

Three new species of *Cloacina* are described: *C. mundayi* from *Macropus rufogriseus,* from Tarraleah, Tasmania, characterised by the presence of a dorsal buccal tooth associated with the duct of the dorsal oesophageal gland; C. *clarkae* from *M. eugenii,* from Kangaroo Island, South Australia, characterised by the shape of the cephalic papillae and the structure of the oesophagus; C. *edward,vi* from *M. bicolor,* from Sunday *I.,* Victoria, characterised by the presence of oesophageal 'plumes', very short spicules and very short vagina.

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Cloacina mundayi n.sp.

FIGS. 1–7

Host and locality: *Macropus rufogrisea*, from Tarraleah, Tas.

This species is a relatively short stout nematode. The material consists of four males and four females. The submedian papillae are small, with the distal segment much smaller than the proximal. The long threadlike cervical papillae are close to the anterior end.

The shallow buccal ring is somewhat hexagonal in shape, and is uneven in depth. A small dorsal oesophageal tooth projects into the buccal cavity, and is traversed by a duct from the dorsal oesophageal gland. The oesophagus is cylindrical, widening only slightly at the posterior end. No teeth are present in the lumen. The nerve ring is at about the mid-length of the oesophagus, and the excretory pore shortly behind it.

The posterior end of the female tapers from in front of the vulva to the tip of the tail; the distance from the anus to the vulva is about equal to the tail length. The vagina is slightly longer than the tail. The eggs are 110 by 65 μm.

The spicules are about 1/2.5–3.0 of the body length. The dorsal lobe of the bursa is unusually long for the genus, and the ventral lobes are united. The bursal rays are as shown in Figs. 6 and 7. The genital cone is short and conical, and on either side of it there is a cuticular inflation. No accessory cone can be seen. Measurements are given in Table 1.

This species is distinguished from all others so far described in the shape of the bursa and in the presence of a dorsal tooth in the buccal capsule. In describing *C. dahli*, Linstow (1897, p. 287) mentions the presence of a gland (seen in T.S.) in the dorsal wall of the oesophagus, with a duct opening dorsally (presumably into the lumen of the oesophagus or into the mouth). Such a distinct gland has not been noted in descriptions of other species of the genus, nor in re-examination of fresh material of various species. It is not present in *C. clarkae* or *C. edwardsi*. In the description of *C. dahli* there is no indication of a dorsal tooth associated with the gland.

Cloacina clarkae n.sp.

FIGS. 8–13

Host and locality: *Macropus eugenii*, from Kangaroo I.

This is a large worm from the stomach of the host. The submedian papillae are long and slender, and the distal segment of each is distinctly longer, but not wider, than the proximal one. The cuticle is thickened just behind the cervical groove. The threadlike cervical papillae are relatively close to the anterior end. The buccal ring is deep, its walls relatively thin, and sloping outwards towards the anterior end; the anterior margin is lobed.

The oesophagus is long and slender, except for a distinct terminal bulb. It is clearly divided into four regions—(1) in the anterior half there are 9–11 distinctive equidistant places where the lining appears to be creased; (2) in the rest of the cylindrical part of the oesophagus the cuticle is more or less featureless; (3) just below the terminal bulb, the oesophagus and its lumen are slightly wider, and in this region about 8 well developed teeth project

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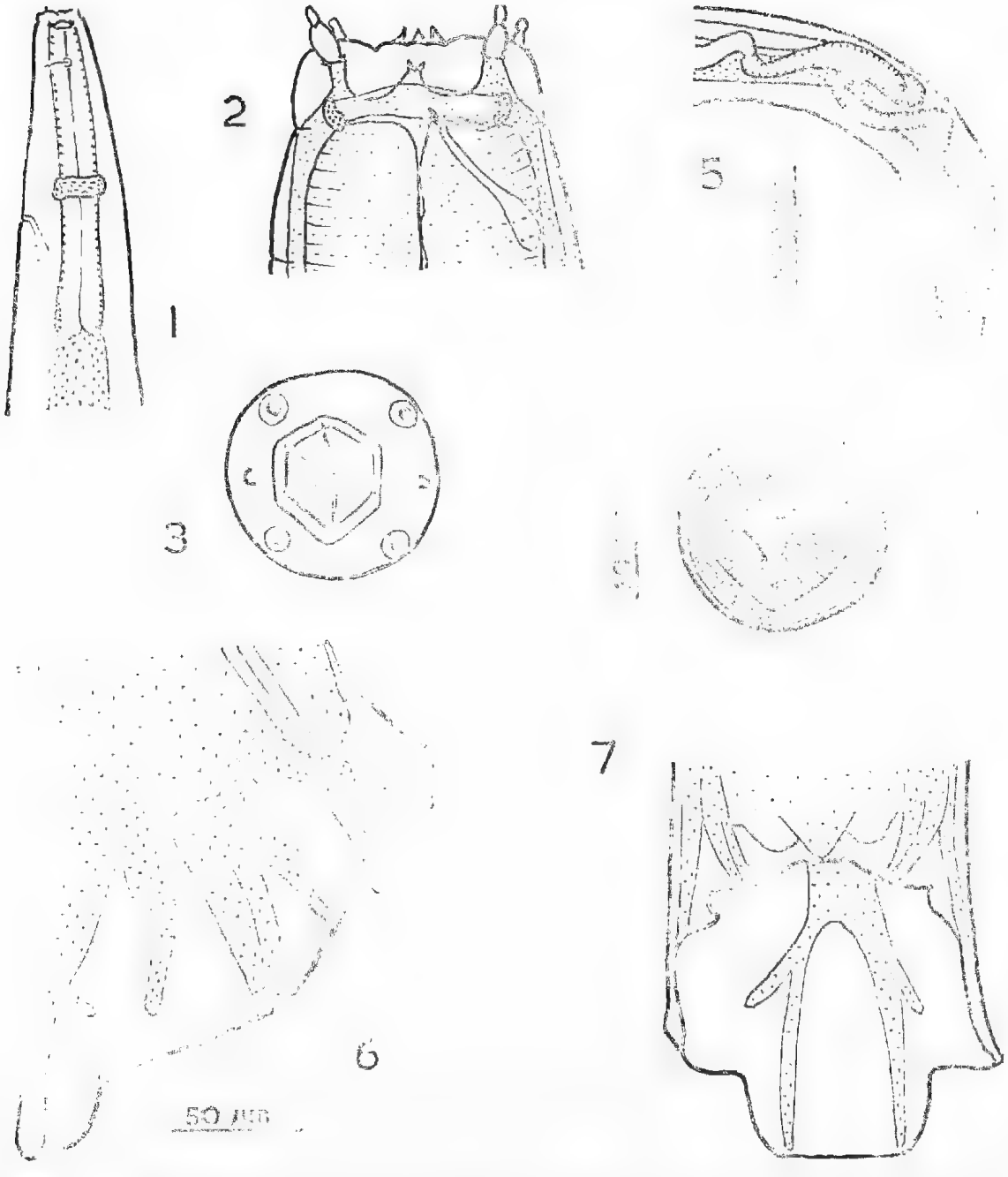
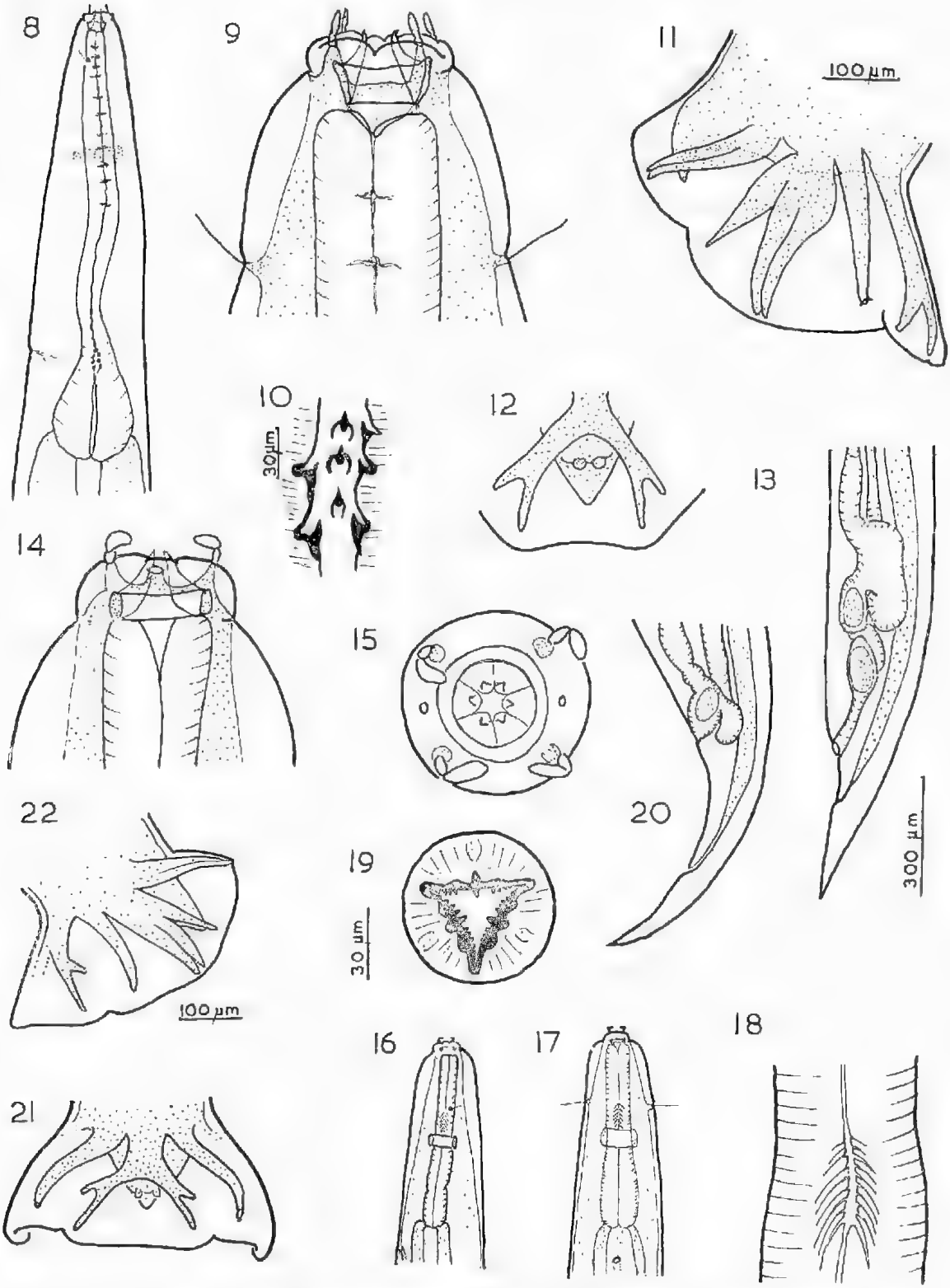


Figs. 1–7. *Cloacina mundayi*. Fig. 1.—Oesophageal region. Fig. 2.—Head, lateral view. Fig. 3.—Head, *en face*. Fig. 4.—T.S. anterior end shortly behind buccal ring. Fig. 5.—Posterior end of female. Figs. 6, 7. Lateral and ventral views of bursa.

Figs. 8–13. *Cloacina clarkae*. Fig. 8.—Lateral view of oesophageal region. Fig. 9.—Head, ventral views. Fig. 10.—Part of oesophagus showing teeth in lumen. Fig. 11.—Lateral view of bursa. Fig. 12.—Dorsal ray and genital cone. Fig. 13.—Posterior end of female.

Figs. 14–22. *Cloacina edwardsi*. Figs. 14, 15.—Lateral and *en face* views of head. Figs. 16, 17. Oesophageal regions of male and female respectively. Fig. 18.—Part of oesophagus showing plumose structures. Fig. 19.—T.S. oesophagus in region of plumose structures. Fig. 20.—Posterior end of female. Figs. 21, 22.—Dorsal and lateral views of bursa.



Figs. 8, 13, 16, 17 and 20 to scale beside Fig. 13.
Figs. 9 and 10 to scale beside Fig. 10.
Figs. 14, 15, 18 and 19 to scale beside Fig. 19.
Figs. 21 and 22 to scale beside Fig. 22.

into the lumen (Figs. 8, 10); (4) the terminal bulb. The nerve ring lies at about a third the length of the oesophagus from the head, and the excretory pore at the level of the anterior end of the oesophageal bulb.

In the female the tail is conical and pointed, and the vulva is about half the tail length in front of the anus. The vagina is rather longer than the distance from the vulva to the tip of the tail, and is somewhat convoluted. The eggs are about 173 x 80 μm, and contain a "tadpole" stage larva.

The bursa is much shorter ventrally than dorsally. The arrangement of the rays is shown in Figs. 11 and 12. The genital cone is well developed and bears dorsally a short pair of appendanges. The spicules are a little more than a quarter of the body length; a gubernaculum is present.

The species is among the medium-large sized *Cloacina* spp., and can be distinguished by the characters of the head and oesophagus. It is perhaps closest to *C. communis* Johnston & Mawson (1939), which however is larger, and in which the oesophageal teeth are arranged differently (Mawson 1961, p. 196).

The specific name is given in recognition of the work of Miss Helen Clark who isolated the worm, and who included a study of the early stages of the life history in work for an Honours Degree in this Department.

Cloacina edwardsi n.sp.

FIGS. 14–22

Host and locality: *Wallabia bicolor*, from Sunday I., Vic.

This apparently new species of the genus *Cloacina* belongs to the group in which the distal segments of the submedian cephalic papillae are much larger than the proximal segments. The cuticle behind the head is thick, becoming less so towards the base of the oesophagus. The long threadlike cervical papillae lie shortly in front of the level of the nerve ring. The buccal ring is short, wide and stoutly built, the walls oval to triangular in section.

The oesophagus is short, more or less cylindrical, with a small terminal swelling in the female, but not in the male. There are no teeth in the lumen, but there are three very distinct "plumose" areas, one on each of the three walls of the lumen (Figs. 18, 19), in the region just anterior to the nerve ring. These areas are formed by confluent ridges on the cuticle lining the lumen. They appear to be similar in form to such structures figured and described for some *Murshidia* spp. from elephants and rhinoceros, but have not previously been described from Australian trichonematines.

The nerve ring surrounds the oesophagus at or just behind its midlength, and the excretory pore is just post-oesophageal.

The posterior end of the female tapers gradually from about the vulva, ending in a slender pointed tail; the vulva is rather more than a tail length in front of the anus. The vagina is very short. The eggs are 83 x 50 μm.

The spicules are unusually short for *Cloacina* spp., about 1/14 of the body length; a gubernaculum is present. The genital cone is well developed, conical, with two small projections forming the accessory cone. The form and arrangement of the bursal rays are shown in Figs. 21 and 22.

This species is distinguished from any previously described by the presence of the plumose structures in the oesophagus, as well as by the unusually short spicules and the very short vagina.

Acknowledgements

I am very much indebted to the people after whom the species are named, who have collected these and other nematodes and sent them to me—Mr. Barry Munday of the Mt. Pleasant Laboratories of the Tasmanian Department of Agriculture, Launceston, Tasmania, Miss Helen Clark of Adelaide, and Mr. Geoff Edwards, a post graduate student (1969) in the Department of Zoology, Monash University, Victoria.

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TABLE 1

Measurements of Cloacina edwardsi, C. mundayi *and* C. clarkae; *unless otherwise indicated, measurements are in μm*

	C. edwardsi		*C. mundayi*		*C. clarkae*	
	male	female	male	female	male	female
Length (mm)	6.3	6.5–7.7	3.1–3.4	4.4–5.0	8.8–9.2	12.3–13.6
Oesoph. length	480	470–520	470–490	470–570	1100–1220	1250–1350
Antr. end—nerve ring	260	250–290	250–260	250–320	300–350	300–350
—cervical pap.	220	170–200	100	80–90	115–160	110 (3x)
—excret. pore	550	480–610	250–340	330–350	890–900	930–1020
Spicule length	430	—	1100–1150	—	2400–2600	—
Tail length	—	290–300	—	210–250	—	260–350
Vulva postr. end	—	680–730	—	410–500	—	430–500
Length/oesoph. L	13	13–15	6.5–7.1	8.6–9.3	7.2–8.5	9.5–10.7
Length/spic. L	14.6	—	2.8–3.0	—	3.4–3.7	—

FURTHER RECORDS OF THE PITTED-SHELLED TURTLE (CARETTOCHELYS INSCULPTA) FROM AUSTRALIA

BY R. SCHODDE, I. MASON AND T. O. WOLFE

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Further records of the Pitted-shelled Turtle, *Carettochelys insculpta,* including the first breeding record, are reported from northern Australia. It is concluded that the species occurs in river systems right around the landward margins of the Sahul Shelf. The stone fruits of *Pandanus,* whenever they are available, appear to comprise an important item of the turtle's diet.

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The Pitted-shelled Turtle[1], *Carettochelys insculpta* Ramsay, sole living species of a family, Carettochelyidae, that apparently occurred widely in palaearctic and nearctic regions up until early Tertiary times, was known only from the river systems of southern New Guinea until 1969 (de Rooij 1915, 1922; Wermuth & Mertens 1961). In that year, the first specimens were recorded for Australia (Cogger 1970). Ten specimens were captured, all in the Daly River, Northern Territory, in freshwater reaches about 13 km above tidal influence. Because the single specimen examined did not appear to differ significantly from New Guinean specimens, and no evidence of breeding was found, Cogger (l.c.) speculated on whether or not the Daly River turtles represented merely a non-breeding outlier of a parent Papuan population. All specimens were relatively small, ranging in carapace length from about 26 to 38 cm. It was also determined from faeces that food ingested by one of them comprised figs and freshwater snails.

A second verified record now comes from the South Alligator River system, approximately 400 km east of the Daly River site. There, in Yellow Waters billabong on Jim Jim Creek, a single female (CSIRO R. No. 320) was caught by a CSIRO fauna survey team on 5 November 1971. The specimen (Fig. 1), deposited in the museum of CSIRO's Division of Wildlife Research, Canberra, is large, having a carapace length of 45.6 cm. This compares with *ca* 48–50.5 cm for the largest New Guinea specimens (Walther 1922; Schultze-Westrum 1963). Other dimensions, taken from life, are: carapace breadth (including marginals) 36.5 cm; total height (carapace + plastron) 14.8 cm; head length (to base of crown) 15 cm; head width 8.1 cm; head + neck length (to gular shields of plastron) 18.5 cm; fore-limb length (posterior margin of flipper) 26.4 cm; hind-limb length (anterior margin of flipper) 25.3 cm; tail (to base of anal shields of plastron) 16.9 cm long, with 12 or 13 dorsal scute bands. Soft part colours: shell, limbs, head and tail, mid to dark olive-brown dorsally, grading to cream ventrally (fleshy cream on plastron); iris mid blue-green-grey. Except for the reduced number of caudal scutes, quoted at 14–16 for New Guinean specimens by de Rooij (1915), the South Alligator specimen appears to be identical with New Guinean forms.

The condition of the reproductive tracts showed the female to be in the process of laying: a large number of enlarged megalecithal ova were present in the ovaries (Fig. 2). Many follicles also appeared to have ruptured recently, and both oviducts were markedly swollen. The large unshed ova were almost the size of shelled eggs according to the dimensions for the latter illustrated by de Rooij (1915, fig. 102). Because Yellow Waters billabong, *ca* 30 km up stream above tidal influence on the South Alligator system, had been landlocked between April and November during the monsoonal dry season, there can be no doubt that eggs had been deposited somewhere along the billabong. This represents the first evidence that the species breeds in Australia.

While kept alive for a time in water, the turtle defaecated large quantities of partly digested husks of the stone fruits of *Pandanus*, as well as a few shoot leaves (*Melaleuca* and

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[1] Known locally in the Northern Territory by the appropriate vernacular of "pig-nosed turtle" (J. Cann, pers. comm.).

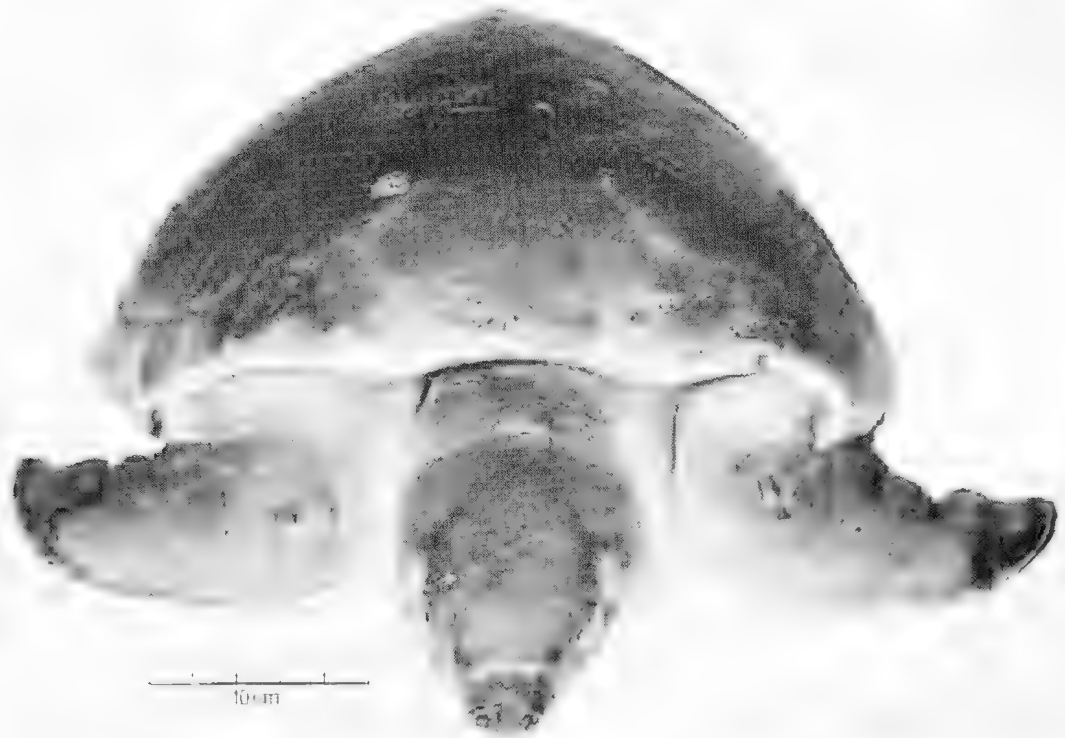

Fig. 1. The Pitted-shelled Turtle, *Carettochelys insculpta* (CSIRO specimen R. No. 320)

Fig. 2 Reproductive tract of ovulating *Carettochelys insculpta* (CSIRO specimen R. No. 320).

Leguminosae spp.), seeds, roots, pieces of aerenchymatous plant stem, and traces of animal matter. The animal matter, comprising *ca* 1% of the defaecated material, included freshwater snails (Thiaridae sp.), water-boatmen (Corixidae sp.), the water beetles *Homeodytes scutellaris* Germ. (Dytiscidae) and *Hydrophilus latipalpus* Cast. (Hydrophilidae), and ants (*Iridomyrmex* sp.). Upon dissection, the colon and lower intestine of the turtle were found to be packed with *Pandanus* fruit husks. Perianth segments remained attached to many of the husks, indicating that the turtle had presumably broken and eaten hard, green, fruiting cones with its jaws—no mean feat. T. G. Schultze-Westrum (pers. comm.) has also observed the species feeding on pandan fruit in New Guinea. Thus, although turtles have proved to be somewhat omnivorous (Schultze-Westrum 1963; Cogger 1970; J. Cann, pers. comm.), the fruits of *Pandanus*, whenever falling from trees of the various species of the genus that commonly line and overhang the estuarine and lower freshwater reaches of rivers in both southern New Guinea and northern Australia, would appear to constitute a rather significant item of their diet.

There have been numerous other records of "freshwater turtles" in northern Australian rivers in recent years (cf. Cogger 1970) and, though in one case unsupported by specimens, at least two appear to be of authentic *Carettochelys insculpta*. One is of specimens examined by J. Cann (pers. comm.) from the upper reaches of the Daly River about 140 km above tidal influence in the Northern Territory. A carapace of one of the specimens has been placed in the Australian Museum, Sydney (Reg. No. R.31717). The other, published incidentally by St. John (1967, p. 527) and Parker (1971), is of observations made by the late A. de Lestang who observed "herds of turtles" devouring the fallen fruits of *Pandanus* (*P. delestangii* St. John) in perennial rivers southwest of Burketown in north-western Queensland and/or eastern Northern Territory. As all other freshwater chelonians in the region are carnivorous, it seems probable that de Lestang's observations refer to *Carettochelys*.

These records suggest that the Pitted-shelled Turtle occurs in the lower (to upper) reaches of major river systems across northern Australia, at least from the Victoria River District of the Northern Territory to as far east as the Gulf country of Queensland and perhaps western Cape York Peninsula. From local information, J. Cann (pers. comm.) believes the turtle to be rather common in most coastal rivers flowing into the Joseph Bonaparte and Van Diemen Gulfs. In overall distribution, then, the species apparently occurs in river systems along the landward margins of the Sahul Shelf. Little is yet known of its occurrence or movements in the intervening Arafura Sea.

Acknowledgements

We are indebted to Messrs. W. Vestjens and J. H. Calaby, CSIRO Division of Wildlife Research, for assistance with measurements and examination of the CSIRO specimen and in the preparation of the text of this paper; and to Dr. T. G. Schultze-Westrum, and Mr. J. Cann of Yarra Road, Phillip Bay, Sydney for additional observations on *Carettochelys insculpta*. Mr. E. Slater, CSIRO Division of Wildlife Research, took the photographs.

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THE MORPHOLOGY AND RELATIONSHIPS OF MUELLERENA WATTSII (HARVEY) SCHMITZ (CERAMIACEAE: RHODOPHYTA)

BY ELISE M. WOLLASTON

Summary

The morphology and life history of *Muellerenu wattsii* (Harvey) Schmitz is described and its relationships discussed. It is recognized as belonging to the tribe Crouanieae (Ceramiales, Rhodophyta) on the basis of thallus morphology and stages in development of the procarp and carposporophyte. Features including regularity of branching pattern and elaboration in development of the involucre surrounding the carposporophyte suggest a probably phylogenetically advanced condition.

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Introduction

Muellerena wattsii (Harvey) Schmitz in Schmitz & Hauptfleisch was described as *Crouania wattsii* by Harvey (1863), who considered it closely allied to *C. agardhiana* [now *Ptilocladia agardhiana* (Harvey) Wollaston 1968]. Schmitz (1889) listed the species as belonging to a new genus *Muellerella* which, however, he formally described (in Schmitz & Hauptfleisch 1897) as *Muellerena* with *M. wattsii* as the type species.

Muellerena is a monotypic genus seemingly quite distinct from other closely related genera. Schmitz (1889) placed it in the Dasyphileae but Kylin (1956) suggested that it was probably more closely related to *Crouania* and considered it to be insufficiently known for correct placement. Hommersand (1963), after examining specimens of *M. wattsii* in TCD, concluded that it was probably correctly placed in Dasyphileae. However, detailed study of both vegetative and reproductive features show that it is best placed in the Crouanieae.

Material used for investigation has been mainly drift plants collected at Stinky Bay, Nora Creina, S. Aust. (*Wollaston*, 14.xi.1955; ADU, A20004; *Wollaston*, 19.v.1964; ADU, A27924) and at Seal Bay, Kangaroo I., S. Aust. (*Womersley*, 21.i.1965; ADU, A28819). These collections included both tetrasporangial and carposporangial plants.

Muellerena wattsii (Harvey) Schmitz in Schmitz & Hauptfleisch 1897: 496. De Toni 1903: 1388; 1924: 490. Lucas 1909: 50. Lucas & Perrin 1947: 344. Mazza 1911: No. 397.

Crouania wattsii Harvey 1863: synop. No. 637, pl. 291. J. Agardh 1876: 86. Tisdall 1898: 503.

Muellerella wattsii Schmitz 1889: 451 (nomen nudum). Kylin 1956: 397.

Thallus to 13 cm high with terete, sparingly-branched axes bearing alternate, distichous lateral branches up to several cm long and usually pinnately branched in the outer part (Fig. 1); laterals borne from alternate axial cells, occasionally with a shorter branch (less than 1 cm long) opposite or between the longer laterals (Fig. 2). These shorter branches are initiated on the basal cell of an original whorl-branchlet and develop in its place. Axial cells are 1–1½ times as long as broad with cells of the central mature thallus usually 350–400 μm long. Each axial cell bears from its upper part a whorl of 5 whorl-branchlets (Figs. 3ii, 4), with the exception that those cells which bear lateral branches often produce only 3 whorl-branchlets and 1 lateral branch (Fig. 3i, iii).

Growth takes place by transverse divisions of an apical cell and whorl-branchlets are initiated usually on the sub-apical cell (Fig. 5) with the first-formed initial of each whorl in a lateral position, the second and third to the right and left of it respectively and those last-formed opposite the first one (Fig. 3ii). During early development, lateral branches are characteristically curved due to their having the first-formed and hence the longest whorl-branchlets borne on the abaxial (outer) side, while the shortest most immature ones are adaxial in position (Fig. 5). However, after initial elongation of 1–several mm, each young lateral produces at its tip further alternate, distichous

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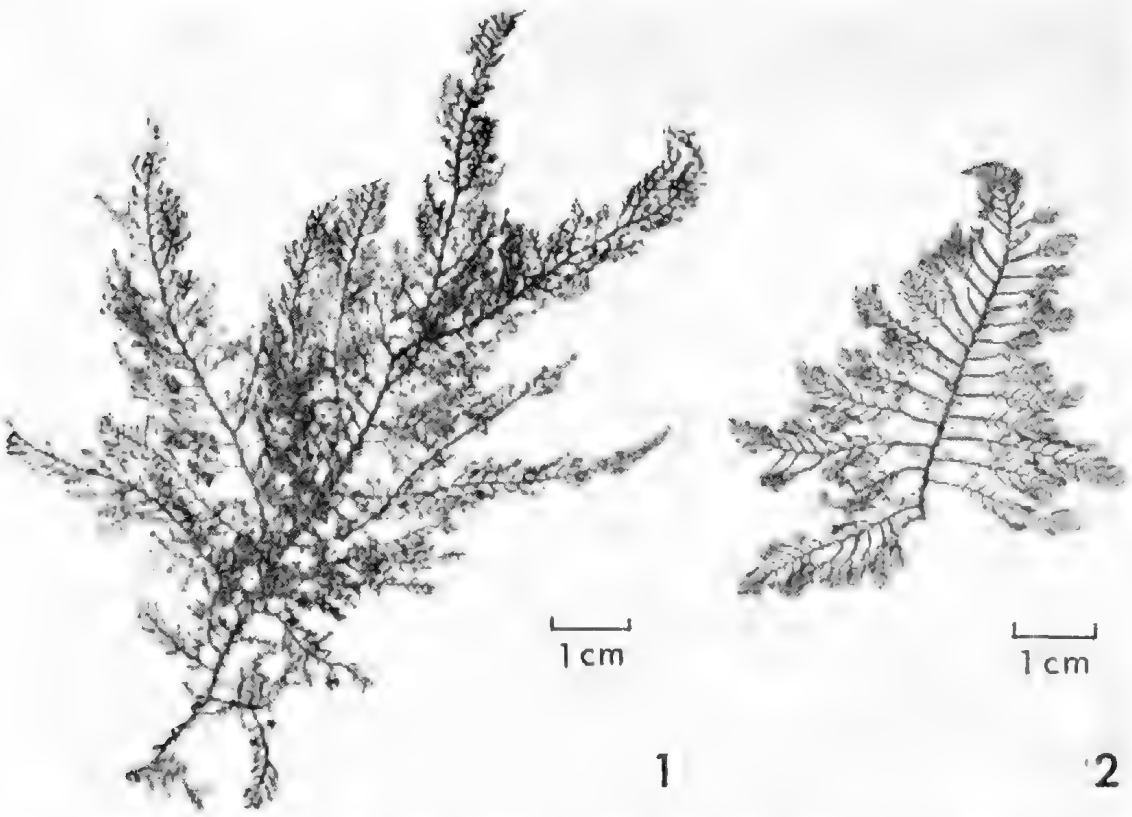

Fig. 1. Plant habit (Stinky Bay, Nora Creina, S. Aust., drift, *Wollaston*, 19.v.1964, ADU A27924).
Fig. 2. Type specimen, TCD (Warrnambool, Vic., cast ashore, *Watts*, Sept. 1860, Harvey 221). Regular, distichous arrangement of short lateral branches and occasional shorter branches opposite or between the longer ones.

lateral branches on alternate axial cells. On each of these axial cells the lateral branch is initiated first followed by whorl-branchlets to the right and left of it and the last formed one opposite the lateral branch (Fig. 3i, ii, iv). Most lateral branches cease growth early but a few continue to elongate and form indeterminate thallus branches (Fig. 2). Young cells enlarge rapidly and gland cells and tetrasporangia may occur very close to branch tips.

Mature whorl-branchlets consist of several consecutive di- or tri-chotomous whorls of cells, and terminate in short, 2- or 3-celled chains of small cells, each up to 7 μm diam., often terminated by a slender, elongate hair to 180 μm long (Fig. 4). Cells of whorl-branchlets are 1–2 times as long as broad and up to 60 μm long in the central part of mature whorl-branchlets. Whorl-branchlets are commonly lost from older axes and particularly from the upper and lower axial face between the distichously-arranged branches.

Axes are corticated, except when very young, by descending, branched filamentous rhizoids of elongate cells which arise from the basal cells of whorl-branchlets (Fig. 6) and intertwine to form a dense axial covering with short, horizontal branches, composed of a chain of several small cells, projecting outwardly. In older parts of the thallus the axial cells become very thin-walled and may be almost indistinguishable within the cortical cylinder.

Ovoid to pyriform gland cells up to 16 μm long, each within a thick gelatinous sheath, occur as homogeneous, refringent structures borne in place of outer branches of whorl-branchlets and scattered, sometimes abundantly, over the thallus (Fig. 7). Cells of the thallus appear to be uninucleate although properly fixed material has not been available for study with specific nuclear stains. Rhodoplasts vary from small and rounded in young cells to reticulate and finally to elongate in mature cells (Fig. 8i–iii).

Procarp and Carposporophyte—Carpogonial branches, 4-celled when mature, are initiated singly on a supporting cell which is one of a whorl of 4 cells borne from the upper part of the terminal cell of a short 2 (-3)-celled special fertile branch (Fig. 9). The fertile branch is produced at the outer end of the basal (or second) cell of a whorl-branchlet and replaces one branch of the normal di- or trichotomy. The sub-apical cell of the fertile branch also bears a whorl of (4-)5 cells (Fig. 9). Each fertile branch is initiated near the tip of a branch axis, so that a succession of maturing procarps and carposporophytes is produced as the branch axis elongates. Cells of the carpogonial branch are formed by transverse divisions of an initial cell which is cut off outwardly from the supporting cell (Figs. 10–13). The lower three cells stain densely and appear homogeneous in structure while the carpogonium is smaller, often with a densely-staining protoplast concentrated in one portion of the cell, and bears an elongate trichogyne, to 90 μm long, usually swollen at its base and its tip (Figs. 12–14). A sterile cell is formed on the upper side of the supporting cell after initiation of the carpogonial branch and is usually well-developed by the time the carpogonial branch is mature (Figs. 11–13).

Following fertilization, the carpogonium enlarges and becomes rounded in form while the trichogyne degenerates and an auxiliary cell develops from the upper part of the supporting cell (Fig. 15). At this stage the three sterile cells, making up the whorl which includes the supporting cell of the carpogonial branch, commence to enlarge and each becomes roughly triangular in shape; the sterile cell borne on the supporting cell divides to form a chain of several cells (Fig. 15) while the cells forming the whorl on the sub-apical axial cell elongate and produce terminally the first cells of branched involucral filaments (Fig. 16). Fusion takes place by means of a connecting cell between the carpogonium and the upper part of the auxiliary cell, leaving only one or two small cell fragments in place of the carpogonium on the degenerating carpogonial branch (Fig. 17).

Branched involucral filaments formed from the enlarged sterile cells on the apical and sub-apical axial cells of the fertile branch develop rapidly, and loosely surround the developing carposporophyte (Fig. 17). The basal cells of the upper whorl of filaments remain characteristically triangular and larger than other cells of these branches (Fig. 17). The auxiliary cell cuts off a gonimoblast cell from its upper side and simultaneously forms a pit-connection with the apical cell of the fertile branch axis (Fig. 18). Through this connection nutriment is possibly conveyed more directly to the carposporophyte, while the old supporting cell acts as the basal cell of an involucral filament. Gonimolobe initials, which each give rise to a rounded group of carposporangia, develop successively with the first one or two gonimolobes produced in a lateral position. Further gonimolobes are produced without regular order so that a total of 6 or more groups of carposporangia at various stages of development may be present at the one time (Fig. 19). As the first carposporangia mature, the newly formed pit-connection between the axial cell and auxiliary cell gradually widens and the connection between the lower part of the auxiliary cell and the supporting cell remains small and probably non-functional or is finally broken (Fig. 19). The involucral filaments, each branched several times, curve upward and loosely surround the mature carposporophyte.

Spermatangia—not recorded.

Tetrasporangia—Spherical, tetrahedrally-divided tetrasporangia, seldom greater than 25 μm diam., are borne on the outer cells of whorl-branchlets in place of vegetative branches (Fig. 20), in a similar position to gland cells. They may occur on any part of the thallus but are usually most abundant on young branches.

Type Locality—Warrnambool, Vic. (*Wans*, Sept. 1860).

Holotype—TCD, Harvey Alg. Aust. Exs. No. 221.

Distribution—From West I. and Kangaroo I., S. Aust., to Warrnambool, Vic.

Discussion

Muellerena walsii is characterized by the following vegetative and reproductive features:

(a) a consistent branching pattern and short lateral branches developed regularly from the outer end of axes,

(b) whorl-branchlets in whorls of 5 on each axial cell, except on those which bear short lateral branches,

(c) fusion between the lower part of the auxiliary cell and the fertile axial cell during carposporophyte development,

(d) a distinct filamentous involucre surrounding the carposporophyte and involving the

original supporting cell of the carpogonial branch.

Vegetative features such as the alternate-distichous arrangement of short lateral branches at the tip of each previously-formed lateral, the form of axial cortication, and the consistency in arrangement and number of whorl-branchlets on each axial cell, suggest a relationship with the *Ptilocladia* group of the Crouanieae. These features were regarded by Wollaston (1968, p. 404) as indicative of a phylogenetically advanced thallus form. Hommersand (1963) stated that *Muellerena wattsii* was quadriverticillate and he considered the order of initiation of whorl-branchlets in a rhodomelaceae sequence (the first abaxial, the next two to the right and left of the first and the fourth one adaxial) to be a significant taxonomic feature characteristic of the Dasyphileae. However, *M. wattsii* has in fact 5 whorl-branchlets per whorl except where short lateral branches are produced, and in these whorls the order of development of the 4 initials could have arisen from a crouanioid sequence in which the second branchlet is formed opposite the first and the third and fourth at right angles to them. Suppression of the adaxial branchlet when adjacent to another axis is commonly found in a number of taxa, for example, in species of *Platythamnion* J. Agardh and *Amoenothamnion* Wollaston (Wollaston 1968). In *Muellerena wattsii* this could explain development of the intermediate whorl-branchlets of each whorl prior to initiation of the adaxial whorl-branchlet(s), which at times is completely lacking at the base of lateral branches. *M. wattsii* clearly evolved a stable pattern of branching and on this basis is probably vegetatively advanced.

Several other vegetative features of *M. wattsii* also suggest relationship with the Crouanieae group. Gland cells, not previously recorded for *M. wattsii*, are similar in form to those found in *Ptilocladia australis* (Harv.) Wollaston, *P. vestita* (Harv.) Wollaston, and *Gulsonia annulata* Harvey, although they lack

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Fig. 3. i-iv. Arrangement and sequence of initiation of short lateral branches (L_1) and whorl-branchlets in whorls on successive axial cells near the tips of axes. (Diagrammatic.) i, ii, iii represent in transverse section the 3 cells shown in iv.

Fig. 4. Transverse section of axial cell bearing a whorl of 5 whorl-branchlets with tetrasporangia.

Fig. 5. Tip of branch axis showing alternate, distichous arrangement of young lateral branches (L_1–L_4) on alternate axial cells and abaxial initiation of first-formed whorl-branchlets on cells of lateral branch axes. (Whorl-branchlets on faces of axes omitted for clarity.)

Fig. 6. Branched, descending cortical rhizoids borne on basal cell (b) of a whorl-branchlet.

Fig. 7. Gland-cells borne in place of branches of whorl-branchlet.

Fig. 8. Rhodoplast structure (i) young cell with rounded rhodoplasts, (ii) enlarging cell with reticulate rhodoplasts, (iii) mature cell with elongate rhodoplasts. (Diagrammatic.)

Fig. 9. Carpogonial branch on special 2-celled fertile branch borne in place of a whorl-branchlet branch on basal (or second) cell of whorl branchlet.

Fig. 10. Carpogonial branch initial cut off outwardly from supporting cell.

Fig. 11. Young carpogonial branch, 3-celled stage, on supporting cell which also bears a small sterile cell (s).

Fig. 12. Carpogonial branch, 4-celled, with developing trochogyne.

Fig. 13. Carpogonial branch with fully elongated trichogyne.

Fig. 14. Fusion of spermatium (sp) with mature trichogyne.

Fig. 15. Auxiliary cell (a) formed from upper side of supporting cell; carpogonial branch with enlarging carpogonium (c) and terminal remnant of trichogyne; sterile cell (s) bearing first cells of involucral filament.

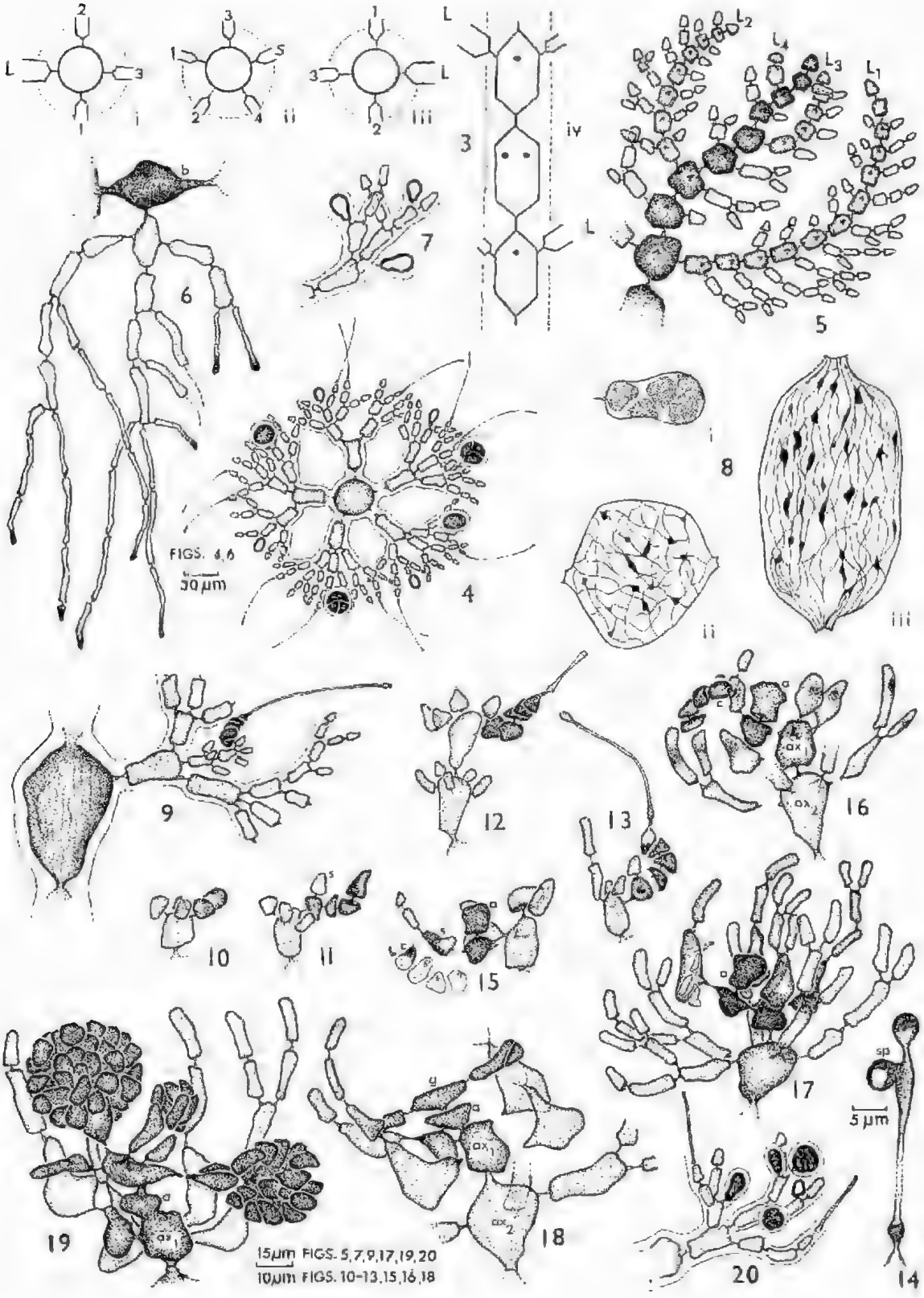
Fig. 16. Carpogonium (c) enlarged just prior to fusion with auxiliary cell (a); involucral filaments commencing to form from cells, including the supporting cell, of whorls on axial cells (ax_1, ax_2) of the fertile branch.

Fig. 17. Protrusion on auxiliary cell (a) marking position of fusion with connecting cell from carpogonium; small cell fragment remaining in place of carpogonium on degenerating carpogonial branch; marked increase in development of involucral filaments.

Fig. 18. Formation of pit-connection between lower part of auxiliary cell (a) and axial cell (ax_1) prior to breaking of connection between auxiliary cell and supporting cell; initials of 2 lateral groups of carposporangia formed on gonimoblast cell (g).

Fig. 19. Enlarged fusion between lower part of auxiliary cell (a) and axial cell (ax_1); succession of carposporangial groups forming on gonimoblast cell; supporting cell, free from carposporophyte, bearing involucral filament.

Fig. 20. Tetrasporangia and gland-cell borne in place of vegetative branches of whorl-branchlet.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FIGS. 4,6
50 µm
5 µm
15µm FIGS. 5,7,9,17,19,20
10µm FIGS. 10-13,15,16,18

the crystal-like inclusions recorded for these species. Branched cortical filaments bearing short outwardly-orientated chains of cells are similar to those found in *Ptilocladia pulchra* Sonder and a tendency towards distichous branching of the thallus, well defined in *Muellerena wattsii*, is also characteristic of the Crouanieae group and is best developed in species considered to be phylogenetically advanced.

Development of the procarp and carposporophyte also basically resembles that found in genera of Crouanieae. The 4-celled carpogonial branch is borne on a special fertile branch as in *Gulsonia*. The connecting cell involved in fusion between the carpogonium and auxiliary cell is much larger in *Muellerena wattsii* than in genera of Crouanieae, but subsequent development of the carposporophyte with lateral initiation of the two first-formed groups of carposporangia is similar to that seen in species of *Ptilocladia*, *Gulsonia* and *Euptilocladia* Wollaston. *Muellerena wattsii* differs, however, in elaboration of the involucre which surrounds the carposporophyte and in the secondary development of a pit-connection linking the lower part of the auxiliary cell to the axial cell upon which the procarp was developed. Following this fusion, the original connection between the supporting cell and the lower part of the auxiliary cell is usually broken so that the supporting cell functions as an enlarged basal cell of an involucral filament similar to its sister-cells of the whorl. The involucral filament borne on the supporting cell is initiated as a sterile cell on the supporting cell during enlargement of the carpogonial branch and elongates at about the same time as the other involucral branches commence to develop. These events probably allow a better nutritional supply to the carposporophyte while at the same time providing for development of the filamentous involucre. Although *Muellerena wattsii* differs from species of *Ptilocladia* in having a more consistent branching pattern, 5 whorl-branchlets per whorl, fusion between the auxiliary cell and fertile axial cell and a more elaborate involucre surrounding the carposporophyte, the two genera are basically similar in both vegetative and reproductive features. This similarity was noted by De Toni (1903) when he placed two species now recognised as *Ptilocladia pulchra* Sonder and *P. agardhiana* (Harvey) Woll. in the genus *Muellerena*. *M. wattsii* is also similar to *Gulsonia* in the presence of gland cells and the development of a special fertile branch bearing the procarp and, later, the carposporophyte. Thus it seems likely that *Ptilocladia*, *Gulsonia* and *Muellerena* are closely related and *Muellerena*, showing greater consistency in vegetative features and elaboration in carposporophyte organization, is phylogenetically the most highly advanced. The range of features already known for genera of the Crouanieae covers a possible evolutionary sequence leading to the increased organization and stability of thallus features characteristic of *Muellerena*. No similar relationship can be traced in the Dasyphileae or other group of the Ceramiaceae and it thus seems logical to include *Muellerena* in the tribe Crouanieae of the Ceramiaceae.

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The larger species are represented mainly by juveniles and it is suggested that the small mammal remains were accumulated by owls.

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Introduction

Victoria Cave, in Tertiary limestone near Naracoorte (lat. 37°0′S, long. 149°48′E) has been open to tourists for many years. In 1969, the Cave Exploration Group of South Australia (CEGSA) discovered further extensive ramifications of the cave and, in one chamber, a silt deposit containing abundant skeletal remains of large animals. Many of these were later identified as remains of extinct marsupial herbivores (sthenurines and diprotodontids) and of the marsupial lion, *Thylacoleo* sp. (Wells, pers. comm.). The sthenurines and diprotodontids are believed to have become extinct at the end of the Pleistocene (Tedford 1967), and the deposit in Victoria Cave is therefore probably of Pleistocene age.

Bone chips occur in cores taken as deep as 2.5 m but the maximum depth of excavation at present is 80 cm.

The potoroines (Macropodidae), petaurids and burramyids have been described previously (Smith 1971); the present paper describes the peramelids, a thylacinid and the dasyurids.

Methods

The methods of sieving the bony remains from the silt, and their subsequent cleaning and preservation have been described (Smith 1971). Measurements of teeth have been made in the way described in that paper, with the exception that, in the peramelids only, the maximum anteroposterior lengths of mandibular molar teeth were measured on the lingual side. (The slope of the anterior cingulum from lingual side to buccal side hindered accurate measuring on the buccal side.) Additional mandible measurements were taken as follows:

Length of ascending ramus: Distance between anterior and posterior borders of the ascending ramus, from the midpoint of the posterior border and perpendicular to the ramus midline.

Breadth at $M_{\frac{4}{}}$: Thickness of mandible below $M_{\frac{4}{}}$.

Height at $M_{\frac{4}{}}$: Distance from alveolar margin at middle of $M_{\frac{4}{}}$ to inferior border of mandible, and perpendicular to the inferior border.

The taxonomy used is that of Ride (1970) unless stated otherwise.

Family PERAMELIDAE

Isoodon obesulus (Shaw, 1797)

The following features were used to distinguish fragmentary remains of *Isoodon* from *Perameles*.

(i) The hypocone of each maxillary molar (except $M^{\frac{4}{}}$) is well developed in *Isoodon* so that in horizontal section these teeth appear as rounded

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blocks. In *Perameles* the hypocones are much smaller and M^1_{γ}, M^2_{γ}, and M^3_{γ} appear as truncated triangles, tapering lingually. The molar alveoli reflect the shape of the teeth, the lingual root relative to the buccal length of the tooth being much longer in *Isoodon* than in *Perameles*.

(ii) In the mandible of *Isoodon*, the anterior edge of the ascending ramus makes an obtuse angle with the horizontal ramus, whereas in *Perameles* the horizontal and ascending portions of the ramus join in a continuous smooth curve (Merrilees 1965) (Figs. 1, 2, 3).

(iii) In *Isoodon* the lingual extremity of the anterior cingulum is almost as high as the apex of the paraconid of M_2, M_3, and M_4, whereas in *Perameles* the greatest height of the anterior cingulum is much less than that of the paraconid.

Isoodon was not abundant in the deposit and adults and juveniles were about equally represented (Table 1).

Modern specimens of *I. obesulus* in the South Australian Museum vary greatly in size, and wide variations occur even in adult specimens of the same sex and locality. The length of M^1_{γ}–$^3_{\gamma}$ varied from 9.2 to 11.4 mm (mean 10.19, s.d. 0.72) in eight South Australian mainland specimens and the length of M^1_4–$_4$ from 12.7 to 15.8 mm (mean 14.49, s.d. 1.08). Victoria Cave specimens are smaller than modern mainland specimens (Table 2) and are almost as small as the insular subspecies, *I. o. nauticus* where, in nine specimens, the length of M^1_{γ}–$^3_{\gamma}$ ranged from 8.4 to 9.5 mm (mean 8.68, s.d. 0.35) and the length of M^1_4–$_4$ from 11.8 to 12.5 mm (mean 12.20, s.d. 0.28). The teeth of Victoria Cave *Isoodon* are morphologically similar to those of modern *I. obesulus*.

Wakefield (1966b and *in* Mulvaney et al. 1964) referred to a distinct, small form of *I. obesulus* from Mildura and from the Fromm's Landing archaeological excavation on the River Murray, but he gave no measurements of this form, nor of the "much larger form abundant in S. Victoria". Pleistocene specimens of *I. obesulus* from Mammoth Cave, Western Aus-

TABLE 1

Mandibular and maxillary fragments of peramelid species found in the Victoria Cave, Naracoorte. Many isolated teeth were collected but have not been included in the table.

Species	Maxillae				Mandibles				Minimum no. of individuals
	Adult		Juvenile*		Adult		Juvenile*		
	Right	Left	Right	Left	Right	Left	Right	Left	
Isoodon obesulus	4	4	—	—	8	10	7	4	17
Perameles gunnii	9	7	1	—	16	23	54	46	77
P. bougainville	11	7	5	8	30	38	32	27	70
Not determinable	2	2	3	3	5	6	9	5	15

* A specimen was considered to be juvenile if P4 and/or M4 were not fully erupted.

TABLE 2

Some dimensions of mandibles and teeth of Isoodon obesulus *from Victoria Cave.*

Dimension	Number of Specimens	Range (mm)	Mean (mm)	Standard error	Coefficient of variation
Length of ascending ramus	7	6.3—7.3	6.79	0.146	5.7
Breadth at M_2	6	2.4—2.8	2.58	0.075	7.1
Height at M_2	6	3.6—4.5	4.10	0.152	9.1
M^1_{γ}–$^3_{\gamma}$ length	3	9.0—9.2	9.10	0.057	1.1
P_4 length	5	2.3—2.6	2.44	0.060	5.5
P_4 breadth	5	1.2—1.5	1.38	0.049	7.9
M^1_4–$_4$ length	6	11.7—12.8	12.27	0.158	3.2

tralia, are similar in size to modern specimens from the same area (Merrilees 1965).

I. obesulus still occurs in the Naracoorte district.

Genus PERAMELES

Perameles was represented by many toothless mandibles and a few tooth-bearing maxillae and mandibles. Adult mandibles, in which P_4 and M_4 were erupted, could clearly be separated on size into two species, distinguished by depth and thickness of the mandible, length of ascending ramus, and length of teeth (compare Figs 2 and 3; and Tables 4 and 5). Juvenile mandibles of the two species overlapped in size but could be separated by the length, and especially by the width, of their molar alveoli. Maxillae, both adult and juvenile, were identified by the size of the molar alveoli.

Perameles gunnii Gray, 1838

Live specimens of the two large long-nosed bandicoots, *P. gunnii* and *P. nasuta* Geoffroy, 1804, appear quite dissimilar, the rump of *gunnii* being barred and that of *nasuta* being uniformly coloured (Ride 1970). However the skulls of the two species are similar in morphology, size and proportions. I^3 provides the main difference, I^3 of *gunnii* being double rooted, antero-posteriorly long and bucco-lingually compressed, whereas I^3 of *nasuta* is single rooted and caniniform (Freedman 1967). This diagnostic feature could not be used on Victoria Cave material as no premaxillae were preserved. Additional differences are that the mandible is more slender in *P. gunnii*, M_4 is shorter buccally and M_4 is shorter antero-posteriorly (Table 3). The figures given in Table 3 do not confirm Tate's (1948) statement that P_4 is much broader in *P. gunnii*.

Remains of the large *Perameles* from Victoria Cave conform in size with modern *P. gunnii* (Table 4) and no morphological differences were detected between fossil and modern specimens. Remains of juvenile *P. gunnii* were relatively abundant, but few adult specimens were found (Table 1).

P. gunnii is not included in a list of the modern native mammals of South Australia (Aitken 1970) although three specimens of *P. gunnii* in the South Australian Museum are registered as from South Australia (M1607 from Mt. Gambier, M1613 from "South Australia" and M3956 from the Rocks, Kougal, south-east of South Australia). All were collected between 1891 and 1893. The present range of *P. gunnii* is southern Victoria and Tasmania (Ride 1970).

Remains of *P. gunnii* were found in an aboriginal midden at Mt. Burr, South Australia (Finlayson 1966, unpublished[1]) and in a late Recent deposit in the Bat Cave at Naracoorte (Tidemann 1967).

TABLE 3

Some dimensions of mandibles and teeth in which Perameles nasuta *differs from* P. gunnii. *These figures were calculated from data given in Tables 2, 3A and 3B of Freedman & Joffe 1967a and Tables 1, 2A and 2B of Freedman & Joffe 1967b.*

Dimension examined	*Perameles nasuta*			*Perameles gunnii*		
	N	Mean (mm)	95% confidence limits of mean	N	Mean (mm)	95% confidence limits of mean
Length of ascending ramus	69	8.79	8.52—9.06	40	6.34	6.23—6.46
Breadth at M_2	71	3.54	3.43—3.65	41	2.82	2.76—2.90
Height at M_2	71	6.70	6.49—6.91	41	5.88	5.70—6.06
P_3 length	65	3.75	3.65—3.84	40	3.34	3.26—3.43
P_3 width	81	2.10	2.06—2.15	40	2.13	2.09—2.17
M_4 width	81	2.71	2.66—2.75	42	2.75	2.68—2.82
M_4 Buccal length	81	3.63	3.56—3.70	43	3.09	3.03—3.15
M_4 Lingual length	82	1.53	1.50—1.56	43	1.44	1.40—1.48
M_4 Anterior width	91	2.37	2.34—2.39	46	2.16	2.13—2.18
M_4 Posterior width	86	1.60	1.58—1.63	46	1.51	1.48—1.55
M_4 length	85	4.64	4.58—4.70	45	4.01	3.96—4.06

[1]Finlayson, H. H. *in* Campbell, T. D., Edwards, R. & Hossfeld, P. S. (1966).—Archaeological excavations in the Southeast of South Australia. 24 pp. Transcript. Australian Institute of Aboriginal Studies Library, Canberra.

Perameles bougainville Quoy & Gaimard, 1824

The small bandicoots from eastern, central and Western Australia have been described as several different species, but Tate (1948) suggested that *P. bougainville, fasciata, notina* and *eremiana* might be local races of a single widespread species. Generally this has been accepted (e.g. Wakefield 1966a) although Ride (1970) retained *eremiana* as a distinct species. Mean measurements of skulls and teeth are mostly larger in the south central population, *notina*, than in the western population, *bougainville* (sens. strict.), but few of the differences are significant (Freedman & Joffe 1967b).

Remains of the small species of *Perameles* from Victoria Cave are similar in size and morphology to modern specimens of *P. bougainville* in the South Australian Museum and to specimens from the Fromm's Landing archaeological excavation (Table 5).

TABLE 4

Comparisons of some dimensions of teeth and mandibles of Perameles gunnii *from Victoria Cave, with those of a modern sample from Tasmania. C.V. — Coefficient of variation.*

Dimension	Modern *P. gunnii* from Tasmania					*P. gunnii* from Victoria Cave				
	n	Range (mm)	Mean	Standard error	C.V.	n	Range (mm)	Mean	Standard error	C.V.
M⅓ width	10	3.6—4.1	3.91	.057	4.6	3	3.6—3.7	3.63	.033	1.6
M⅓ buccal length	10	2.8—3.2	3.03	.032	3.3	3	2.9—3.0	2.97	.033	1.9
M⅓ lingual length	10	1.3—1.6	1.47	.037	7.9	3	1.0—1.3	1.20	.100	14.4
M⅓–⅗ alveolar length	10	11.4—12.4	11.86	.105	2.8	4	11.4—12.4	11.80	.245	4.2
Length of ascending ramus	10	6.1—7.4	6.70	.127	6.0	10	5.2—6.2	5.75	.100	5.5
Breadth at M⅔	10	2.6—3.2	2.99	.060	6.4	9	2.3—2.8	2.54	.055	6.6
Height at M⅔	10	5.8—7.6	6.66	.153	7.3	8	4.5—6.4	5.57	.190	9.7
M⅔ alveolar length	10	3.6—4.1	3.90	.056	4.5	9	3.4—4.0	3.73	.078	7.0
M⅓–⅔ alveolar length	10	14.6—16.6	15.57	.172	3.5	5	15.0—15.5	15.18	.086	1.3

TABLE 5

Comparisons of some dimensions of teeth and mandibles of Perameles bougainville *from Victoria Cave with those from Fromm's Landing (specimens collected in levels 0-9).*

Dimension	*P. bougainville* from Fromm's Landing					*P. bougainville* from Victoria Cave				
	n	Range (mm)	Mean	Standard error	C.V.	n	Range (mm)	Mean	Standard error	C.V.
M⅓–⅗ length	—	—	—	—	—	4	9.1—10.4	9.60	.334	7.0
Length of ascending ramus	8	3.8—5.5	4.65	.201	12.2	16	4.4—5.6	4.99	.082	6.5
Breadth at M⅔	18	2.0—2.7	2.24	.044	8.4	25	1.8—2.5	2.16	.043	10.0
Height at M⅔	16	3.4—5.4	4.46	.128	11.5	24	3.6—5.4	4.33	.115	13.0
P⅓ length	6	2.4—2.8	2.58	.060	5.7	7	2.2—2.8	2.66	.081	8.1
M⅓ length	2	2.9—3.0	2.95	.050	2.4	5	2.7—3.2	2.96	.087	6.6
M⅓ post. width	3	1.8—2.0	1.90	.058	5.3	5	2.0—2.3	2.12	.058	6.2
M⅔ length	5	3.0—3.3	3.18	.058	4.1	8	3.2—3.6	3.48	.049	4.0
M⅔ post. width	4	2.1—2.4	2.25	.065	5.7	8	2.2—2.4	2.34	.032	3.9
M⅗ length	8	3.0—3.4	3.19	.058	5.2	8	3.0—3.4	3.23	.041	3.6
M⅗ post. width	8	1.9—2.2	2.09	.040	5.4	8	2.0—2.3	2.13	.037	4.9
M⅘ length	5	3.2—3.5	3.32	.049	3.3	12	3.2—4.0	3.47	.067	6.7
M⅘ post. width	5	0.9—1.4	1.20	.095	17.7	12	1.0—1.4	1.19	.031	9.1
M⅓–⅘ length	3	11.9—12.4	12.1	.152	2.2	5	12.4—13.7	12.88	.218	3.8

Of twelve Victoria Cave examples of M^1_1, one showed a short but distinct anterior cingular shelf, six showed a slight depression in the anterior buccal region and in five the anterior wall was continuously smooth. Merrilees (1965) found that one Victorian specimen and two of fifteen from Western Australia showed the anterior-buccal depression on M^1_1. On the basis of one Victorian specimen of *P. gunnii*, Merrilees (1965) believed that a small cingular shelf on M^1_1 might be characteristic of that species, but this is not confirmed by my examination of eleven Tasmanian specimens in the South Australian Museum, in which none has a distinct cingular shelf and only three have an anterior-buccal depression.

P. bougainville was equally abundant in the deposit as *P. gunnii*, but a much higher proportion of *P. bougainville*, the smaller species, was adult (Table 1).

The eastern Australian range of *P. bougainville* at the time of European settlement is poorly known. It occurred on the Liverpool Plains in eastern New South Wales (Ride 1970) and it was apparently abundant near Mildura on the River Murray (Wakefield 1966a). Its remains were found in an owl pellet accumulation of uncertain age in the Grampians, Victoria (Wakefield 1963), but not in other western Victorian cave deposits (Wakefield 1964). In the Fromm's Landing archaeological excavation, it was found from surface level to layers radiocarbon-dated at 2105 ± 85 years BP (Wakefield *in* Mulvaney et al. 1964) but it was not represented in the Mt. Burr archaeological excavation, although *P. gunnii* and *I. obesulus* occurred there (Finlayson 1966 [footnote 1] and personal observations). The Victoria Cave specimens therefore extend the known range of the species in former times into south-eastern South Australia.

In Western Australia, *P. bougainville* survives today only on Bernier and Dorre Islands in Shark Bay (Ride 1970). However, its remains have been found in several caves on the Nullarbor Plain and along the southern half of the west coast of Western Australia (Lundelius 1960, 1963) and in a Pleistocene deposit in Mammoth Cave (Merrilees 1965). It occurred as a modern species in central and western Australia (Ride 1970).

Family THYLACINIDAE

Thylacinus cynocephalus (Harris, 1808)

Three isolated teeth are tentatively assigned to this species.

S.A.M. P16120d is a worn canine, probably from a right mandible, with much of the enamel broken away and the root broken. The size (max. antero-posterior length of root 11.8 mm, max. width of root 8.5 mm) is similar to that of modern specimens of *T. cynocephalus* in the South Australian Museum. In the modern specimens the crown is not severely worn, for the upper and lower canines do not meet directly; but the crown of the fossil tooth has either been severely worn, or was broken before death. There is no anterior wear surface such as occurs in many modern specimens of *T. cynocephalus* where I^1_1 meets the lower canine. The fossil tooth is wider relative to its length than are the canines of the dingo (*Canis familiaris* Linnaeus, 1758, var. *dingo* Blumenbach, 1780), its enamel is smooth rather than crenulated as in phocids, and it is more robust than canines of *Sarcophilus harrisii* (Boitard, 1841). I have not examined any *S. laniarus* (Owen, 1838).

S.A.M. P16120h is an incisor, probably a right I^1_1, 3.9 mm wide, 4.3 mm long and with a crown height of 4.6 mm. The root is robust, curved and entered the premaxilla to a depth of 12.9 mm. The occlusal surface is in two planes, the larger surface being the plane of wear against I_1, the smaller being the contact surface with the lower canine. The fossil tooth lacks the lateral cuspules found in incisors of *C. f. dingo*, lacks the transverse groove of phocids and is more cuboid than the incisors of *S. harrisii*, where the incisors are crowded and compressed laterally.

A second incisor tooth, S.A.M. P16120j, is probably a right I^1_1. It is 4.3 mm wide, 5.1 mm long and the crown is 3.9 mm high. The root is deep and straight; the tip has been lost. The wear surface is faceted in two planes, the larger being the wear surface against I^1_1, the smaller that against I^2_1. In neither *C. f. dingo* nor phocids are the lower incisors faceted, and in *S. harrisii* the lower incisors are compressed like the uppers.

Additional teeth of *T. cynocephalus* were found associated with remains of a *Protemnodon* (c.f. *P. brehus*) in a rock pile a short distance from the silt deposit. These teeth were almost certainly derived from one individual, and comprise two upper canines, a left mandibular canine, six of the eight upper incisors and all six lower incisors. All are comparable in size to those of modern adult male *T. cynocephalus* in the South Australian Museum but are larger than those of modern adult females.

(*T. cynocephalus* is strongly sexually dimorphic (Ride 1964).)

T. cynocephalus has been extinct on mainland Australia since before European settlement, although it existed then in Tasmania. During the Pleistocene, however, it was widespread on the mainland, as shown by its remains in cave deposits in Victoria, New South Wales, South Australia and south-western Australia (Ride 1964).

Family DASYURIDAE

Dasyurus maculatus (Kerr, 1792)

The only identified fragment of *D. maculatus* is a broken left maxilla (S.A.M. P16115i) containing the canine alveolus and the six cheek teeth. These do not differ in size or morphology from those of modern specimens. Some tooth dimensions of the fossil are: P^1, length 3.3 mm, width 1.8 mm; P^3, l 4.4 mm, w 2.5 mm; M^1, buccal length 6.1 mm, w 4.3 mm; M^2, bl 6.6 mm, w 5.3 mm; M^3, bl 6.6 mm, w 6.6 mm; M^4, bl 1.6 mm, w 7.2 mm; M^{1-3}, l 19.5 mm.

D. maculatus was not rare in the south-east of South Australia early in this century (Jones 1923, p. 88) but is now extinct in this state (Aitken 1970).

Dasyurus viverrinus (Shaw, 1800)

The skull of *D. viverrinus* can be distinguished from that of the similar-sized *D. geoffroii* Gould, 1841, by the posterior palatal vacuities which are small in *viverrinus* but large in *geoffroii* (Thomas 1888). The posterior palate is not preserved in any Victoria Cave specimen.

The teeth of specimens of the two species in the South Australian Museum, and of Victoria Cave specimens, are similar in size and morphology (Fig. 4), and there is overlap in all linear dimensions of individual teeth and of toothrows. The ratio of the distance from protocone to anterior stylar cusp, to the distance from protocone to posterior stylar cusp, is significantly greater in M^1 and M^3 of *D. geoffroii* than in *D. viverrinus*. (M^1: *D. viverrinus*, ratio = 0.525, *D. geoffroii*, 0.570, $P<.05$ (t test); M^2: *D. viverrinus*, 0.659, *D. geoffroii*, 0.634, not significant; M^3: *D. viverrinus*, 0.664, *D. geoffroii*, 0.733, $P<.05$ (t test)). The ratios in the Victoria Cave specimens are closer to those of *D. viverrinus* (Victoria Cave M^1 ratio, 0.507, M^2, 0.623, M^3, 0.686) and because of this similarity, the Victoria Cave specimens are referred to *D. viverrinus*. Examination of more complete material could possibly alter this decision.

Twenty-one maxillary fragments and 34 mandibular fragments were recovered. Most of the latter lacked teeth and although many isolated teeth were found, none could be fitted to any particular jaw with certainty. Twenty-two of the fragments were from adults, 33 from juveniles. A minimum of seven adults and 12 juveniles are represented. Some dimensions of the teeth are given in Table 6.

TABLE 6

Some dimensions of teeth and alveoli of Dasyurus viverrinus *from Victoria Cave.*

Dimension	n	Range (mm)	Mean	Standard error	Coefficient of Variation
M^4 length	3	5.0—5.7	5.30	.208	6.8
M^2 length	6	5.0—5.5	5.15	.076	3.6
M^3 length	2	5.3—5.4	5.35	.050	1.3
M^4 length	1	1.2	—	—	—
M^{1-3} alveolar length	4	14.5—15.1	14.68	.152	2.1
P^4 alveolar length	4	3.1—4.0	3.4	.196	11.5
M^1 alveolar length	10	3.9—4.9	4.25	.111	8.2
M^2 alveolar length	10	4.2—5.0	4.53	.074	5.2
M^3 alveolar length	14	4.0—5.1	4.44	.071	6.0
M^4 alveolar length	5	4.3—5.3	4.72	.166	7.8
M^{1-4} alveolar length	4	18.0—20.1	19.10	.528	5.5

D. viverrinus is found in many cave deposits in western Victoria (Wakefield 1964) and has been found in the Bat Cave, Naracoorte (Tidemann 1967). The species was formerly common in South Australia (Jones 1923, p. 91) but it is now extinct in this state (Aitken 1970).

Genus ANTECHINUS

Specimens of *Antechinus* were distinguished by the following criteria.

(i) The maxillary molars are more robust, and less compressed antero-posteriorly than in *Sminthopsis*.

(ii) The mandibular fourth premolar is reduced and is always smaller than P_3^3, whereas in *Sminthopsis* and *Antechinomys* P_4^4 is larger than P_3^3.

(iii) Generally the mandible is more robust than in *Sminthopsis* and the masseteric fossa wider. However, some small mandibles of *A. stuartii* are similar in size to those of large *S. murina*.

(iv) The entoconid is always well-developed as it is in *Sminthopsis crassicaudata*. It is much reduced or absent in other species of *Sminthopsis* and in *Antechinomys* (Beasley 1903).

Antechinus flavipes (Waterhouse, 1838)

The mandibular molars of modern specimens of *A. flavipes* in the South Australian Museum are robust, the average width of M_2^2 being 1.34 mm and that of M_3^3, 1.42 mm (Table 7). The length of M_1^1–$_4^4$ is equal to or greater than 7.2 mm and the length of M_1^1–$_3^3$ equal to or greater than 5.5 mm. The premolar teeth are broad and crowded, leaving no spaces between adjacent teeth (Fig. 5).

From Victoria Cave, 10 maxillary and 40 mandibular fragments from a minimum of 23 individuals were indistinguishable in morphology and size from those of the modern specimens of *A. flavipes* (Table 7). All were adults. I have not examined skulls of *Phascogale calura* Gould, 1844 and from published descriptions I cannot exclude the possibility that some of the Victoria Cave mandibles are of that species.

Antechinus flavipes inhabits rainforest, dry sclerophyll forest and woodland, where the animals obtain their insect food from the tree-trunks and large limbs, and from logs. Isolated populations are found in north-eastern Queensland and in south-western Western Australia, while the main population ranges from south-eastern Queensland through eastern New South Wales to Victoria and south-eastern Australia, its distribution being mainly on the inland side of the Great Dividing Range, but extending to the coast at both the northern and south-western extremities (Wakefield & Warneke 1967). Naracoorte is within this range. Remains of *A. flavipes* have been found in the Wombeyan Caves, New South Wales, in a deposit that is probably Upper Pleistocene in age (Ride 1960), but have not been found in Pleistocene (nor Recent) layers of McEachern's Cave, in the extreme south-west of Victoria (Wakefield 1967).

Antechinus stuartii Macleay, 1841

The dentition of *A. stuartii* is identical morphologically with that of *A. flavipes* and, although the former species is on the average much smaller, there is overlap in all dimensions of skull and teeth (Wakefield & Warneke

TABLE 7

Comparisons of some dimensions of teeth and mandibles of Antechinus flavipes *from Victoria Cave with those of a modern sample from southern South Australia and south-western Victoria.*

Dimension	*A. flavipes* from Victoria Cave					Modern *A. flavipes* (n — 18)			
	n	Range (mm)	Mean	Standard error	C.V.	Range (mm)	Mean	Standard error	C.V.
M_1^1–$_3^3$ alveolar length	6	5.9—6.1	5.98	.031	1.3	5.5—6.9	6.12	.087	6.0
M_3^3 width	5	2.1—2.4	2.28	.058	5.7	2.1—2.6	2.36	.030	5.5
Length of ascending ramus	19	4.5—5.9	5.11	.096	8.2	4.5—5.7	5.19	.077	6.3
M_2^2 width	16	1.2—1.4	1.32	.016	5.0	1.2—1.4	1.34	.017	5.2
M_3^3 width	23	1.3—1.5	1.37	.013	4.6	1.3—1.5	1.42	.019	5.5
M_1^1 alveolar length	23	1.5—1.9	1.75	.022	5.9	1.8—2.0	1.88	.015	3.3
M_1^1–$_4^4$ alveolar length	21	7.2—8.1	7.54	.049	3.0	7.2—8.1	7.59	.065	3.7

1967). After measuring modern specimens of both species I have arbitrarily chosen to distinguish as *stuartii* all specimens in which the alveolar length of M^1–^{3} is equal to or less than 5.7 mm and that of M_1–$_4$ is equal to or less than 7.1 mm. In both modern and fossil mandibles the premolars are markedly crowded (Fig. 6), with P_4 often being set obliquely to the line of the jaw.

Six maxillary and 16 mandibular fragments, from a minimum of 11 animals, have been found in Victoria Cave. All but one are adults. They are similar in morphology and size to modern specimens (Table 8).

A. stuartii has not been recorded previously from South Australia, although its present range extends as far west as Portland in Victoria, only 70 km east of the South Australian border (Wakefield & Warneke 1967). Its remains are common in cave deposits in western Victoria where in McEachern's Cave in the extreme south-west, it is found in both Pleistocene (15,200 ± 320 years BP) and Recent layers (Wakefield 1964, 1967).

The present ranges of *A. stuartii* and *A. flavipes* are complementary, the distribution of *stuartii* being coastal to that of *flavipes*, but overlap does occur, e.g. in western Victoria (Wakefield & Warneke 1967).

Antechinus swainsonii (Waterhouse, 1840)

A. swainsonii and *A. minimus* (Geoffroy, 1803) are characterized by their long claws and long snouts. The molar teeth are as long as, or nearly as long as, those of *A. flavipes* [e.g. in 3 specimens of *A. swainsonii* (S.A.M. M2421, M7047 and M7496), M^1–^{3} = 5.5–6.0 mm (mean 5.73), M_1–$_4$ = 7.5–7.8 mm (7.6)], but are much narrower [M^3 = 1.9–2.0 mm (1.97), M_2 = 1.1 mm (in all 3 specimens), M_3 = 1.1–1.2 mm (1.17)]. The premolars too are much narrower than in *A. flavipes* and are not crowded, adjacent teeth often being separated by a space. In addition, the mandibular premolars have long talonids with sharp posterior cuspules, whereas the talonids of *A. flavipes* premolars are short with blunt cuspules. The mandibles of *A. swainsonii* and *A. minimus* are more slender than those of *A. flavipes*, and longer than those of *Sminthopsis* (Fig. 7).

Nine mandibles, from a minimum of five animals, conformed with the *swainsonii-minimus* characteristics, and I have tentatively classified them as *A. swainsonii* because all have a long mandibular symphysis, extending posterior to the front to P_3. The symphysis in *A. minimus* is shorter (Tate 1947). In addition, the greatest breadth of the masseteric fossa in four Victoria Cave specimens ranges from 4.2 to 5.0 mm, whereas in *A. minimus* its greatest breadth does not exceed 4.2 mm (Thomas 1888). In Victoria Cave specimens, the mean width of M_2 is 1.13 mm (3 spec.), mean width M_3 is 1.22 mm (4 spec.) and length M_1–$_4$ ranges from 6.7 to 7.2 mm (mean 7.0) in four specimens.

A. swainsonii has not been recorded alive in South Australia (Aitken 1970), but its remains were found in a late Recent deposit in the Bat Cave, Naracoorte (Tidemann 1967). A single, incomplete, toothless mandible from level 1 of the Fromm's Landing archaeological excavation on the River Murray was assigned

TABLE 8

Comparisons of some dimensions of teeth and mandibles of Antechinus stuartii *from Victoria Cave with those of a modern sample from Bondo, N.S.W.*

Dimension	*A. stuartii* from Victoria Cave					Modern *A. stuartii* (n = 10)			
	n	Range (mm)	Mean	Standard error	C.V.	Range (mm)	Mean	Standard error	C.V.
M^1–^{3} alveolar length	4	5.1—5.7	5.50	.141	5.1	5.3—5.9	5.57	.068	3.9
M^3 width	3	2.0—2.2	2.13	.067	5.4	1.9—2.1	1.96	.022	3.6
Length of ascending ramus	5	4.2—5.4	4.60	.207	10.1	3.9—4.4 n = 7	4.19	.083	5.2
M_2 width	5	1.1—1.3	1.22	.037	6.9	1.1—1.3	1.20	.015	3.9
M_3 width	7	1.2—1.3	1.24	.020	4.3	1.2—1.3	1.27	.015	3.8
M_4 alveolar length	10	1.6—1.8	1.72	.025	4.6	1.5—1.8	1.69	.038	7.1
M_1–$_4$ alveolar length	7	5.8—7.1	6.67	.180	7.2	6.5—7.0	6.85	.052	2.4

to this species (Wakefield *in* Mulvaney et al. 1964). *A. swainsonii* is commonly found in cave deposits in western Victoria (e.g. Wakefield 1964, 1967). On the Australian mainland, *A. minimus* has a limited range around the South Australian-Victorian border near the coast (Wakefield & Warneke 1963).

Genus SMINTHOPSIS

Fragments of *Sminthopsis* were identified by the relatively large P^4 and by the greater antero-posterior compression of the maxillary molars than in *Antechinus*. The mandible is generally more slender than in *Antechinus* and the ascending ramus shorter antero-posteriorly, but there is overlap between *S. murina* and *A. stuartii* in mandible size.

Sminthopsis murina (Waterhouse, 1838)

Mandibles of *S. murina* may be distinguished from those of *S. crassicaudata* (Gould, 1844) by differences in the morphology of the talonids. The entoconids are reduced or absent in *S. murina* but well-developed in *S. crassicaudata* (see Bensley 1903). In the maxillae, interdental fenestrae are smaller and less numerous in *S. murina* than in *S. crassicaudata* (pers. comm. Michael Archer, Western Australian Museum).

In *Antechinomys laniger* (Gould, 1856), which also lacks the entoconid, the postero-external shelf of the lower molars is much broader than in *S. murina*. The dentition of *S. leucopus* is said to be distinguishable from *S. murina* by the presence of spaces between adjacent premolar teeth (Thomas 1888), but this character is variable in the specimens of *S. murina* in the South Australian Museum.

Sixteen maxillary and 57 tooth-bearing mandibular fragments from a minimum of 31 animals were found. Only two were juveniles. A further 61 toothless mandibles, 32 right and 29 left, are probably referable to this species. Some dimensions of the adult specimens and of a modern sample are given in Table 9. The maxillary interdental fenestrae occupied a larger proportion of the interdental space than in many modern specimens and the entoconid was not present in any Victoria Cave mandible. Adjacent premolars, both maxillary and mandibular, usually touched; there was never a conspicuous gap between the premolars (Fig. 8).

In addition to the specimens listed above, one small adult mandible (S.A.M. P16118z) was found that is morphologically identical with *S. murina* but is much smaller, the length of M_1–$_4$ being only 4.8 mm.

S. murina is widespread in South Australia but is nowhere common (Jones 1923, p. 118, Aitken 1970). There is a specimen in the South Australian Museum from Bordertown but Tidemann (1967) did not find this species in a late Recent deposit in the Bat Cave, Naracoorte. The morphologically-similar species, *S. leucopus* (Gray, 1842), is found in Recent, but not Pleistocene layers in McEachern's Cave, extreme south-western Victoria and in other cave deposits in south-western Victoria (Wakefield 1964, 1967).

Sminthopsis crassicaudata (Gould, 1844)

S. crassicaudata was represented by only three mandibles and one maxilla from a minimum of three individuals, all adult. Some dimensions of these are: length of M_1–$_3$, 4.8

TABLE 9

Comparisons of some dimensions of teeth and mandibles of Sminthopsis murina *from Victoria Cave with those of a modern sample from South Australia.*

Dimension	*S. murina* from Victoria Cave					Modern *S. murina* (n = 10)			
	n	Range (mm)	Mean	Standard error	C.V.	Range (mm)	Mean	Standard error	C.V.
M^1–^{3} alveolar length	9	4.6—5.0	4.74	.050	3.2	4.5—5.2	4.76	.062	4.1
M^3 width	9	1.9—2.1	1.98	.022	3.4	1.7—2.0	1.85	.027	4.6
Length of ascending ramus	15	3.5—4.6	4.06	.077	7.3	3.4—4.6	4.05	.137	10.7
M^2 width	17	1.0—1.1	1.05	.012	4.9	0.9—1.1	1.00	.015	4.7
M^3 width	23	1.1—1.2	1.14	.010	4.4	1.0—1.2	1.09	.028	8.0
M^4 alveolar length	30	1.4—1.7	1.48	.014	5.3	1.4—1.8	1.56	.037	7.5
M_1–$_4$ alveolar length	26	5.6—6.3	5.98	.035	3.0	5.5—6.2	5.88	.077	4.2

mm; length of ascending ramus (3 specimens), 3.6–3.9 mm (mean 3.73); M^4 width (3), 1.0 mm; M_4 alveolar length (3), 1.4–1.5 mm (1.43); alveolar length M^4–$_4$ (3), 5.5–5.7 mm (5.67).

This species has a wide range in southern Western Australia, South Australia, Victoria, Western New South Wales and south-western Queensland (Ride 1970), and in the South Australian Museum there are many specimens from the south-east of South Australia. It was found in the Bat Cave deposit, Naracoorte (Tidemann 1967) and in Recent cave deposits in south-western Victoria (Wakefield 1964, 1967).

Discussion

Method of accumulation of the small vertebrate remains.

Analysis of the remains of each species, into adults and juveniles, shows that there is considerable variation between species in the proportion of adults. The larger species, *Bettongia penicillata* and *Potorous apicalis*, are represented almost entirely by juveniles (Smith 1971), as is the large bandicoot, *Perameles gunnii*. Adults and juveniles of smaller species, such as *Isoodon obesulus* and *Potorous platyops*, were found in about equal numbers, while the small dasyurids (*Antechinus* and *Sminthopsis*) and the petaurids and burramyids were nearly all adults. Slower eruption of the teeth in the larger species may account for some of this variation, but it does not account for the wide variations seen between two species of the one genus. For example, within *Perameles* no more than one quarter of the larger *P. gunnii* were adults, but more than half of the smaller *P. bougainville* were adults.

The biased age structure suggests that the cave did not act as a simple pitfall trap, but that the bones were brought in by predators able to capture animals as large as an adult *P. bougainville* or *Potorous platyops*, or a juvenile *P. gunnii* or bettong. Mammal predators that inhabit dens usually die within them occasionally. *Thylacinus cynocephalus* was able to take larger prey (Ride 1970) and so the predators could have been dasyurids, *Dasyurus maculatus* or *D. viverrinus*, or owls. The very low incidence of *D. maculatus* suggests that this species was not the predator. *D. viverrinus* is better represented but the high proportion of juveniles indicates that it was a prey species rather than a predator. The small mammals therefore probably accumulated from owl pellets. The method of accumulation of the large herbivores in the deposit is not yet known.

Climatic interpretations

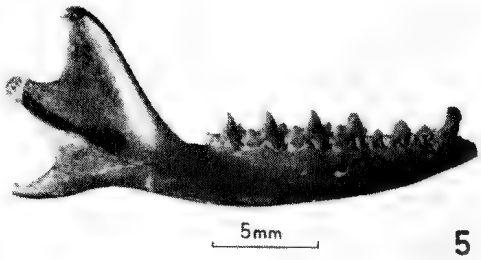
Modern populations of the scansorial species *Antechinus flavipes* and *A. stuartii* are sympatric in areas of dry sclerophyll forest such as at Glenlofty, western Victoria, where stringybark (*Eucalyptus macrorrhyncha*) and box (*E. melliodora* and *E. goniocalyx*) are associated with a sparse ground cover of sawsedge (*Gahnia radula*) and tussock grass (*Poa*) (Wakefield & Warneke 1967). Populations of the ground-dwelling *A. swainsonii* are densest in wet sclerophyll forest, but they also occur in other habitats such as open woodland and stunted coastal eucalypt scrub with tussock grass (Wakefield & Warneke 1963).

Modern *Sminthopsis murina* and *S. crassicaudata* inhabit both wet and arid areas and little is known of their habitat requirements. *Perameles bougainville* was similarly wide ranging at the beginning of European exploration, and its habitat requirements are also unknown.

P. gunnii and *I. obesulus* occur sympatrically in Tasmania. Both species require scrub for nesting and the food of both consists mainly of earthworms and insect larvae. However, *Isoodon* remains within the scrub to feed, whereas *Perameles* forages far out into open areas (Heinsohn 1966). If the Pleistocene *Perameles* and *Isoodon* had similar ecological requirements to their modern descendants, one might infer that the apparent scarcity of *Isoodon* indicated that the vegetation of the area was an open woodland, with little dense scrub. On the other hand, the greater abun-

Fig. 1. Left mandible of *Isoodon obesulus* (S.A.M. P16112x) from Victoria Cave.
Fig. 2. Right mandible of *Perameles gunnii* (S.A.M. P16104v) from Victoria Cave.
Fig. 3. Left mandible of *Perameles bougainville* (S.A.M. P16103f) from Victoria Cave.
Fig. 4. Left maxilla of *Dasyurus viverrinus* (S.A.M. P16115a) from Victoria Cave, occlusal view of M^1 to M^4.
Fig. 5. Right mandible of *Antechinus flavipes* (S.A.M. P16001j) from Victoria Cave.
Fig. 6. Right mandible of *Antechinus stuartii* (S.A.M. P16119i) from Victoria Cave.
Fig. 7. Right mandible of *Antechinus swainsonii* (S.A.M. P16009a) from Victoria Cave.
Fig. 8. Right mandible of *Sminthopsis murina* (S.A.M. P16021a) from Victoria Cave.

1



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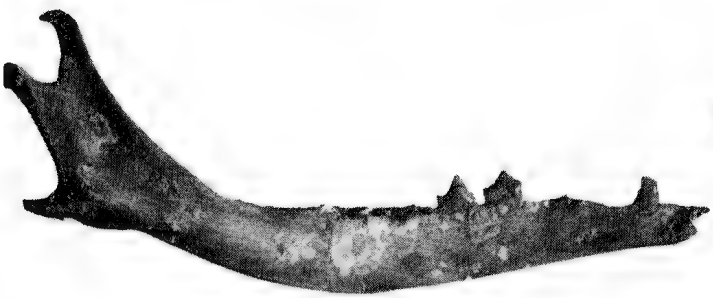

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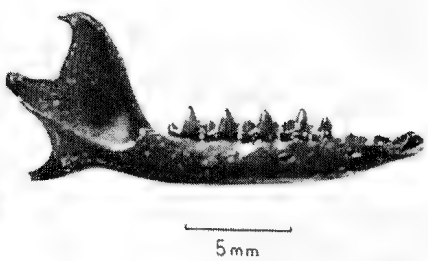

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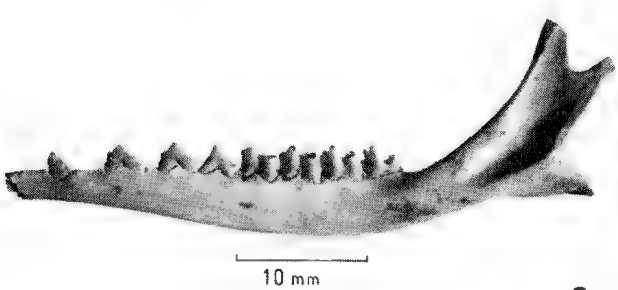

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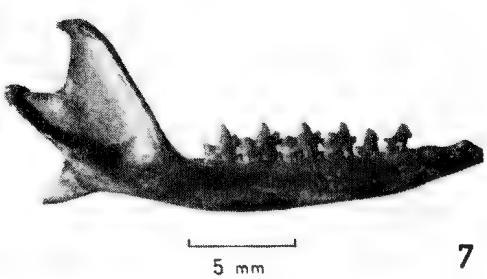

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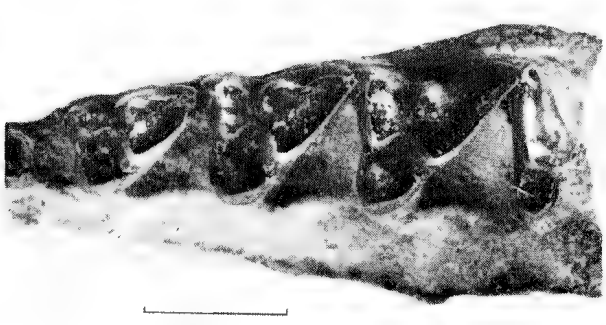

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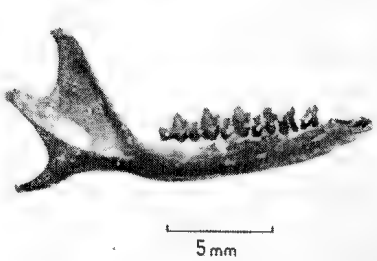

8

dance of *Perameles* might be an artefact of selective predation, for animals foraging in scrub would be less susceptible to owl attack than animals foraging in the open. However in the Mammoth Cave deposit, *P. bougainville* is about twice as abundant as *I. obesulus*. This is believed to be a true reflection of a larger population of *Perameles* in the Pleistocene, for the deposit does not seem to have originated from owl pellets, but appears to have been a talus deposit, accumulating as animals fell through holes in the roof (Merrilees 1965).

The combined evidence of the represented species of potoroines, petaurids and burramyids (Smith 1971) and of the peramelids and dasyurids indicates that at the time of accumulation of the deposit Victoria Cave was surrounded by dry sclerophyll forest

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THE GENUS ACUARIA BREMSER (NEMATODA: SPIRURIDA) IN AUSTRALIA

BY PATRICIA M. MAWSON

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Characters considered useful in distinguishing species of this genus are cordon length and pattern, the shape and ratio of the lengths of the spicules, and the number and arrangement of the caudal papillae of the male. A key to most of the known species, based on male characters, is also given.

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Introduction

Almost all known species of the genus *Acuaria* Bremser (sens. str.) are from passerine birds of the order Oscines; there appears to be only one exception to this: *A. upupa* Rasheed, 1960, from the coraciiform bird *Upupa epops* from India. *Acuaria* spp. have been recorded from galliform and gruiform birds, and from cormorants, herons and birds of prey, but all species, of which the male is described, are found to belong to related acuariid genera. Where only the female is described, identification of the genus is uncertain, but may be inferred from the cordon structure, if this is described.

The incidence of *Acuaria* (sens. str.) species in birds dissected in this department is shown in Table 1. Crows are by far the most commonly infected and are also the most heavily infested birds, perhaps however, only because of the greater size of the gizzard. Of the 21 smaller passerines listed, belonging to 14 species, none yielded more than three specimens, and eight birds contained only females. Under these conditions (and these apparently pertain also in other places—see Chabaud & Petter 1961), it is almost impossible to be certain of the variation within a species. However, in the present material, two species are present in some numbers. *A. anthuris* from *Corvus* spp., and *A. skrjabini* from imported finches (cagebirds) among which a heavy infestation occurred. Within each of these species there is a close agreement in certain characters: the

TABLE 1

Incidence of Acuaria *spp., and of nematodes generally, in "land birds" dissected. Numbers refer to specimens, not species.*

Bird group	Number dissected	With nematodes	With *Acuaria* sp.
Passeriformes	958	360	71
Alaudidae	2	1	1
Campephagidae	16	11	2
Turdidae	18	6	4
Monarchidae	4	2	1
Muscicapidae	41	11	1
Pachycephalidae	37	16	2
Falcunculidae	7	7	1
Meliphagidae	189	45	4
Artamidae	10	2	2
Cracticidae	100	53	3
Corvidae	77	69	50
Other families	457	137	—
Caprimulgiformes	18	11	—
Coraciiformes	28	14	—
Strigeiformes	25	17	—
Accipitriformes	61	38	—
Cuculiformes	21	5	—
Columbiformes	43	1	—
Psittaciformes	157	4	—
Galliformes	7	2	—
Gruiformes	56	17	—

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cordon lengths in male and female (different in the two sexes), the shape, size and length ratio of the two spicules, and the number and arrangement of the caudal papillae of the male.

Specimens from other Australian hosts were grouped together according to these characters; in an attempt to compare them with species already described, a key to most of the known species, based on these characters, was compiled. This is given below.

Examination of the shapes of the cuticular bosses in the cordons of the Australian species shows that these may be useful in comparing them. The detailed structure of the cordons, especially as seen in transverse section, has been suggested by Skrjabin *et al* (1949) as a useful generic character in the Acuariidae. Williams (1930) and Rasheed (1960) give figures of the surface pattern in some species (though those in the latter publication are too much reduced to be of critical value). The patterns in each of the Australian species are similar in all specimens, of both sexes.

Acuaria *species from Australian birds*

Alaudidae
MIRAFRA JAVANICA Horsfield. *Acuaria mirafrae* n. sp.
Campephagidae
LALAGE LEUCOMELA Vig. & Hos. *A. petterae* n. sp.
Turdidae
DRYMODES BRUNNEOPYGIA Gould. *A. petterae* n. sp.
Monarchidae
MYIAGRA INQUIETA (Latham). *A. petterae* n. sp.
Falconculidae
OREOICA GUTTURALIS (Vig. & Hors.). *A. petterae* n. sp.
Meliphagidae
MELIPHAGA VIRESCENS Vieillot. *A. petterae* n. sp.
M. PLUMULA Gould. *A. petterae* n. sp.
ACANTHAGENYS RUFOGULARIS Gould *A. petterae* n. sp.
Artamidae
ARTAMUS CINEREUS Vieillot. *A. petterae* n. sp.
Pachycephalidae
COLLURICINCLA HARMONICA WHITEI Mathews. *A. colluricinclae* n. sp.
Cracticidae
CRACTICUS NIGROGULARIS (Gould). *A. petterae* n. sp.
STREPERA VERSICOLOR (Latham). *A. streperina* Johnston & Mawson
Muscicapidae
MICROECA LEUCOPHAEA (Latham). *A. microecae* n. sp.
Corvidae
CORVUS CORONOIDES Vig. & Hors. *A. anthuris* (Rud.)
C. MELLORI Mathews. *A. anthuris* (Rud.)
C. BENNETTI North. *A. anthuris* (Rud.)
C. ORRU Bonaparte. *A. anthuris* (Rud.)

Key for identification of male specimens of Acuaria spp.

The descriptions of *A. gagensis* Bisseru and *A. iwashkini* Erhardova are not available to me; a full description has not been seen of *A. eremophila* Erkulov. *A. tenuis* Duj. has been omitted because the cordon length and the number and arrangement of the caudal papillae are not known; it falls among species below choice 14 in the key. Species from crows, *A. attenuata* (Rud.), *A. ornata* (Gendre), *A. longicaudata* Hoeppli & Hsü, and *A. scutata* Maplestone, and synonyms of these, have been assigned to one group, the "*A. anthuris* complex". It is probable that examination of the types of all described species attributed to *Acuaria* would show considerable synonymy, and might also indicate more important differences between some species than are revealed by existing descriptions.

1. Left spicule longer than 190 μm ... 2
1. Left spicule shorter than 190 μm ... 9
2. Spicule ratio 1.1–1.4 ... 3
2. Spicule ratio 1.5 or more ... 5
3. Cordons very long, extending well past oesophagus ... "*A. anthuris* Complex"
3. Cordons very short, not extending much past excretory pore ... 4
4. Body length 4–6 mm, spicule ratio 1.4 ... *A. mayori* Lent, Freitas & Proença
4. Body length 10–11 mm, spicule ratio 1.1–1.4 ... *A. cordata* (Mueller)
5. Left spicule less than 230 μm long ... 6
5. Left spicule more than 250 μm long ... 7
6. Cordons end about midlength of muscular oesophagus ... *A. subula* (Duj.)
6. Cordons nearly as long as oesophagus ... *A. colluricinclae* n. sp.
7. Left spicule 262 μm ... *A. turdi* (Wang)
7. Left spicule over 300 μm ... 8
8. First pair of postanal papillae about a third tail length from second pair ... *A. cyanocitta* (Boyd)
8. First and second pairs of postanal papillae not much separated ... *A. streperina* J. & M.
9. Spicule ratio 1.5 or over ... 10
9. Spicule ratio less than 1.5 ... 14
10. Cordons reach to end of muscular oesophagus ... *A. conica* Maplestone
10. Cordons very short, not much past excretory pore ... 11
11. Six pairs of postanal papillae ... 12
11. Seven pairs of postanal papillae ... 13
12. Left spicule 165 μm long ... *A. sialia* Williams
12. Left spicule 150 μm long ... *A. papillifera* Linst.

13. Left spicule 140 μm long ... *A. paragalliardi* Ch. & P.
13. Left spicule 170 μm long ... *A. parorioli* Ch. & P.
14. Cordons more or less to end of glandular oesophagus ... 15
14. Cordons hardly longer than muscular oesophagus ... 20
15. Four pairs of preanal papillae ... 16
15. Fewer than four pairs of preanal papillae 18
16. Left spicule 129 μm long ... *A. crami* Rasheed
16. Left spicule longer than 150 μm ... 17
17. Left spicule slightly grooved near tip ... *A. pattoni* Williams
17. Left spicule deeply grooved throughout length ... *A. minor* Williams
18. Three pairs of preanal papillae ... *A. brevispicula* Maplestone
18. Two pairs of preanal papillae ... 19
19. Seven pairs of postanal papillae ... *A. alii* Rasheed
19. Six pairs of postanal papillae ... *A. singhi* Rasheed
20. Spicule ratio close to 1.0 ... 21
20. Spicule ratio 1.1–1.4 ... 25
21. Spicule length less than 130 μm ... 22
21. Spicules longer than 130 μm 24
22. Six pairs of postanal papillae ... *A. cremophila* Erkulov
22. Seven pairs of preanal papillae ... 23
23. Cordons not much past nerve ring ... *A. kungi* Singh
23. Cordons reach about to end of muscular oesophagus ... *A. microcecae* n. sp.
24. Cordons not past nerve ring ... *A. martinagliai* Le Roux
24. Cordons nearly to end of muscular oesophagus ... *A. upupa* Rasheed
25. Six pairs of postanal papillae ... 26
25. Seven pairs of postanal papillae ... 31
26. Postanal papillae in two groups of three pairs ... 27
26. Postanal papillae not in two distinct groups ... 29
27. Spicule ratio about 1.1 ... *A. mirafrae* n. sp.
27. Spicule ratio 1.3–1.4 ... 28
28. Caudal alae widen at midlength ... *A. quiscula* Williams
28. Caudal alae about same width throughout ... *A. dollfusi* Ch. & Petter
29. Cordons reach only to cervical papillae ... *A. cettiae* Hsü
29. Cordons reach further than cervical papillae ... 30
30. Right spicule grooved for most of its length ... *A. gracilis* (Gendre)
30. Right spicule simple ... *A. dicrura* Rasheed
31. Three pairs of preanal papillae ... *A. brumpti* Ch. & Petter
31. Four pairs of preanal papillae ... 32
32. Left spicule less than 125 μm long ... *A. galliardi* Ch. & Petter
32. Left spicule more than 135 μm long ... 33
33. End of right spicule enlarged ... *A. skrjabini* Ozerska
33. Tip of right spicule without prominent enlargement ... 34
34. Cordons reach past excretory pore, and more than half distance between head and posterior end of muscular oesophagus ... *A. buttnerae* Ch. & Petter
34. Cordons shorter, less than half this distance ... 35
35. Parasitic in African oriole ... *A. orioli* Ch. & Petter
35. Parasitic in Australian passerines ... *A. petterae* n. sp.

Descriptions of Species

The general morphology of *Acuaria* spp. is so similar that only the special features of each species will be described. Measurements are given in Table 2; those of parts of the oesophagus are taken from the anterior end of the body to the end of the organ in question; the spicules are measured in lateral view (often very different from those taken in ventral view).

Acuaria anthuris (Rudolphi, 1819)

FIGS. 1–3

Hosts and localities: *Corvus coronoides* from Adelaide and Pt. Augusta, S. Aust.; *C. mellori* from Balgowan, S. Aust. and Launceston, Tas.; *C. bennetti* from Lock, S. Aust. and Erldunda, N.T.; *C. orru* from Plenty River, N.T.; *C.* sp. from Pearson I., S. Aust.

Acuaria anthuris has been recorded many times from different parts of the world; reference lists and discussion of its synoymy may be found in Skrjabin *et al* (1965) and Chabaud & Petter (1961). The present study deals only with the variations observed in the Australian specimens. The species is quite common in Australian crows and ravens. Measurements are given in Table 2. The general appearance, except where noted below, agrees with descriptions given by Singh (1948), Rasheed (1960) and Chabaud & Petter (1961).

The cordons extend well past the oesophagus in both sexes, reaching a little under a third of the body length in the male and a little more than this in the female, but never quite reaching to the vulva. The cordon structure (Fig. 1) is different from that figured by Rasheed.

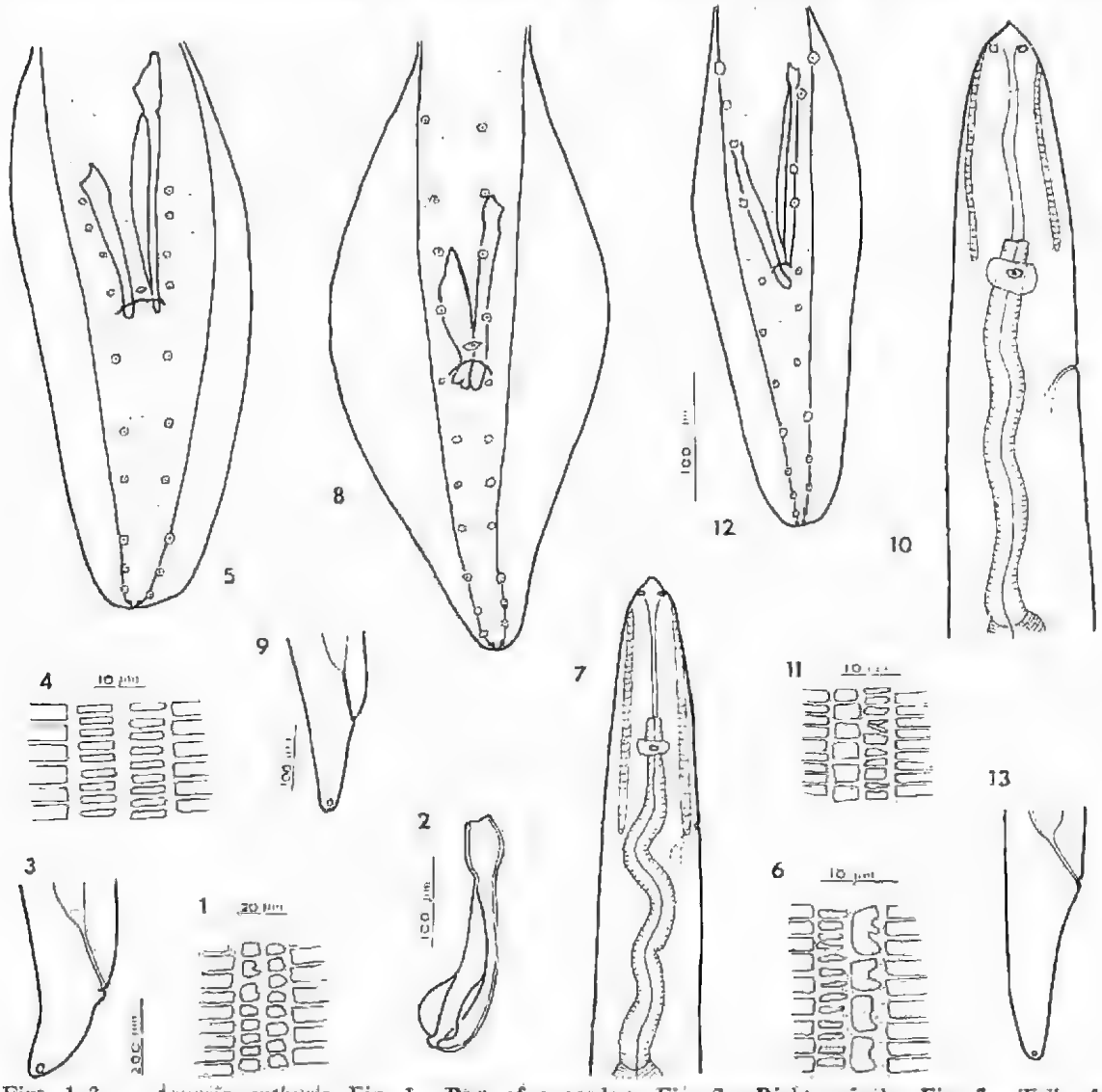
The papillae on the male tail are usually more or less symmetrical, comprising four pairs and one median preanal papillae, and six pairs of postanal papillae, arranged as three pairs on the anterior half of the tail and three pairs of rather smaller papillae on the last

TABLE 2

Measurements of Acuaria *spp. Unless otherwise stated all measurements are in μm.*

		Acuaria anthuris range	(mean)	*Acuaria skrjabini*	*Acuaria streperina*	*Acuaria petterae* range	(mean)	*Acuaria colluricinclae*	*Acuaria microecae*	*Acuaria mirafrae*
Male	Length (mm)	9.7–13.4	(11.4)	7.1–9.0	—	5.1–6.9	(5.9)	6.8	4.6	
	Oesophagus	2500–4400	(2900)	1200–1900		1000–1500	(1259)	2300	1500	1330, 1760
	Musc. oesoph.	700–1080	(924)	420–730		400–610	(514)	700	460	480, 620
	Vestibule	200–280	(248)	130–170		150–180	(165)	170	120	150, 170
	Antr. end—nerve ring	300–360	(323)	150–215		175–225	(202)	200	165	185, 210
	—cerv. pap.	270–430	(330)	140–200		160–210	(193)	190	170	175, 200
	—excr. p.	380–530	(461)	220–330		240–320	(276)	330	260	270, 280
	L. spicule	230–310	(274)	190–200		140–185	(171)	210	100	140, 140
	R. spicule	190–270	(226)	110–140		110–140	(130)	130	100	130,125
	L. spic./R. spic.	1.1–1.4	(1.2)	1.4–1.7		1.2–1.4	(1.3)	1.6	1.0	1.1, 1.1
	Cordon length	3200–4500	(4100)	200–330		120–295	(197)	2000	460	270, 330
	L/oesoph. length	2.8–4.8	(3.9)	4.5–6.0		4.0–6.3	(4.7)	2.9	3.0	4.5, 4.3
Female	Length	19.1–30.3	(25.4)	23.9–28.4	16.8	16.0–24.9	(21.5)	12.4	21.1	—
	Oesophagus	3000–5000	(4200)	1500–2000	3200	1620–2600	(2096)	3.5	2.6	
	Musc. oesoph.	1000–1500	(1291)	600–1200	830	800–980	(864)	1200	900	
	Vestibule	250–350	(302)	160–200	210	210–230	(219)	250	160	
	Antr. end—nerve ring	300–530	(408)	180–240	300	260–300	(274)	320	225	
	—cerv. pap.	320–600	(437)	180–240	330	200–300	(266)	290	190	
	—excr. p.	550–800	(662)	260–330	450	320–400	(371)	420	330	
	—vulva (mm)	8.8–14.9	(11.5)	11.2–14.9	8.8	8.7–12.5	(10.8)	6.6	10.9	
	Antr.—Vulva, as % length	43–50%	(45.6%)	44–52%	52.4%	46.8–50.8	(48.4%)	53.2	51.6	
	L./oesoph. length	4.9–7.6	(6.2)	12.8–15.7	5.5	8.7–14.4	(10.7)	3.6	8.1	
	Cordon length	5600–9200	(8400)	200–450	1900	250–380	(350)	2500	1600	

quarter of the tail, as well as a pair of very small phasmids almost terminally. The members of a postanal pair are not always strictly opposite to one another. Individual variations from this occur, some specimens having one or two papillae missing from one side or the other. Of 85 male worms examined, 18 showed some abnormality in the caudal papillae. Most of these were one papillae more or less on one side or the other; in a few there was one papilla more or less in the terminal group of postanal papillae. In three specimens there were six pairs in the preanal group, the most posterior of these lying just posterior to the anus, so that they could be regarded as an extra postanal pair except that they continued as a closely spaced line of small preanal papillae on each side and were quite separated from the larger papillae of the anterior group of postanal papillae which were further apart. Except for these three specimens, all had six pairs of postanal papillae, of which the anteriormost lay



Figs. 1–3. *Acuaria anthuris*. Fig. 1.—Part of a cordon. Fig. 2.—Right spicule. Fig. 3.—Tail of female.
Figs. 4–5. *A. streperina*. Fig. 4.—Part of a cordon. Fig. 5.—Posterior end of male.
Figs. 6–9. *A. skrjabini*. Fig. 6.—Part of a cordon. Fig. 7.—Anterior end of male. Fig. 8.—Posterior end of male. Fig. 9.—Tail of female.
Figs. 10–13. *A petterae*. Fig. 10.—Anterior end of male. Fig. 11.—Part of a cordon. Fig. 12.—Posterior end of male. Fig. 13.—Tail of female.
Figs. 2, 5, 7, and 13 to scale beside 2; figs. 8, 10, 12, and 13 to scale beside 12.

some distance behind the anus. The spicules are grooved (as described by Singh 1948) and alate (Fig. 2). The left spicule is larger than the right except at the tip and the expanded parts of the alae are wider.

Chabaud & Petter (1961, p. 210) report *A. anthuris* of two types; the first (from *Garrulus glandarius* and *Pica pica*), rather smaller, with six pairs of postanal papillae in the male; the second (from *Corvus corone*), larger and with seven pairs of postanal papillae, in addition to the phasmids. The only measurement given is that the males of the smaller specimens are less than 12 mm long. The smaller specimens agree with Rudolphi's specimens selected from material (apparently containing more than one species), by Schneider (1866) as the type for *A. anthuris*. The Australian material, though perhaps a little longer, agrees with these types.

Acuaria streperina Johnston & Mawson, 1941: 254.

FIGS. 4–5

Host and locality: *Strepera versicolor melanoptera* from Waikerie, S. Aust.

The type specimens of *A. streperina* have been re-examined and the original description must now be amended; they are old specimens, poorly fixed and much contracted. The length given for the oesophagus, 700 μm in the male and 800 μm in the female, is that of the muscular part of the organ; the end of the glandular part is 2.1 mm from the head in the female, which is strongly contracted, and 1.4 mm in the male, which is less so. The cordons reach nearly to the end of the oesophagus in the female, and to the end of the muscular oesophagus in the male. There are six (not five) pairs of postcloacal papillae in the male, arranged with three well spaced pairs on the proximal two-thirds of the tail and three pairs, closer together, on the distal third. The papillae of the latter group are much smaller and harder to find. The spicules each have an enlarged proximal end, which is less heavily chitinised and was apparently not included in the original measurements. The spicules are 310 μm and 180 μm long, with a ratio of 1:1.7. The largest eggs are 45 x 28 μm.

A single female worm from the type host species is referred to *A. streperina*. It was collected and fixed after death and so is in a relaxed condition. Its measurements are different in those of the type female largely because of this. Eggs in this specimen are not embryonated and are thin-shelled. Measurements are given in Table 2.

The species is very close to *A. cyanocitta* (Boyd, 1950) but is distinguished by the arrangement of the postanal papillae in the male.

Acuaria skrjabini Ozerska, 1926: 103-111; *vide* Skrjabin *et al.*, 1965: 114.

FIGS. 6–9

Hosts and locality: Exotic aviary finches from New South Wales: *Tiaris canora*, *Lonchura malacca* and *Estrilda melpoda*.

These specimens occurred in large numbers in many specimens of the finches and were considered by the owner of the aviary to be the cause of the death of the birds. They agree generally with the figures and description of *A. skrjabini* by Ozerska and also by Singh (1948), the principal differences being that there are 7 pairs of postanal papillae in the male, as described by Singh, not six as shown by Ozerska; the spicule ratio is nearer that in Ozerska's specimens than those of Singh. There is a distinct enlargement at the distal end of the right spicule.

The cordons in the male reach to, and usually beyond, the excretory pore, and those of the female are longer, reaching to about half the distance from the head to the end of the muscular oesophagus.

The caudal alae of the male are distinctly wider anteriorly. There is only a slight distinction in spacing between the first four postcloacal papillae and the last three. In some specimens the postcloacal pairs are not arranged symmetrically and in a few one member of a pair is absent. Both spicules are indented at the tips and this is clearer in the right spicule as it ends more broadly.

The egg size is 40–43 by 23–24 μm; this is rather shorter than Ozerska's measurements, and distinctly larger than those of Singh.

Acuaria petterae n. sp.

FIGS. 10–13

Hosts and localities: *Lalage leucomela* from Katherine Gorge, N.T., type host; *Meliphaga virescens*, *M. plumula* and *Cracticus nigrogularis* from the Petermann Ranges, N.T.; *Artamus melanops* from Alice Springs, N.T.; *Cinclosoma cinnamomeum* from Tobermory Stn., N.T.; *Myiagra inquieta* and *Drymodes brunneopygia* from Blanchetown, S. Aust.

Probable hosts and localities (only females present): *Acanthogenys rufogularis* from Blanchetown, S. Aust.; *Anthochaera carun-*

culata from Verran, S. Aust.; *Artamus melanops* from Port Augusta, S. Aust.; *Oreoica gutturalis* from the Petermann Ranges, N.T.

Although the hosts listed above cover a wide range of bird groups, and a wide geographical range, there appear to be no specific differences among the specimens from each. Although there is some variation in the position of the cervical papillae, and in the length of the cordons in the male, there is often as much variation between specimens from one host as between specimens from different hosts.

The cordons are short. They do not extend as far as the nerve ring in the male, or further than the excretory pore in the female.

The vulva is at about the mid-body, just in front of or just behind this. The vagina passes backwards. Eggs are 38–39 by 21–23 μm.

The caudal alae of the male are slender and only slightly wider in their anterior halves. There are typically four pairs and one median preanal papillae, seven pairs of postanal papillae and a pair of very small phasmids. The postanal papillae are not arranged in two groups, but lie progressively closer together towards the tip of the tail. In some specimens there are more or fewer papillae on one side or the other, but these appear to be abnormalities. The spicules are unequal; the tips of both are blunt and rounded. The species appears to be very close to *A. orioli* Chabaud & Petter (1961), based on specimens from an oriole from Dahomey, which had been placed (with reserve) by Gendre (1912) in his species *A. gracilis*, from *Buchanga atra* from the same locality. Gendre states that the specimens from the oriole were in nearly all points similar to those from the drongo, distinguished only by the number of postanal papillae in the male, and the shape of the tip of the male tail. The cordons of *A. orioli* are longer in both sexes, than those of the Australian specimens. In the absence of more information about *A. orioli*, the Australian specimens are regarded as a distinct species. In some ways it resembles *A. skrjabini* but differs from this species in the more slender build of the spicules, the unenlarged tip to the right spicule, the shape of the caudal alae, and the detailed structure of the cordons.

Acuaria colluricinclae n. sp.

FIGS. 14–16

Host and locality: *Colluricincla rufiventris* from Eyre Peninsula, S. Aust.

The material consists only of one male and one female specimen, but these differ distinctly from *A. petterae* which appears to be the commonest species of the genus in Australian passerines. Measurements are given in Table 2.

The cordons extend nearly to the posterior end of the glandular oesophagus in both sexes, a little nearer in the female. Detail of the cordon structure are shown in Fig. 14.

The spicules are unequal in length; the right spicule ends in a swollen tip. There are four pairs and one median preanal papillae, 6 pairs of postanal papillae, and one pair of phasmids. The postanal papillae are asymmetrical (Fig. 15), presumably an abnormal condition; the first 3 pairs are well spaced and spread over the anterior 220 μm of the 280 μm long tail, while the last 3 pairs are smaller and lie on the terminal 50 μm.

The species is distinguished from other Australian ones by the ratio of the spicules, the structure of the right spicule, the grouping of the postanal papillae, and the cordon length. It is distinguished from other close species as shown in the key to species.

Acuaria microecae n. sp.

FIGS. 17–20

Host and locality: *Microeca leucophaea* from Waikerie, S. Aust.

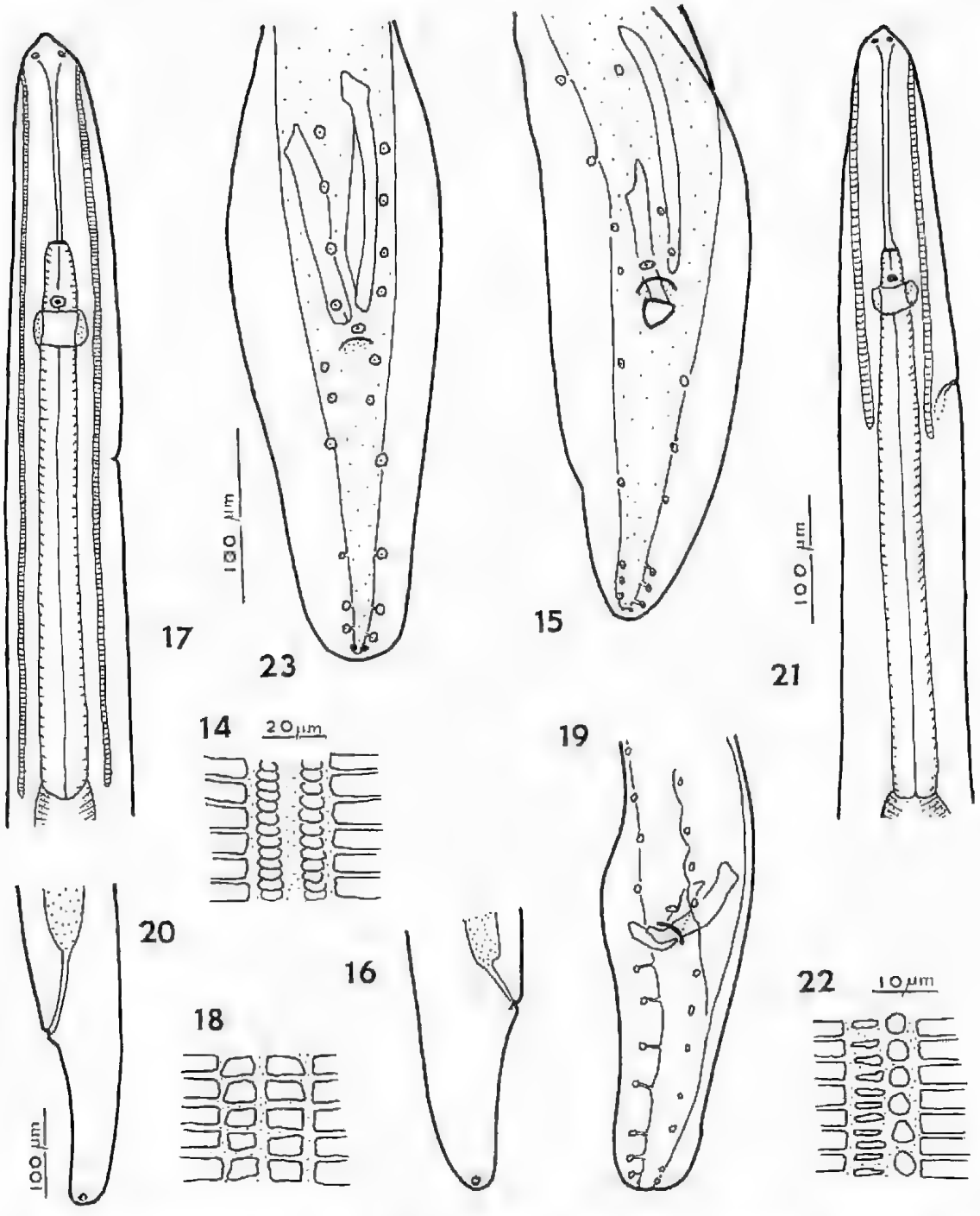
The measurements of this species, of which only 1 male and 1 female are present, are given in Table 2.

The cordons of the male reach to the end of the muscular oesophagus; those of the female to about halfway between the head and the posterior end of the glandular oesophagus.

There are four pairs and one median preanal papillae, seven pairs of postanal papillae and a pair of subterminal phasmids. The postanal papillae on each side are more or less evenly spaced along the tail, the posterior ones slightly closer together. The spicules are equal in length and similar in build; each has a pair of short alae towards the distal end, and the rounded tip is bent ventrally.

The vulva is slightly behind the midbody; the eggs are 35 x 21 μm.

The species is distinguished from others from Australia by the presence of equal spicules. It differs from other species in which the spicules are equal and in which there are 7 pairs of postanal papillae, in having longer cordons and in the very short spicules.



Figs. 14–16. *Acuaria colluricinclae*. Fig. 14.—Part of a cordon. Fig. 15.—Posterior end of male. Fig. 16.—Tail of female.

Figs. 17–20. *A. microecae*. Fig. 17.—Anterior end of male. Fig. 18.—Part of a cordon. Fig. 19.—Posterior end of male. Fig. 20.—Tail of female.

Figs. 21–23. *A. mirafrae*. Fig. 21.—Anterior end of male. Fig. 22.—Part of a cordon. Fig. 23.—Posterior end of male.

Figs. 15, 19, and 21 to scale beside 21; figs. 16 and 20 to scale beside 20; figs. 17 and 23 to scale beside 23; figs. 18 and 22 to scale beside 22.

Acuaria mirafrae n. sp.

FIGS. 21–23

Host and locality: *Mirafra javanica* from the Northern Territory.

This collection comprises only two whole and one broken male worms. Measurements are given in Table 2.

The cordons extend a short distance behind the excretory pore. The detail of the cordon pattern (Fig. 22) is somewhat similar to that of *A. petterae*.

There are four pairs and one median preanal papillae, six pairs of postanal papillae and a pair of subterminal phasmids. The postanal papillae are arranged in two groups of three pairs. The right spicule ends bluntly and the tip is slightly indented.

The species is distinguished from *A. petterae* by the number of postanal papillae and by the rather longer cordons. It is close to *A. gracilis* Gendre in the body measurements, but differs in the spicule ratio and the arrangement of the postanal papillae.

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A LATE PALAEOZOIC GLACIATED GRANITE SURFACE AT PORT ELLIOT, SOUTH AUSTRALIA

BY A. R. MILNES AND R. P. BOURMAN

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Introduction

Fleurieu Peninsula, South Australia, has for many years been studied from the point of view of its scattered exposures of glacigene sediments (now known to extend over a large proportion of South Australia) and its landforms, many of which have been accorded a glacial origin. Such investigations (e.g. Howchin 1898a, 1898b, 1908, 1910a, 1910b, 1926, 1929; Campana & Wilson 1955) were initiated by the discoveries of glaciated Cambrian and Proterozoic bedrock surfaces in the Inman Valley (Selwyn 1859) and at Hallett Cove (Tate 1889). Crowell & Frakes (1971) summarised and in part reinterpreted many of the earlier investigations in the context of a regional study of the Late Palaeozoic glaciation in Australia.

The age of the glacigene sediments in many localities in South Australia was determined by Ludbrook (1956, 1967, 1969a,b) from foraminiferal studies as Lower Permian. Tentative evidence for a Late Carboniferous to Lower Permian age for the glaciation, in the form of a possible Late Carboniferous microflora in glacigene sediments in the Lake Phillipson bore in north-west South Australia, was recorded by Balme (1957). Harris & McGowran (1971) recently described palynomorph assemblages of Permian age in glacigene sediments from several localities adjacent to Fleurieu Peninsula, and in addition, recorded a reworked Devonian microflora in glacigene sediments from Waterloo Bay on Yorke Peninsula. For the purpose of the present paper, we will refer to the age of the glaciation as Late Palaeozoic.

Our contribution was initiated by the discovery of a glaciated granite surface at Port Elliot, and other glacial features throughout Fleurieu Peninsula. These finds have provided significant information on the local effects of the Late Palaeozoic glaciation, and the direction of movement of the ice.

The Encounter Bay Granites

The Encounter Bay Granites[1] crop out in the Encounter Bay area as discontinuous masses along the coastline, and on the adjacent small islands. The contact of the granites with the surrounding Kanmantoo Group metasedimentary rocks is exposed in only two localities, Rosetta Head and Wright Island. In all other localities, it is obscured either by Late Palaeozoic to Recent sediments, or by the sea. Several large xenoliths of unaltered Kanmantoo Group metasedimentary rocks within the granites are possibly roof pendants, and may

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[1] *Encounter Bay Granites* is the term used to describe collectively the several related varieties of granitic rocks that crop out in the Encounter Bay area and at Cape Willoughby, Kangaroo Island. It is intended that it replace the synonymous term "*Encounter Bay Granite*" defined by Dasch, Milnes & Nesbitt (1971).

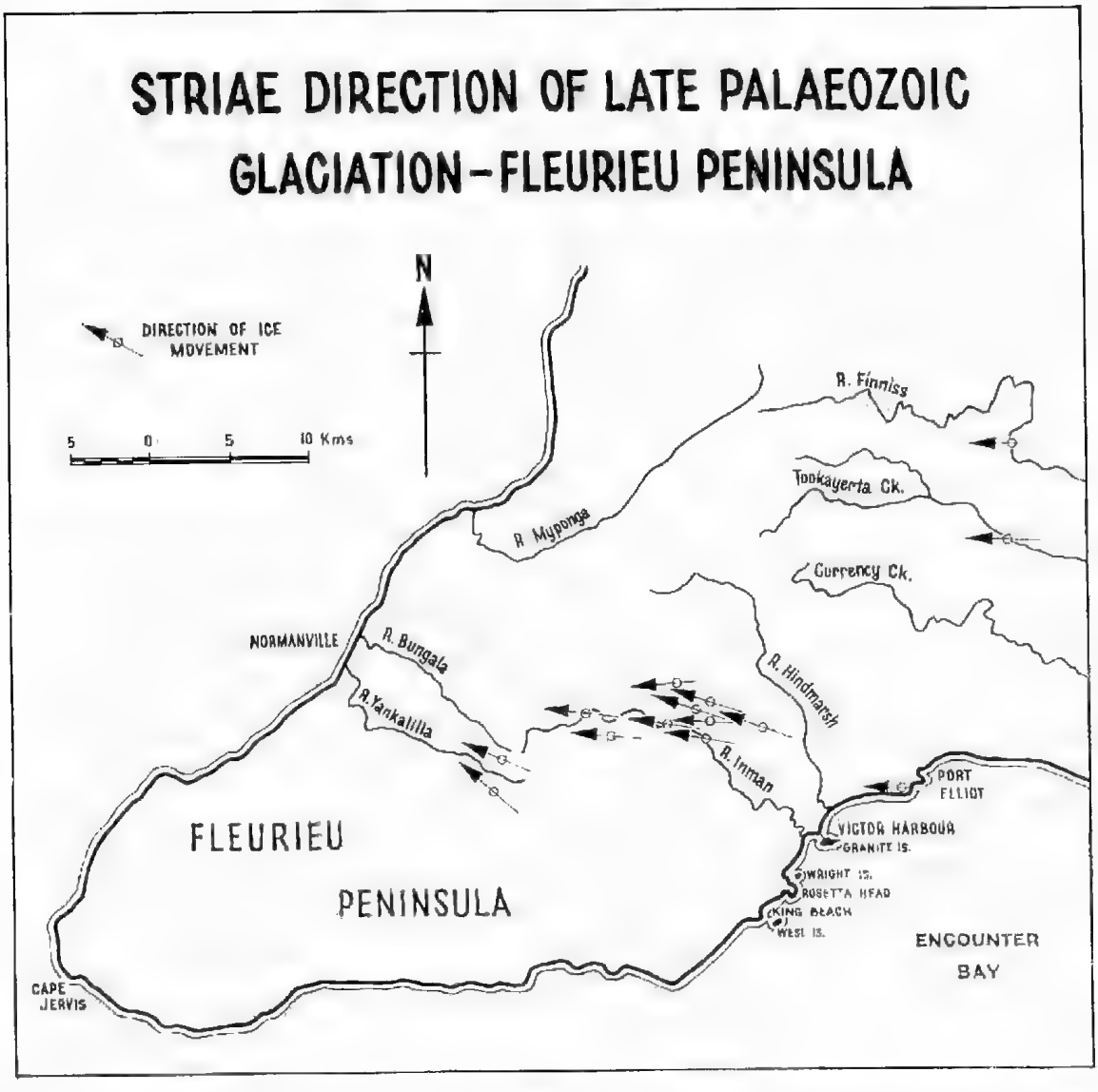


Fig. 1. Map showing the known occurrences of Permo-Carboniferous glaciated pavements and corresponding striae directions, Fleurieu Peninsula, South Australia.

indicate the close proximity of the present level of exposure to the roof of the original intrusion. Thus, the granites from West Island to Port Elliot appear to have originally formed part of the north-western wall and roof of a large pluton, which may have extended for some distance eastwards in the present position of the Southern Ocean and the western portion of the Murray Basin.

The granite outcrops show considerable modification as a result of surface weathering and erosion. Features such as sheeting, flared slopes, and gnammas, all of which are characteristic of inselberg structures, have been observed in many localities. In addition, a marked development of tafoni, micropediments, and corestones has been noted.

The Glacial Pavement and Associated Features at Port Elliot

An undulating smoothed and polished granite surface occurs at the edges of a pathway excavated across the top of the promontory between Knights Beach and Green Bay, Port Elliot (Figs. 1–3). The surface is poorly exposed (Figs. 4, 5) but crops out intermittently

Fig. 2. Low level oblique aerial photograph of the promontory between Knights Beach and Green Bay, Port Elliot, on which the glaciated granite pavement is exposed.

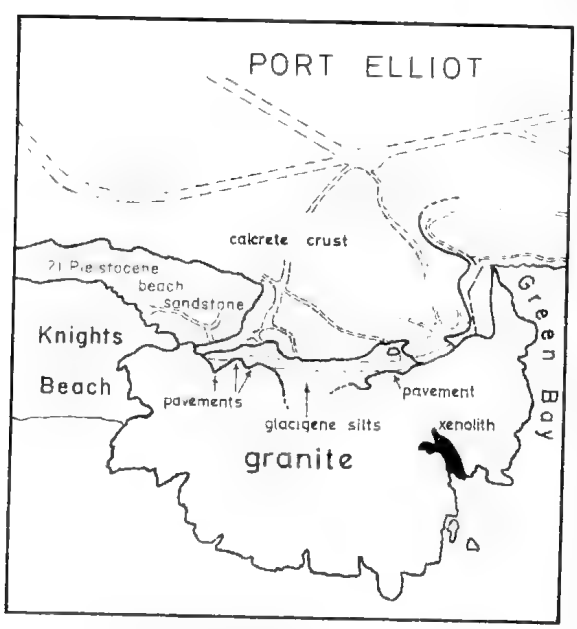


Fig. 3. Geological sketch of the same locality as shown in Fig. 2.

over a distance of approximately 30 m, and is extremely variable in orientation. It is overlain by thinly to very thinly bedded silts.

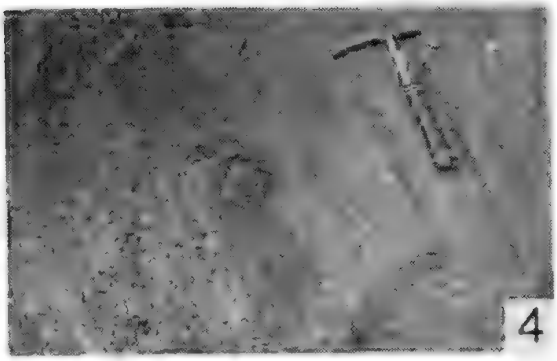
The area of exposure, corresponding to the easternmost extent of the pavement, is less than 1 m square. However, its extension for at least 1 m further westwards has been proved by minor excavation. Well preserved striations and grooves and possible crescent-shaped gouges were observed on the pavement in this exposure only (Fig. 4), and indicate a direction of movement of the glacial ice from approximately east to west (255° to 260°). These surface features have been partly obliterated (probably by traffic along the pathway) on those parts of the pavement exposed for some length of time, but are extremely well preserved on that part of the pavement recently exhumed from beneath a cover of silts.

The sediments overlying the pavement are well exposed in the cutting at the edge of the pathway across the top of the promontory, and are similar to sediments described by earlier workers as glacigene from other parts of Fleurieu Peninsula. They consist of thinly to very thinly bedded brown to red and greyish white coloured silts with minor grit bands and lenses. Many beds show extremely fine laminations. Bedding attitudes vary from horizontal to a shallow dip towards the north-west, but in view of the variability of the underlying surface, are interpreted as primary depositional attitudes.

Immediately beneath the granite pavement, there is a weathered zone of varying thickness characterised by the presence of innumerable small-scale fractures which appear to have mainly developed parallel to the pavement surface (Fig. 5). In addition, a skin of goethite up to 1 cm thick has formed on parts of the pavement (Fig. 6). These features are a result of recent weathering.

The glacigene silts are directly overlain by a calcareous conglomerate, up to 1 m thick, which infills fractures in the uppermost beds of the silts (Figs. 7, 8). The conglomerate is in turn overlain by a consolidated calcareous beach sandstone which crops out spectacularly in the cliffs at the back of Knights Beach. The sandstone is capped by a layer of massive to nodular calcrete, and this laps directly on to the granite on the western and eastern margins of the promontory (Figs. 2, 3).

The pavement and overlying glacigene silts are presently about 10 m above sea level. However, it is clear that they have been at or below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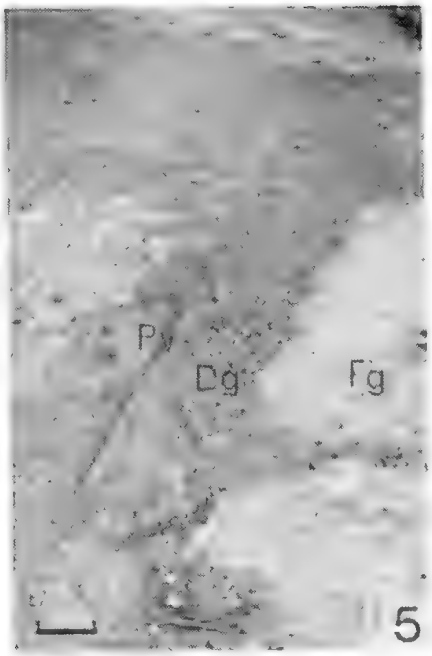
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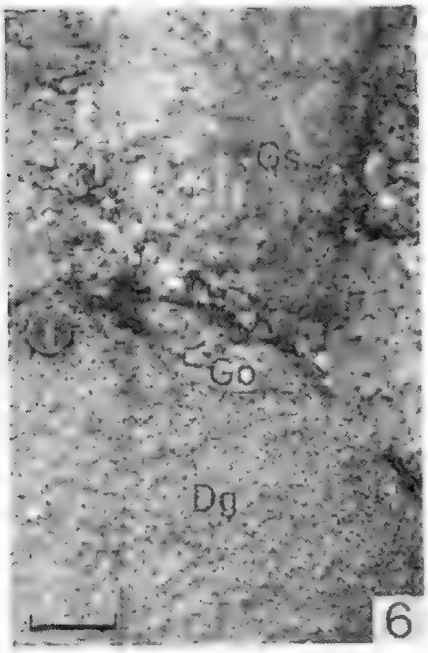
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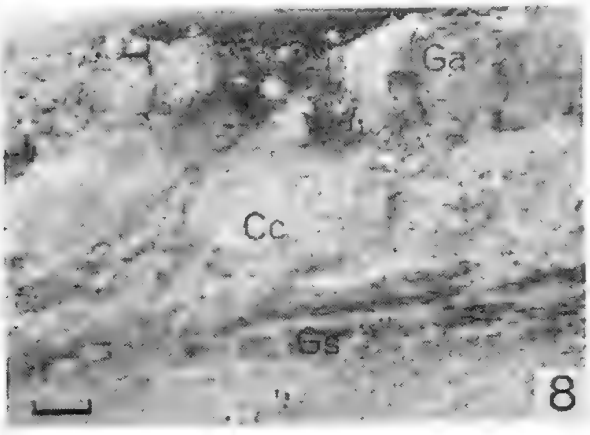
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sea level because of the nature of the overlying sediments. The conglomerate is interpreted as the result of reworking of both the glacigene sediments and the beach sandstone, prior to the formation of the calcrete crust. Furthermore, it seems likely that the reworking occurred after the main period of beach development, but in a similar although somewhat more sheltered environment, perhaps protected from the full erosive capacity of the sea by the outcropping granite. In view of the thick development of sandstone immediately inland from the granite, it is probable that a considerable proportion of the glacigene sediments originally present in this locality has been removed.

The pavement apparently defines part of the southern margin of a local glacigene sediment-filled basin, which occupies the area between the granite outcrops at Port Elliot and the hills of Kanmantoo Group metasedimentary rocks 3 km to the north. Glacigene sediments have been logged to depths of 175 m and 91 m in two bores drilled in this basin to the north-east of Port Elliot (Crawford & Thomson 1959). However, the sediments do not crop out at the surface as mapped on the *Encounter* 1-mile sheet, being effectively blanketed by more recent deposits including outwash, alluvium and, nearer the coastline, consolidated (?) Pleistocene beach-dune sandstones and unconsolidated present-day beach and dune sands.

Other Glacigene Sediments in the Port Elliot District

Further outcrops of glacigene sediments, consisting of very thinly laminated white to buff coloured clays and associated sands with sporadic erratics, occur in a narrow north-easterly trending valley just over 4 km north of Port Elliot township. The erratics include exotic granites, gneisses and quartzites, together with boulders of locally derived metasandstone, but there is no evidence of erratics of the nearby Encounter Bay Granites. One boulder of coarse grained gneiss contains blue opalescent quartz, and is similar to rock-types found in the older Proterozoic basement inliers north-west of this locality.

Discussion

The glaciated granite pavement at Port Elliot is significant with regard to an interpretation of the Late Palaeozoic to Recent geological and geomorphological history of the Encounter Bay area, especially in relation to the nature and distribution of the outcrops of Encounter Bay Granites. The pavement links with the glaciated Kanmantoo Group metasedimentary rock pavements throughout Fleurieu Peninsula in revealing glimpses of a recently exhumed Late Palaeozoic landscape. Furthermore, it indicates that the Encounter Bay Granites were exposed at the earth's surface during and possibly prior to the glaciation, and near the same level within the intrusion as presently exposed. Additional evidence for their exposure is provided by the profusion throughout Fleurieu Peninsula of erratics of Encounter Bay Granites, which are distinguished by their characteristic opalescent blue quartz crystals.

The direction of ice movement determined from the surface features preserved on part of the pavement is consistent with the directions determined in a similar fashion from 12 glaciated Kanmantoo Group metasedimentary rock surfaces (Fig. 1) on a wide variety of topographical features (Howchin 1926; Brock 1964[2]; Maud 1967[3], and unpublished field observations), and thus we are able to extend the known area of approximate east to west movement of the Late Palaeozoic ice. At

[2]Brock, E. J. (1964)—The denudation chronology of Fleurieu Peninsula. M.A. thesis Univ. Adelaide (partly unpublished).

[3]Maud, R. R. (1967)—The Permian of the area around Mount Compass. (Unpublished manuscript, C.S.I.R.O. Division of Soils, Adelaide.)

Fig. 4. The eastern-most exposure of the glaciated granite pavement, showing parallel striae.
Fig. 5. Steeply dipping portion of the granite pavement (Pv) exposed edge-on near the centre of photograph. Zone of disintegrating granite (Dg) between the pavement and fresh granite (Fg). Scale represents 20 cm.
Fig. 6. Contact between glaciated granite pavement and overlying glacigene silts (Gs). Thin skin of goethite (Go) covers the pavement surface at the base of silts. Disintegrating granite (Dg) beneath pavement. Scale represents 10 cm.
Fig. 7. Calcareous conglomerate (Cc) infilling fractures in upper beds of glacigene silts (Gs). Scale represents 10 cm.
Fig. 8. Section showing glacigene silts (Gs) at base (dipping at shallow angle to the west), overlain by calcareous conglomerate (Cc) and a massive calcrete (Ca) crust. Scale represents 30 cm.

Penneshaw (Christmas Cove) on Kangaroo Island, Ward (1922) recorded a restricted exposure of glacigene sediments and a smoothed and striated Kanmantoo Group metasedimentary rock surface that also indicated an "east-west direction" of ice movement. This direction, however, is at variance with that measured at Hallett Cove (Howchin 1926; Crowell & Frakes 1971) on one of the two other glaciated pavements in South Australia for which there is published information. Here the indicated direction of ice movement is towards the north-north-west. Pritchard (1892) described glaciated surfaces with similar north-south oriented striae on Cambrian limestone near Curramulka on Yorke Peninsula. Although there are glacigene sediments in the area (Crawford 1960), the origin of the typical flat limestone outcrops has been misinterpreted by Pritchard.

Striae directions on the Hallett Cove pavements are anomalous when compared with those measured from the numerous pavements to the south. Moreover, Hallett Cove is separated from the pavement localities of Fleurieu Peninsula by at least two major faults, along which there has been marked vertical displacement during the Tertiary (Thomson & Horwitz 1962). Providing there has been no post-glacial rotation of the Proterozoic rocks, the striae directions and the occurrence of erratics of Encounter Bay Granites at Hallett Cove may have resulted from either:

(a) the south to north movement of an initial continental ice sheet over Fleurieu Peninsula and its immediate environment as suggested by Crowell & Frakes (1971), followed by the later development of a westerly moving ice sheet; or

(b) the effect of topography on a north-westerly moving ice sheet.

The first possibility requires that north-trending striae initially developed on bedrock surfaces on Fleurieu Peninsula were obliterated in all localities but Hallett Cove by younger westerly moving ice. It thus introduces the concept of multiple glaciation, but there is as yet no unequivocal evidence for this in South Australia. Neither the crossing striae observed on many pavements, nor the striated pavement developed on glacigene sandstone near the bank of the Finniss River (Fig. 1) require multiple glaciation (Flint 1957). The remarkable consistency of striae directions on Fleurieu Peninsula and eastern Kangaroo Island over varied topography does not support the concept of a system of irregular valley glaciers proposed by Campana & Wilson (1955) and Crowell & Frakes (1971), but the movement of a thick and extensive ice sheet.

Evidence for the direction of ice movement, in addition to striae which are usually only reliable indicators of local ice movement, is provided by the distribution of certain erratics. In particular, the occurrence in glacigene sediments on Fleurieu Peninsula of a distinctive feldspar-quartz porphyry and of coarse grained non-foliated red granites, apparently derived from the suite of granitic rocks that crops out between Murray Bridge and Dergholm (south-western Victoria), indicates an overall north-westerly ice movement, if we assume that the present outcrop distribution of these granites approximates to their real extent. This direction is close to the average of the Fleurieu Peninsula and the Hallett Cove striae directions.

Thus, although the striae on Fleurieu Peninsula pavements are constant in direction over considerable topographic relief, topography of a much greater magnitude during the Late Palaeozoic could have channelled north-westerly moving ice in a westerly direction across Fleurieu Peninsula. The possibility of deflection of the ice by a north-easterly trending valley at Hallett Cove has long been considered (Sprigg 1942). Such topographic influences on a north-westerly trending ice sheet seem to account for the observed facts.

We interpret the present distribution of the outcrops of Encounter Bay Granites as the result of dissection of an originally extensive pluton by the exploitation, either of structural features such as jointing or of pre-existing drainage valleys, by westerly moving Late Palaeozoic ice. Evidence for glacial erosion includes the pavement at Port Elliot and the abundance of granite erratics within the glacigene sediments throughout Fleurieu Peninsula. In fact, the granite outcrops seem to have been preserved until recently beneath a cover of glacigene sediments, the reworking of which has produced the conspicuous boulder fields seen for example near Rosetta Head and King Beach. The occurrence of many granite types foreign to the Encounter Bay Granites in these fields does not support the suggestion by Crowell & Frakes (1971) that the boulders in these localities were derived from nearby outcrops by mass-wasting or by the action of storm waves.

Conclusions

The smoothed and striated granite surface at Port Elliot, together with 12 glaciated Kanmantoo Group metasedimentary rock surfaces throughout Fleurieu Peninsula and one on Kangaroo Island, exhibit a remarkable consistency of striae directions over a variety of topographic forms. This can only be the effect of a thick ice sheet, which is shown to have moved westwards over Fleurieu Peninsula. The striae directions measured from glaciated surfaces at Hallett Cove are anomalous in this regard. However, these differences may reflect topographic influences.

The present broad distribution of outcrops of Encounter Bay Granites is interpreted primarily as the result of ice action, although there is abundant evidence of considerable later modification of some outcrops.

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ADDITIONS TO THE HYLID FROG FAUNA OF NEW GUINEA, WITH DESCRIPTION OF A NEW SPECIES, LITORIA TIMIDA

BY M. J. TYLER AND F. PARKER

Summary

Litoria timida, a new species of New Guinean hylid frog of the *Litoria dorsalis* group, is described and reported from five localities, ranging from the headwaters of the Fly River to the vicinity of Port Moresby. Three additional species of *Litoria*, formerly known solely from Australia, are reported from localities adjacent to Torres Strait. The diagnostic characters of each species are described, together with notes on habitat preferences and habit.

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Introduction

The portion of the island of New Guinea adjacent to Australia, now within the Western District of Papua, is of considerable zoogeographic interest because of the close faunal similarity with the Cape York Peninsula of Queensland. Although the first publication on a collection of frogs from this part of New Guinea appeared nearly a century ago (Macleay 1878), this and subsequent contributions (Roux 1920; Loveridge 1956) dealt with very small samples and, until recently, the extent of the frog faunal similarity to Queensland remained uncertain (Tyler, in press).

During three years residence at Daru one of us (F.P.) has collected several thousand frogs throughout the Western District. Here we confine our attention to some of the representatives of the Hylidae in this collection, reporting details of the distributions and habitats of three species formerly known to occur only in Australia, and describing one new species. Details of the field expeditions that resulted in the collection of some of the specimens have been published elsewhere (Parker 1970).

Methods

The specimens forming the subject of the paper are deposited in the collections of institutions abbreviated in the text as follows: American Museum of Natural History (A.M.N.H.); Australian Museum (A.M.); Museum of Comparative Zoology (M.C.Z.); Papua and New Guinea Museum (P.N.G.M.); South Australian Museum (S.A.M.); Department of Biology, University of Papua and New Guinea (U.P.N.G.). The letters F.P. in parentheses preceding specimen reference numbers indicate that these are field numbers for currently unregistered material.

Methods of measurement and morphological and geographical descriptive terminology follow those of Tyler (1968a) for species then referred to the cosmopolitan genus *Hyla*. Such species from New Guinea and Australia comprise an endemic genus for which the name *Litoria* has been proposed (Tyler 1971). The descriptive abbreviations used are E-N (distance between the eye and the naris); IN (internarial span); HL (head length); HW (head width); S-V (snout to vent length); TI. (tibia length).

Western District localities cited in the text are shown in Figure 1.

Litoria timida n. sp.

Holotype: S.A.M. 11658. An adult male collected at Menemsorae, Western District, Papua New Guinea by F. Parker on 30 March, 1969.

Definition: An extremely small lowland species (males 21.3-23.9 mm; females 26.3 mm) characterised by its elongated head, curved and extremely sharply defined canthus rostralis, large and prominent eyes, unwebbed fingers and reduced webbing between the toes.

Description of Holotype: The head is flattened, angular and distinctly longer than broad (HL/HW 1.246), its length equivalent to more than one-third of the snout to vent length. The snout is extremely prominent and angular when viewed from above, prominent and projecting

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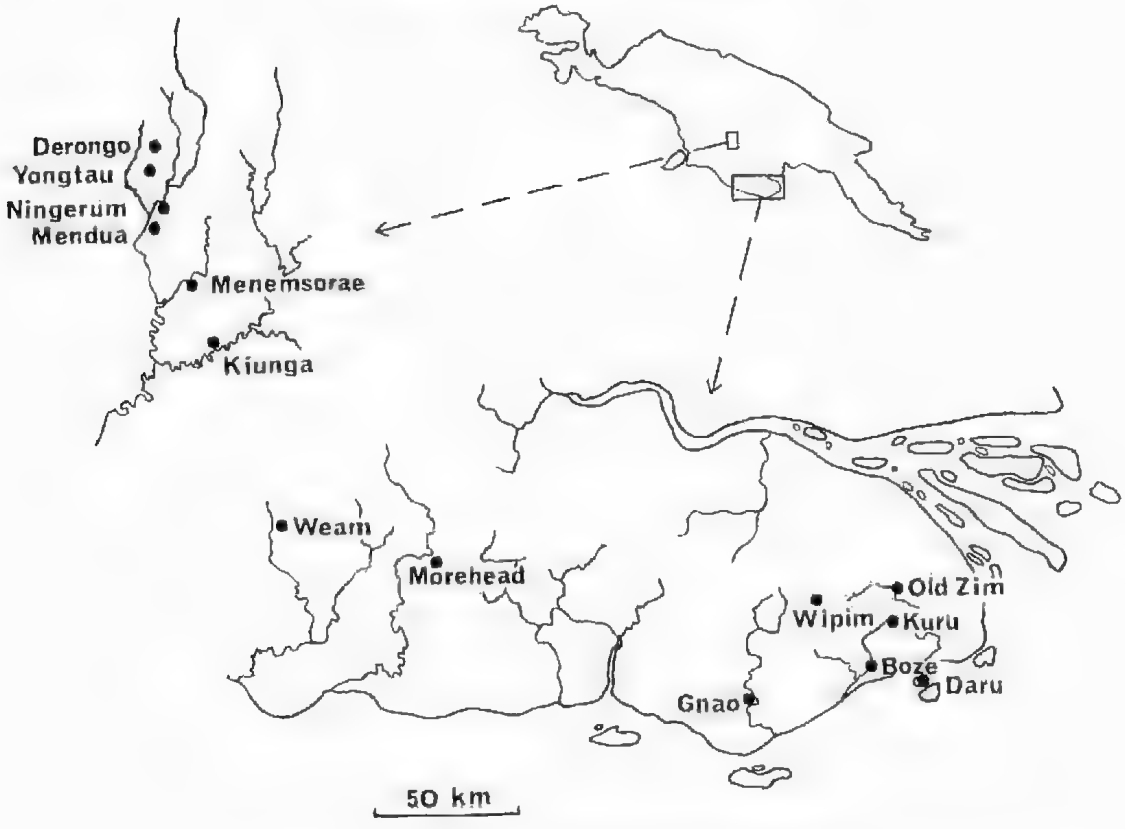

Fig. 1. Collecting sites in the Western District, Papua.

far beyond the anterior limit of the mandible in profile. The nostrils are dorso-lateral, their distance from the end of the snout being considerably less than that from the eye. The distance between the eye and the naris is very much greater than the internarial span (E-N/IN 1.527). The canthus rostralis in long, well defined and curved, and the loreal region steeply sloping. The eye is very large and prominent, its diameter slightly less than the distance between eye and naris. The tympanum is prominent, having a diameter equivalent to approximately one-half of the eye diameter, and separated from the eye by a distance equivalent to one-half of the diameter of the tympanum. The vomerine teeth are on two prominent, raised and slightly oblique series between the choanae. The tongue is small and circular.

The fingers are long, slender, unwebbed and lack lateral fringes, in decreasing order of length 3>4>2>1. The terminal discs are large, the diameter of the disc of the third finger being twice the diameter of the penultimate phalanx.

The hind limbs are long and slender with a TL/S-V ratio of 0.605, and toes in decreasing order of length 4>5 = 3>2>1. The webbing between the toes is reduced, reaching the subarticular tubercle at the base of the penultimate phalanx on the third and on the fifth toe. There is a prominent, elongate inner metatarsal tubercle and a prominent round outer metatarsal tubercle.

The dorsal surfaces of the head, body and limbs bear scattered and poorly developed tubercles. The throat and chest are smooth, and the abdomen and posterior ventral surfaces of the femora granular.

This male specimen has a single, submandibular vocal sac and glandular, but unpigmented, nuptial pads.

The dorsum is dull brown and mottled with slightly darker and irregular patches. The ventral surfaces are very pale cream with a brown reticulum on the throat and chest. There is fine light stippling on the ventral and posterior surfaces of the thighs. Dimensions: Snout to vent length 21.5 mm; tibia length

Fig. 2. *Litoria timida*, paratype (M.C.Z. 82390).

13 mm; head length 8.6 mm; head width 6.9 mm; eye to naris distance 2.9 mm; internarial span 1.9 mm; eye diameter 2.7 mm; tympanum diameter 1.5 mm.

Variation: The paratype series consists of sixteen adult males and one gravid female: M.C.Z. 82380-90, S.A.M. 11659-61, collected at Menemsorae with the holotype M.C.Z. 82400, Derongo; M.C.Z. 82377-78, Yongtau. The series forms a remarkably homogeneous group, the snout to vent length range of the sixteen males being only 21.3-23.9 m. The snout to vent length of the female is 26.3 mm. Similarly, there is scant variation in their proportions: TL/S-V 0.605-0.647 (mean 0.627), E-N/IN 1.381-1.722 (1.577), HL/HW 1.114-1.348 (1.245), HL/S-V 0.376-0.413 (0.399).

In all specimens the canthus rostralis is consistently a prominent feature, the eyes are large and protruding and vomerine teeth are present.

With two exceptions the paratypes are brown dorsally with or without faint and irregularly shaped paler markings. The exceptions are grey; one uniformly so, whilst the other (M.C.Z. 82400) bears two very broad and clearly demarcated, pale, dorso-lateral stripes extending from the eye to the groin. Pigmentation of the ventral surface of the throat and body varies from a very light stippling to extensive dark brown reticulations on the throat, chest and anterior half of the abdomen.

In life the dorsum is brown with paler markings, and the posterior surfaces of the thighs are dark brown with or without a few yellow spots. The labial stripe is white, and the iris a reddish bronze, being palest around the pupil. The flanks vary from brown to pale yellowish, and the groin is bright yellow. The ventral surfaces are yellow and the ventral markings reported above are brown.

Ten additional specimens have been collected from localities to the east of the Western District: M.C.Z. 82379, 'Oroi, Purari River [Lat. 7°23'S., Long. 145°11'E.], Gulf of Papua (obtained by F.P.); S.A.M. 10656-8, 11657; U.P.N.G. 2510-11, 2581-3, Brown River Forest Reserve, north of Port Moresby (collected by J. I. Menzies). They differ from

the type series in the following respects: the posterior surfaces of the thighs and the groin bear a striking pattern of yellow markings on a dark brown background, and several exhibit a very narrow, light, mid-vertebral stripe.

Comparison with other species: *Litoria timida* is a member of the *Litoria dorsalis* group, defined by Tyler (1968a), which contains *L. dorsalis* of New Guinea and *L. microbelos* of northern Queensland. The members of the group share long, slender, unwebbed fingers, reduced interdigital webbing of the toes and extremely small adult size.

Litoria timida is larger than *L. dorsalis* and *L. microbelos* (maximum adult size of males and females: *dorsalis* 21 mm and 22 mm; *microbelos* 19.4 mm and 18.9 mm). The feature by which these species can be distinguished most readily is the canthus rostralis: strongly curved and sharply defined in *timida*, but straight or slightly curved and not a prominent feature in *L. dorsalis* and *L. microbelos* (Fig. 3). From *L. microbelos* the new species is further distinguished by its colouration: examples of *L. microbelos* are usually only very slightly stippled and there is a tendency for the dorso-lateral surfaces to be darker than the dorsal. In *L. timida* pigmentation is more extensive, and in the only specimen in which the dorso-lateral surfaces differ from the dorsal, the dorsal portion is darkest. *Litoria microbelos* lacks vomerine teeth (present in *L. timida*) and has much shorter hind limbs, as indicated by a comparison of the ranges of the TL/S-V ratios: 0.605-0.647 in *L. timida*, 0.500-0.579 in a series of thirteen *L. microbelos* from Cairns—S.A.M. 12571-4, M.C.Z. (Uncat.).

Fig. 3. Heads of A. *Litoria timida* and B. *L. dorsalis* demonstrating the difference in the shape of the canthus rostralis. Both specimens are males and there is no evidence of sexual dimorphism.

Litoria dorsalis resembles *L. microbelos* more closely than it does *L. timida*. Pattern of pigment on the dorsum of *L. dorsalis* most commonly tends to form broad and slightly contrasting, longitudinally arranged, light and dark stripes. Vomerine teeth are present but difficult to detect when elevations of the vomerine bones are absent. The range of TL/S-V ratios is intermediate between those of *L. timida* and *L. microbelos* (0.541-0.621).

The only other hylid species recorded from the Southern Lowlands of New Guinea (recognised as a faunal unit by Tyler (1968a), and including the Western District of Papua) which approximate the size of *L. timida* are *L. bicolor* and associated species. Such species are usually uniformly bright green dorsally, and can be further distinguished from *L. timida* by possession of webbing between the fingers, lateral fringes on the fingers, and fully webbed toes.

The high TL/S-V ratio of *L. timida* approaches that of *L. nasuta*. Because the first couplet in the relevant key to hylid species compiled by Tyler (1968a) involves separation of species on the basis of a TL/S-V ratio higher than or lower than 0.65, comparison with *L. nasuta* is necessary. In habitus these species are quite distinct, *L. nasuta* being much larger and having a very long, slender head and body. Adult *L. nasuta* attain 45 mm (males) and 55 mm (females); juveniles (and adults) can be readily distinguished by their possession of longitudinal skin folds on the dorsum.

Habitat: The type locality of Menemsorae and Derongo and Yongtau are in the vicinity of Ningerum at the headwaters of the Fly River in the extreme northwestern part of the Western District (Fig. 1), and are within dense rain forest. The terrain is gently undulating to the south of Ningerum and hilly to the north. The series from Menemsorae were collected on the leaves of plants adjacent to, or overhanging, the water of a permanent swamp in the forest.

Oroi is situated in tropical rainforest partly cleared to form garden areas. It is believed that the specimen obtained there had been collected in the extensive adjacent sago swamps. The Brown River Forest Reserve similarly provides an extremely moist habitat.

Call: Calling males were observed occupying a horizontal position on leaves close to the water. We lack tape recordings of the calls, but note

that audibly they are readily distinguishable. The call of *L. timida* was likened to two short clicks, each followed by a pause, and then a sequence of rapid notes: "tik . . . . . tik . . . . . tititititi". In contrast, the call of *L. dorsalis* comprises a series of from six to twenty short, "woodeny buzzes", and that of *L. microbelor* a low, insect-like "creeeek", becoming progressively higher pitched.

Notes: It was noted that indigenees of the Ningerum area did not recognise the new species. They consistently considered specimens to be juveniles of larger species such as *L. thesaurensis* or *L. amboinensis*.

The specific name proposed for the species alludes to the timid nature of the animal. When disturbed it rapidly attempts to escape.

ADDITIONS TO THE PAPUAN HYLID FROG FAUNA

Litoria nigrofrenata (Gunther)

Until recently this species was known solely from the types collected at an unspecified locality on the Cape York Peninsula, re-examined by Moore (1961) and Tyler (1968b). Additional specimens were subsequently collected by the second author on the Cape York Peninsula at Endeavour River, Leggits (Jones) Lagoon and Big Tableland (all within a 15 km radius of Cooktown).

The occurrence of this species in New Guinea is based on the following nineteen specimens:

Boze, Binaturi River: M.C.Z. 81097; Kuru: M.C.Z. 81094-96, P.N.G.M. (F.P.) 438 (2), S.A.M. 11408; Morehead: M.C.Z. 84549-50, S.A.M. 11316-19, 10660, 11407 (3); Old Zim. Oriomo River: M.C.Z. 79723-24, S.A.M. 10621 (2); Weam: M.C.Z. 79725-26. These localities are all situated to the south and south-west of the outlet of the Fly River and are within 60 km of the coast.

The diagnostic characters of this species are as follows: Size moderate (maximum snout to vent lengths: males 41 mm, females 42 mm). Head elongate with the snout projecting in profile; head consistently longer than broad. First finger longer than second; fingers without webbing; fourth toe webbed to base of penultimate phalanx; terminal discs small. Dorsal surfaces of the head, body and limbs uniform pale brown, with a broad, dark brown stripe extending from the tip of the snout to a position posterior to the tympanum. There is a horizontal white bar anterior to the eye partially bisecting this dark lateral band (Fig. 4).

Because few detailed comparisons of such disjunct populations have been undertaken and none previously published, measurements and proportions of specimens of *L. nigrofrenata*

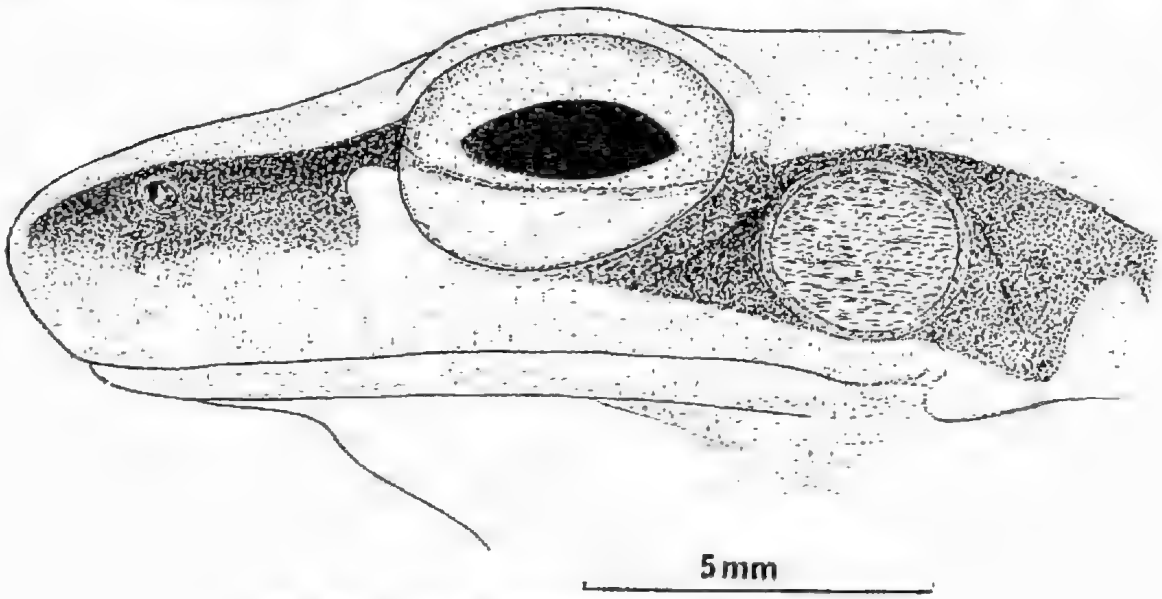

Fig. 4. Lateral view of head of *Litoria nigrofrenata*.

from New Guinea and Australia are presented below.

	AUSTRALIA	NEW GUINEA
Number	12	5
S–V (males)	37.2–41 (mean 38.2)	36.9–38.8 (mean 38.0)
S–V (females)	38.9–41.3 (mean 40.1)	41.8 (mean 41.8)
TL/S–V (pooled)	0.541–0.697 (mean 0.629)	0.584–0.666 (mean 0.632)
EN/IN (pooled)	0.925–1.162 (mean 0.999)	0.975–1.083 (mean 1.007)
HL/HW (pooled)	1.078–1.309 (mean 1.180)	1.181–1.262 (mean 1.230)
HL/S–V (pooled)	0.360–0.398 (mean 0.376)	0.387–0.404 (mean 0.396)

In life the dorsal surfaces vary from a pale yellowish-brown to reddish-brown; adults are immaculate, but juveniles are speckled with darker pigment.

Litoria nigrofrenata exhibits considerable variation in leg length and individuals with TL/S-V ratios equal to or exceeding 0.65 key out in Tyler's (1968a) key of lowland species to *L. nasuta*. Specimens with lower TL/S-V ratios key out to *L. vagabunda*.

Litoria nasuta is similar in habitus to *L. nigrofrenata* but is distinguishable by possession of longitudinal skin folds on the dorsal surface of the body and by lack of a lateral head stripe. In contrast, *L. vagabunda* is a broad-headed species with short limbs (TL/S-V of allotype — 0.513) (Tyler 1968a). *Litoria vagabunda* is dark blue in preservative and so probably green in life.

Litoria nigrofrenata was collected in sparsely forested areas and savanna, and particularly in open patches of grass on damp or swampy ground. Some specimens were taken beside airstrips and others in grass-covered clearings bordering tracks through the forests. It is an extremely timid nocturnal species, leaping rapidly towards the cover of dense vegetation when disturbed. By day it behaves similarly when found sheltering in tall grass.

Litoria rothi (de Vis)

Litoria rothi is a member of the *L. peroni* species group. Until recently it was regarded as identical with *L. peroni* which, in reality, it replaces in north-east Australia (I. R. Straughan, personal communication).

The New Guinea material consists of the following specimens: Gnao, Pahoturi River: M.C.Z. 84551; Old Zim, Oriomo River: M.C.Z. 79727; Wipim: S.A.M. 10623; Boze, Binaturi River: M.C.Z. 79728, 81613-15, P.N.G.M. (F.P.) 350; Weam: M.C.Z. 79729, S.A.M. 13113; Morehead: M.C.Z. (F.P.) 37605 (3), P.N.G.M. (F.P.) 561, S.A.M. 13111-12.

This arboreal species is characterised by the following features: size moderate (maximum snout to vent length of males = 42 mm, females 44 mm); fingers approximately one-third webbed with flattened, dilated terminal discs; tympanum partially hidden by pronounced supratympanic fold; dorsal surfaces of preserved specimens dull brown, sometimes with poorly defined, irregular patches; back of thighs black, with two or three uniformly shaped, pale cream markings. There are black markings in the inguinal and axillary regions, and a black line along the inferior margin of the supratympanic dermal fold; iris (in life) dull red above the pupil, and pale grey or pale gold below it.

The only member of the *L. peroni* species group formerly known to occur in the southern lowlands of New Guinea is *L. amboinensis*, reported by Tyler (1968a) from Mabilabol on the Ok Sibil River in West Irian, and more recently found by one of us (F.P.) to coexist with *L. rothi* in the Western District. *Litoria amboinensis* is a much larger species with fully webbed fingers, and lacks the black thigh markings of *L. rothi*.

Litoria rothi was found in sparsely wooded areas and in monsoon forest. It was commonly collected at night on leaves of plants within 2 m of the ground; the series collected at Boze were on the leaves of an ornamental *Croton* near village houses. During daylight it was found within curled leaves, under bark and in similar refuges.

Litoria rubella (Gray)

Litoria rubella is a wide-ranging species in Australia, occurring in diverse habitats over the entire northern half of the continent. Its presence in New Guinea has been established by the collection of the following 77 specimens: Daru Island: M.C.Z. (F.P.) 30592; Weam: M.C.Z. (F.P.) 31467, 81609-12, 81099-81100; Morehead: A.M.N.H. 84527, S.A.M. 10630 (2), 13120-23, 13125-29, P.N.G.M. (F.P.) 334, (F.P.) 562, M.C.Z. (F.P.) 30936 (2), (F.P.) 30937 (2), (F.P.) 30938 (14), (F.P.) 37606, (F.P.) 37607 (30), A.M. 32709-14.

The characteristic features of the species are: small size (maximum S-V of males 32 mm, females 34 mm) and squat habitus with very short hind limbs; expanded digital discs; fingers approximately one-third webbed and toes extensively webbed; colouration brown with broad, darker brown dorso-lateral stripes on the body. In life the dorsal surfaces are brown, suffused with a greyish, yellowish or reddish tinge. All specimens taken at Morehead were densely marked with small black flecks, but such markings were absent in those from other localities. The posterior surfaces of the thighs are either immaculate yellow or unpigmented but for a fine brown stippling.

Of the species occurring in New Guinea and recognised by Tyler (1968a), *L. rubella* is most closely related to *L. congenita*, from which it is readily distinguished by its possession of the dark dorso-lateral stripes, and by shorter hind limbs (TL/S-V range for *rubella* — 0.335-0.432; 0.477-0.520 for *congenita*, *vide* Tyler 1968a, p. 72).

Litoria rubella was collected mainly in open, man-made grasslands within lightly forested country. Most specimens were collected on airstrips. It is a nocturnal species, hiding by day in situations such as cracks in fence posts and amongst plant leaves. At night it was found within 2 m of the ground, and consistently did not make any attempt to escape when illuminated by a spot light.

Acknowledgements

We are greatly indebted to Dr W. G. Inglis, Director of Environment and Conservation, South Australia, for constructive criticism of the manuscript, and to Mr J. I. Menzies, Department of Biology, University of Papua and New Guinea for specimens of *L. timida* from Brown River Forest Reserve.

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TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA

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THE ASCIDIANS OF SOUTH AUSTRALIA II. EASTERN SECTOR OF THE GREAT AUSTRALIAN BIGHT AND INVESTIGATOR STRAIT

BY PATRICIA KOTT

Summary

Seventy-two species of ascidians from South Australian waters are discussed. Fourteen of these are new and 42 have previously been reported from South Australian gulf waters. Morphological convergence to exploit the environment is evident in many of the forms present. The data support the existence of a marine faunal boundary at the eastern end of the Great Australian Bight. It is suggested that there are ecological factors responsible for the difference between the South Australian gulf and open coast ascidian fauna.

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Introduction

Collections of ascidians have been previously made from St. Vincent and Spencer Gulfs (Kott 1972a) and from Port Phillip Bay and other locations on the Victorian coast (Millar 1966). The present collections are the first reported on from the southern coast of Australia between Middleton Beach, Albany (S.W. Aust.) and Spencer Gulf.

Seventy-two species of the Class Ascidiacea from South Australian locations (Fig. 60) are recorded. Of these, 42 had already been reported from St. Vincent Gulf, Spencer Gulf and Encounter Bay (Kott 1972a). Fourteen new species are described.

The association of species in the areas being considered differs from that in the gulf areas (Kott 1972a). Colonies in which each zooid maintains independent openings to the exterior are apparently favoured and many species demonstrate convergence in their adaptations to exploit the environment, especially in regard to their siphonal apparatus.

The large number of species taken, and especially the large proportion of new species, reflects the new habitats that are now being explored by SCUBA diving.

Type specimens are deposited in the South Australian Museum (SAM) or the National Museum of Victoria (NMV).

Order ENTEROGONA
Suborder APLOUSOBRANCHIA
Family **CLAVELINIDAE**
Subfamily CLAVELININAE

Clavelina mirabilis n.sp.

Type Location: Waldegrave I.: in gravelly sand, attached to limestone, 23 m, *Shepherd*. *Holotype*: SAM, E902. *Paratypes*: SAM, E903.

FIGS 1, 2

Description: The colonies consist of a spherical, sand covered, base from 2–5 cm in diam. with a thick, naked, branching stalk arising therefrom. The thoraces of zooids extend from the terminal branches, each enclosed in its own test covering. The living specimen is buff or yellow brown. In preservative, however, the test of the stalk is reddish-purple, although the terminal, free thoracic parts of the zooids are almost transparent. The gravel and sand attached to the spherical basal part forms a firm outer coat.

The zooids are up to 4 cm in length and extend parallel to one another down through the stalk portion into the base of the colony. The atrial aperture is sessile although the branchial aperture is on a short siphon. When the thorax is contracted, the atrial aperture is withdrawn to the middle of the dorsal surface, while the branchial aperture remains terminal. When the zooid is extended, however, the atrial aperture is produced to the anterior end of the zooid, more or less level with the branchial aperture. There are 15 longitudinal thoracic muscle bands extending from the ventral surface, from the branchial aperture and from the mid line between the branchial and atrial apertures. These extend towards the posterior end of the thorax, and continue in a wide band on either side of the abdomen. There are 18 rows of about 45 rectangular stigmata. The stomach is present in the posterior end of the abdomen and it has 4 thickenings in its wall.

Remarks: The zooids of this species are larger than other colonial species of the Clavelinidae, and the species is unusual in that the zooids

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extend the whole length of the colony and are not confined to the upper free part as in *Podoclavella cylindrica;* nor are they completely embedded as in *Clavelina haudinensis* (see below).

Most species of the family are attached to a substrate by the bottom of the stalk. In the present species, however, the unique adhesive property of the sides, as well as the bottom of the basal part of the colony, has resulted in an encrustation of sand, shell and other foreign particles to form its distinctive hard, spherical, surface which appears to have been embedded in the substrate to anchor the colony. The habit is most unusual since the spherical shape of the base of the colony does not appear to provide a rigid attachment or root system and there could be some movement of the colony in the substrate.

The habit may be compared with that of certain Stolidobranchia and Phlebobranchia where adherent sand forms a hard protective envelope around free-living individuals that are not fixed to the substrate.

Clavelina nodula n.sp.

Type Location: Off Waldegrave I., *Shepherd*. *Holotype*: SAM, E898. *Paratypes*: SAM, E908.

FIG. 3

Description: The colony consists of a firm, translucent, branching stalk of 1.0 cm in diam. The zooids, separate from one another and each in its independent covering of delicate, completely transparent, test, are crowded around the free ends of the common stalk and its branches. The living zooids are bright orange in the centre but colourless in preservative. In the present specimens the zooids are mostly retracted into the common stalk. They are 4–8 cm long, depending on their degree of contraction. The abdomen is many times longer than the very short thorax. There are up to 20 oblique or longitudinal (sometimes coalescing) muscle bands on the thorax, of which 5–10 cross the mid-ventral line posterior to the branchial siphon. The thoracic musculature extends to the postero-dorsal corner of the thorax and continues in wide bands along either side of the abdomen. There are three rows of about 20 stigmata. The gut loop may be relatively long. The stomach is in the posterior end of the abdomen and its glandular lining is divided into four sections.

Remarks: The zooids of this species, although smaller, resemble closely those of *Pycnoclavella diminuta* (Kott), although there are fewer stigmata in the present species. The colony form provides the main distinction between the species. In *P. diminuta* zooids are parallel to one another, and may be entirely independent although the test of adjacent zooids may fuse, or be confluent for varying distances from the base to form a stalk. In *Clavelina nodula* the zooids are not parallel to one another, but radiate from around the free end of a distinct common stalk. Clumps of protruding zooids at different points along the stalk precede the formation of a branch and appear to contribute to the later development of that branch. The addition of new zooids, developing from vascular stolons within the stalk, do not directly affect its diameter although they are accommodated in the stalk when withdrawn from the surface as in the present preserved specimens.

Clavelina haudinensis Kott, 1957: 87 (specimens with small larvae, from Rottnest I. and Laverton Bay). ?Millar, 1966: 363. Non *Clavelina haudinensis* Kott, 1972a: 4.

New Record: Elliston Bay. *Previous Records*: W. Aust. (Rottnest I.); Vic. (Laverton Bay)—Kott 1957.

Description: Small capitate colony consisting of an almost spherical head and short wide stalk. The test of the head is very delicate and completely transparent while that of the stalk is firmer. Zooids are embedded completely and open all around the surface of the head from which they radiate in toward the stalk. The preserved zooid is transparent with pigment spots in the mid line, dorsal and ventral to both apertures. There are about 12 longitudinal muscle bands in the thorax, of which only 2 extend across the mid line ventral to the branchial siphon. There are 16 rows of about 40 stigmata. The stomach is about half way down the abdomen and is small, with its inner glandular wall divided into four distinct sections.

Remarks: A re-examination of specimens previously identified as this species (Kott 1957) has shown that indeed there are two species represented, suggested by different larvae (Kott 1969a), and that *C. haudinensis* is distinguished by its slightly smaller zooids, with more rows of stigmata but with fewer longitudinal muscles on the thorax and crossing the ventral mid line. Zooids in the present species also tend to radiate in from the surface of the head in contrast to a more parallel arrangement observed in other specimens that rep

resent a distinct new species to be described in a later work (Kott, in press (3)).

Podoclavella moluccensis Sluiter. Kott, 1972a: 5 and synonymy.

New Records: Elliston Bay. For *Previous Records, Description*, see Kott 1972a.

Remarks: The zooids rising from the basement membrane are separate from one another for their whole extent. There are four pigment spots dorsal and ventral to and on either side of the branchial aperture.

Podoclavella cylindrica (Quoy & Gaimard). Kott, 1927a: 5 and synonymy.

New Record: Waldegrave I. For *Previous Records, Descriptions*, see Kott 1972a.

Podoclavella meridionalis Herdman, 1891: 603; 1899: 4. Hartmeyer, 1919: 104. Hastings, 1931: 81. Kott, 1957: 91.

New Record: Pearson I. *Previous Records*: W. Aust. (Cape Boileau, Cape Jaubert)—Hartmeyer 1919. Qld. (Great Barrier Reef, Mackay)—Hastings 1931; Kott 1957. N.S.W. (Port Jackson, Nelson's Bay, Port Stephens)—Herdman 1899.

FIG. 4

Description: Only a single specimen is available. This consists of a long stalk and rounded head slightly shorter than the length of the stalk. The whole zooid is about 10 cm high. The test is soft, transparent and gelatinous on the head but the test of the stalk is tougher. The test surrounding the siphons is especially delicate. The body wall of the zooid is pigmented blue to black and is easily seen through the transparent test. The branchial aperture is terminal and recurved so that the opening is directed laterally and downwards. The smaller atrial aperture from the antero-dorsal corner of the head is directed upwards. There are 3 rows of branchial tentacles at the base of the branchial siphon. The largest tentacles in the most posterior row alternate with moderate-sized tentacles in the middle row, while in the third and most anterior row there are twice the number of small tentacles. There is no true dorsal lamina although triangular languets are expanded from the transverse vessels at the side of the mid-dorsal line. There are 34 rows of at least 100 stigmata on each side of the body. The dorsal tubercle has an undulating longitudinal slit. In the present specimen the abdomen is very contracted and the course of the gut obscured. The stomach is identified as a region where the gut wall has a glandular appearance but does not appear to be of greater diameter than the rest of the intestine. The body wall is thick and heavily pigmented. Longitudinal muscles extend from both siphons and cross one another on the thorax and extend down both sides of the abdomen.

Remarks: Although records of this species are few, it has a circum-Australian distribution. It could be a common component of the fauna in sheltered caves and reef overhangs where hitherto it has been inaccessible to collectors.

Oxycorynia arenosa n.sp.

Type Location: Investigator Strait (Stn. Y18), low, flat reef, 30 m. *J. Watson. Holotype*: NMV, H168. *Paratypes*: NMV, H169.

FIGS. 5–7

Description: The colonies form cylindrical or finger-like lobes only very slightly expanded at their free end. They are 1.0–1.75 cm in diam. and up to 9 cm long. They sometimes branch along their length or rise from a common base. The surface of the central lobe is sandy to a depth of about 2 mm, although the anterior portion of the zooids protrudes through the sandy layer and is covered by a thin layer of sand-free, transparent test. The central part of each lobe inside the sandy layer of test is soft and transparent. In preservative, the zooids have black pigment cells in the thorax which confer the dark colour seen through the sandy layer. Zooids open all around the surface of the cylindrical lobes for their whole length. Zooids extend toward the interior of the colony and their long posterior abdominal stolons continue down along the length of the lobe and into the base of the colony. The branchial and atrial openings are plain-rimmed and may be funnel-shaped. There are 12 broad longitudinal bands of muscle fibres on each side of the thorax extending along both sides of the abdomen. There are 6 rows of 20 long rectangular stigmata. The abdomen is about twice the length of the thorax with a long oesophagus and a spherical stomach in the posterior end of the abdomen. The zooid is only about 0.5 cm long.

Remarks: The small number of rows of stigmata and the arrangement of the zooids radiating in from all around the cylindrical stalk distinguishes this species from most others in the family where there are usually more rows of stigmata and the zooids open on the free ends of lobes and extend through the colony

parallel to one another. The parallel longitudinal thoracic muscles extend from both siphons along the length of the body and do not, as in the other species of this family, extend from across the endostyle. *Oxycorynia fasicularis* (Drasche) (see Michaelsen 1930 for synonymy), does have zooids radiating from around the head of the colony but here there is a distinct, zooid-free stalk distinguishing it from the present species and the zooids are completely embedded.

Subfamily HOLOZOINAE

Atapozoa marshi Brewin, 1956: 31.

New Record: Investigator Strait (Stns. Y14, 17). *Previous Record*: W. Aust. (Trigg I.) —Brewin 1956.

FIGS. 8, 9

Description: The colonies form lobes of varying length up to 6 cm and from 1 to 2 cm in diam. The zooid-free basal stalk is more or less the same diameter as the head of the colony, although it does not have adhering sand and is of a slightly firmer consistency. There is a very thin encrustation of sand on the surface test around the head of the colony. The zooids open to the surface by separate, 6-lobed branchial and atrial apertures. There is a brown pigment spot above the dorsal tubercle. There are about 15 longitudinal muscles on the thorax and three rows of 15 stigmata. The oesophagus is short. The rounded stomach is especially small and is smooth-walled. There is a large group of male follicles to the left of the gut loop. In one colony there is a single immature embryo contained in a brood pouch from the postero-dorsal corner of the thorax.

Remarks: The colony is similar to that of *Oxycoeynia fasicularis* (Drasche) (see Michaelsen 1930), and the shape of the colonies in both species varies in a similar fashion. The zooids, however, distinguish the species.

Atapozoa mirabilis n.sp.

Type Location: Elliston Bay, floor of cave, 6 m. *Other Records*: Elliston Bay, 11 m, *Shepherd*. *Holotype*: SAM, E899. *Paratype*: SAM, E896.

FIG. 10

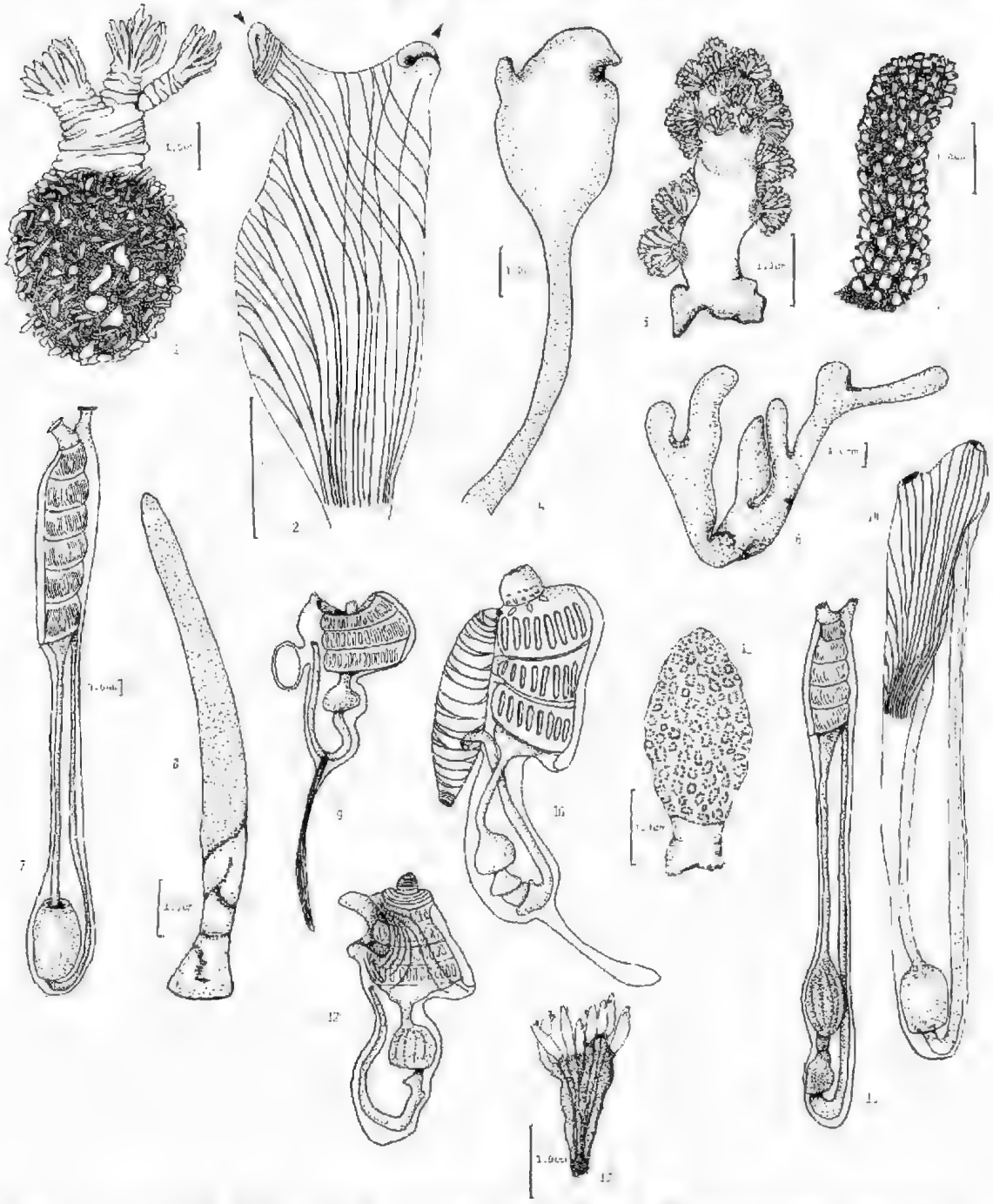
Description: The colony consists of hollow lobes and lamellae coalescing with one another to form a thick and convoluted mass about 15 cm long and 4 cm high, traversed by passages and spaces. There are large common cloacal apertures present, randomly distributed around the lobes, and these are often, but not always, near the top of the colony. The zooids are randomly arranged and do not appear to be in rows. They are seen as white dots in the semi-transparent and very soft test. The zooids open by their branchial apertures onto the outer surface of the colony, while the atrial apertures, directed posteriorly, open into the internal connecting cavities of the lobes and lamellae. Both apertures are 6-lobed and supported on siphons of which the branchial is half the length of the posteriorly directed atrial siphon. There is a short abdomen about the same length as the thorax and a bulbous vascular process extends from the posterior end of the abdomen. This process varies greatly in length in different zooids. Zooids are 2–3 cm long. The thorax has a layer of fine circular muscle bands continuous around the siphons, and there are fine longitudinal muscle bands internal to the circular muscles. These extend down the thorax and join into bands along either side of the dorsal surface of the abdomen and along either side of the vascular appendage. There are 3 rows of branchial tentacles, and 3 rows of 8 long rectangular stigmata. The dorsal lamina is represented by 2 pointed languets opposite the transverse vessels. There is no sign of the gonads in the gut loop in the present specimen. The stomach is spherical and smooth-walled and is present half-way down the abdomen. The oesophagus is fairly long. The rectum is often turned over into the proximal part of the posteriorly-directed atrial siphon, which is often blown out into what appears to be a large balloon-like reservoir.

Remarks: Both the colony and the zooids resemble *Atapozoa deerata* (Sluiter) and *A. vasta* (Millar) (see Kott 1967). The branchial aperture in the present species, however, is not so long, the zooids are not protected by furrows and ridges of the test as in *A. deerata*, and there is no central mass of test around which the cloacal spaces ramify, since here the centre of each lobe is occupied by a large common cloacal space. The vascular process has also been described previously for species of this genus (see *Sigillina deerata*: Hastings 1931).

Atapozoa fantasiana (Kott). Kott, 1972a: 7 and synonymy.

New Record: Denial Bay. For *Previous Records, Description*, see Kott 1972a.

Remarks: In one specimen from Denial Bay, there is some purple pigment scattered through-



Figs. 1, 2. *Clavelina mirabilis*. Fig. 1.—Colony. Fig. 2—Thorax of zooid showing musculature.
Fig. 3. *Clavelina nodula*. Colony.
Fig. 4. *Podoclavella meridionalis*. Individual.
Figs. 5–7. *Oxycorynia arenosa*. Fig. 5.—Portion of colony showing zooids. Fig. 6.—Outline whole colony. Fig. 7.—Zooid.
Figs. 8, 9. *Atapozoa marshi*. Fig. 8.—Colony. Fig. 9.—Zooid showing posterior abdominal musculature.
Fig. 10. *Atapozoa mirabilis*. Zooid.
Figs. 11, 12. *Distaplia distomoides*. Fig. 11.—Colony. Fig. 12.—Zooid.
Figs. 13, 14. *Pycnoclavella diminuta*. Fig. 13.—Colony. Fig. 14.—Zooid; musculature removed from abdomen.
Fig. 15. *Polycitor obeliscum*. Zooid.

out the test and in the other specimen from the same station the test is semi-transparent and there are distinct rings of black pigment in the surface round each of the apertures. Otherwise both are similarly rather fleshy, flat and investing colonies, and the zooids are identical.

Distaplia distomoides (Herdman).

Amaroucium distomoides Herdman, 1899: 75.

New Records: Waldegrave I. Elliston Bay
Previous Record: N.S.W. (Port Jackson).

FIGS. 11, 12

Description: The colonies are cone-shaped and supported on a thick fleshy stalk. Living specimens are rusty-brown or brilliant purple, although in preservative they are cream to buff coloured. The test is soft and there is no adherent sand or foreign particles. The zooids are arranged in circular to oval systems all around the head. The stalk is zooid-free. There are longitudinal to oblique muscles on the thorax and there is the usual wide atrial opening protected by a well produced anterior lip. There are 8 longitudinal and oblique muscle bands on the thorax. There are 4 rows of about 12–15 stigmata crossed by parastigmatic vessels. The stomach is shield shaped and has 8 rounded ridges internally. The oesophagus is relatively short and there is a posterior stomach in the descending portion of the gut loop. There is a large rosette of male follicles to the right of the gut loop. As the colony becomes larger, the stalk is reduced, and the largest colonies are almost entirely sessile as in Herdman's type specimen.

Remarks: The present species resembles *Distaplia valli* Herdman (see Van Name 1918) especially in the shape of the colony, and in the reduction in the length of the stalk as the zooid bearing head increases in size. It is distinguished by the small number of stigmata in each row and the 8 conspicuous glandular stomach folds. Herdman's type specimen of this species is redescribed in Kott (in press (2)).

Distaplia stylifera (Kowalevsky). Brewin, 1953: 60 and synonymy. Kott, 1957: 95, Millar, 1963: 713.

Didemnum stylifera Kowalevsky, 1874: 443.

New Record: North of Waldegrave I. *Previous Records*: W. Aust. (Cape Jaubert to Fremantle). Qld. (Port Tennyson)—Kott 1957. Also the Red Sea, South Africa, and the east coast of north America (see Brewin 1953).

Description: The colony consists of a rounded head 1 cm long, on a stalk of less diameter but approximately equal length. There are 4 rows of 12 stigmata and the zooids are arranged in oval to circular systems opening evenly around the head. Mature gonads are not present.

Remarks: Although the shape of the colony and the zooids are identical with those of *D. stylifera*, the absence of the diagnostic gonads in a sac separated from the abdomen prevents the positive identification of this single specimen.

Sycozoa pedunculata (Quoy & Gaimard). Kott, 1972b: 234 and synonymy.

Aplidie pedunculatum Quoy & Gaimard, 1834: 626.

New Record: Investigator Strait (Stn. Y16) For *Previous Records, Description*, see Kott 1972b.

Remarks: A single small specimen only is available.

Sycozoa cerebriformis (Quoy & Gaimard), Kott 1972b:8 and synonymy.

New Records: Denial Bay, near Ceduna. Elliston Bay. For *Previous Records, Description*, see Kott 1972a.

Family **POLYCITORIDAE**

Pycnoclavella diminuta (Kott), Millar, 1963: 715.

Clavelina diminuta Kott, 1957: 89.

New Records: Elliston Bay, Spencer Gulf (Tipara Reef), St. Vincent Gulf (nr Port Noarlunga, 15 m depth, on rock or epizoic on other ascidians). *Previous Records*: W. Aust. (Cape Boileau, Rottnest I.)—Kott 1957: Millar 1963.

FIGS. 13, 14

Description: Colonies are 2 cm high. Two or more zooids may be fused basally but anteriorly the thoraces of the zooids are always independent. The test is semi-transparent throughout and contains spherical, dark bodies, especially anteriorly. There are 3 rows of stigmata and about 12 fine longitudinal muscle bands on the very short thorax, extending along the ventral surface of the abdomen. The abdomen is about twice the length of the thorax.

The stomach, in the posterior end of the abdomen, is rounded and smooth-walled externally but there are some longitudinal interruptions in the glandular wall. Some of the thoracic muscle bands extend across the endostyle while the more dorsal bands extend from the atrial aperture and from across the mid-line between the apertures. The specimens are identical with the type specimens from Rottnest I. and are larger than those from Cape Boileau (Millar 1963).

Further colonies, apparently of this species, were collected from Tipara Reef in Spencer Gulf (Shepherd, 11 m., 20.viii.1971). The living zooids are yellow. As in Millar's specimens, the zooids are only 1 cm high, of which the upper one quarter is clear glassy test with the usual enclosed dark spherical bodies. The remainder of each zooid is encrusted with sand and is adherent to adjacent zooids. Basally, the test tapers into a fine root-like stolon with fine side branches and the basal part of the colony is a tangled mass of these stolons. There does not appear to be any organic continuity between the stolons of adjacent zooids and there is no basement membrane as in previously described specimens. The zooids have only 5 thoracic muscle bands which extend along both sides of the abdomen in fine bands; and although there are the usual 3 rows of stigmata, there are only 16 stigmata in each half row. Numbers of both muscle bands and stigmata are therefore much reduced in these specimens from Tipara Reef. The stomach is of the usual form. Embryos start their development at the base of the oviduct as is characteristic of this genus. Well developed embryos taken from the oviduct about half way up the abdomen are 1.3 mm long, the tail is wound once around the body, there is an ocellus but no otolith, and there are three 'tube'-like papillae characteristic of the genus (Trason 1963).

Remarks: All specimens share the pyenoclavelid characters of short thorax and large eggs which are fertilized at the base of the oviduct, developing as they pass up toward the atrial aperture. The absence of the basal membrane in the specimens from Tipara Reef could be a response to the sandy substrate in which they are rooted. There is considerable variation, however, in the number of stigmata and the number of longitudinal muscle bands in the specimens, which is not related to the size of the zooid. Further collecting may demonstrate that more than a single species is involved.

Polycitor giganteum (Herdman). Kott, 1972a: 9 and synonymy

New Records: Waldegrave I., Elliston Bay; Pearson I., Investigator Strait (Stns. X15, 21). *Previous Records*: See Kott 1972a.

Description: The present colonies vary from small, conical and sessile, to large and spherical, constricted from a sandy base. The basal test is translucent but the test of the head is almost glassy and transparent. Zooids open all round the head and radiate into the base of the colony as is usual for the species. There are 15 longitudinal thoracic muscle bands extending in a wide band along the ventral half of the abdomen. There are 10 rows of about 20 stigmata. The stomach, in the posterior end of the abdomen, has four folds. Gonads are present in the gut loop.

Polycitor obeliscum n.sp.

Type Locality: Investigator Strait (Stn. Y18), 30 m. on a low, flat reef, *Watson*. *Holotype*: NMV; H167.

FIG. 15

Description: The colony forms a pointed, sessile cone. The test is gelatinous and firm, and there is sand basally. Zooids open all around the surface and appear to be arranged more or less in longitudinal lines. Zooids radiate in from the surface to the base of the colony. The abdomen is about four times the length of the thorax. Both apertures are 6-lobed and the atrial aperture is on a short siphon. There are 20 longitudinal thoracic muscles and some transverse muscles on the thorax. There are 5 rows of about 12 stigmata. The stomach which is present in the posterior third of the abdomen is large and smooth-walled although it may be collapsed into folds. There is a small, rounded, posterior stomach.

Remarks: A colony of this species superficially resembles that of *Distaplia distomoides*. The zooids, however, are typically of the genus *Polycitor* and are distinguished from other species in that genus by the very small number of rows of stigmata.

Eudistoma renieri (Hartmeyer). Kott, 1972a: 10 and synonymy.

New Record: Elliston Bay. *Previous Records*: see Kott 1972a.

Description: The present colony forms an irregularly elongate or oval to circular cushion with rounded walls. It is up to 1.5 cm high

and 3 cm in diam. It is fixed by most of the basal surface and the upper surface is smooth. In the living colony, the circles of zooids show as bright red stars in a pale test. However, in preservative, the stars are colourless and the test is black, the pigment being contained in the round cells in the test. The zooids are arranged in circles of up to 6, with the atrial openings adjacent to one another in the centre of the circle forming a pseudo-cloacal opening. There are strong longitudinal muscles on the siphon but there is no conspicuous circular sphincter. There are 15 strong muscle bands on the thorax extending along either side of the abdomen. There are 15 stigmata in each of the three rows.

Remarks: The arrangement of the zooids in circles is usual for this and other related species of the genus. The fleshy firm consistency of the colony is typical of the species.

Cystodytes dellechiajei (Della Valle). Kott, 1972a: 11 and synonymy.

New Record: Elliston Bay. For *Previous Records, Description*, see Kott 1972a.

Family **POLYCLINIDAE**

Subfamily EUHERDMANIINAE

Euherdmania australis Kott, 1957: 103.

New Records: Elliston Bay, off Waldegrave I., Investigator Strait (Stn. Y19). *Previous Records*: Vic. (Port Phillip Heads). N.S.W. (Camden Haven)—Kott 1957.

FIGS 16–18

Description: The colonies are formed of the usual sandy, finger-like, lobes containing a single zooid. The atrial aperture is sessile in the middle of the obliquely flattened to concave free end of the lobe. The branchial aperture is just ventral to the flattended free end and is protected above by a crescentic flap of sand-stiffened test which covers the opening. The aperture itself is in a sand-free area covered by this flap. There are 13 rows of stigmata with parastigmatic vessels. Branchial papillae are present in the middle of the primary and parastigmatic transverse vessels on each side of the body. The anus is present half way up the thorax and has 10 pointed lobes on the border. The stomach is small, with about 16 rather irregular and often branching folds. In the specimens from Waldegrave I., about 8 developing embryos are present in the thoracic part of the oviduct, the most mature embryo being present toward the distal end of the duct. The eggs are therefore fertilised at the base of the oviduct and appear to start their development as they move up toward the opening. Testes are bunched in the short posterior abdomen. Muscles are present, especially round the dorsal border of the branchial aperture, but do not extend far down the thorax. When the anterior part of the zooid is contracted, the lower part of the thorax is pulled upwards, placing the opening of the oviduct opposite the atrial opening.

Larvae: The larvae are 0.9 mm long. They have 3 shallow, wide, papillae in the mid-line. Sets of 3 median ampullae are present in the intervals between the papillae, and in each set the middle ampulla is larger and its free end is flattened, while the dorsal and ventral ampullae in each set are smaller and conical. Small vesicular cells are supported all over the body wall of the larvae.

Remarks: The larva is of the polyclinid type, developing ampullary vesicles and with the usual papillary cells surrounded by accessory cup-like suckers. The papillae are not modified as in other species of this and the related genus, *Placentela* (see Kott 1969a).

Ritterella herdmania Kott, 1957: 102; 1972a: 11 and synonymy.

New Record: Elliston Bay. *Previous Records*: see Kott 1972a.

Description: The colonies consist of small slender lobes, 1 cm long, with expanded spatulate tips, joined basally. Minute zooids open around the border of the lobes. There are 5 rows of stigmata and 5 stomach folds. Papillae are present on the transverse vessel.

Pseudodistoma australis Kott, 1957: 101; 1963: 78.

New Records: Waterloo Bay, Waldegrave I. *Previous Records*: W. Aust. (Rottnest I.)—Kott 1957, 1963.

FIG. 19

Description: Colonies are soft, rounded and sessile, up to 2 cm in diam. and no more than 0.5 cm thick. The test is especially soft and semi-transparent. The zooids may be orange-brown with flecks of black, and in the preserved colony spherical black pigment-cells remain. Zooids open over the upper surface by two separate, 6-lobed openings. There are 3 rows of about 20 stigmata. There are 15 strong longitudinal muscle bands on the thorax

which extend as a single band down the ventral side of the abdomen and onto the posterior abdomen. The stomach is small and smooth walled, with a distinct typhlosolar line, and is present half way down the abdomen. The oesophagus is fairly short. The thoracic muscles extend down the ventral side of the abdomen and to the left of the intestinal loop onto the posterior abdomen, which, in these specimens, appears to arise from the left side of the intestinal loop owing to the strong contraction of the body musculature. The thorax, abdomen and posterior abdomen are of equal length. Gonads are not developed in the present specimens. In specimens from Waldegrave I, there is occasionally a large balloon-like brood pouch.

Remarks: The specimens have been compared with the type specimen of *Pseudodistoma australis* and found to be identical, although in the type the posterior abdomen is better developed with mature gonads. *Pseudodistoma cyrnusense* Pérès, 1952, and *P. fragilis* Tokioka, 1958, are related species with a sessile colony, short abdomen and oesophagus, small smooth stomach, and the testis follicles bunched at the posterior end of the posterior abdomen. *P. cyrnusense* has only 12 stigmata per row, while both *P. australis* and *P. fragilis* have 20 or more stigmata per row. *P. fragilis* is distinguished from the present species by the presence of up to 3 embryos in a brood pouch, while in *P. australis* only a single embryo has been found in the brood pouch that is constricted from the postero-dorsal aspect of the thorax (see Kott 1963).

Pseudodistoma cyrnusense Pérès, 1952: 37.

New Record: Elliston Bay. *Previous Records*: Mediterranean—Pérès 1952.

FIG. 20

Description: The colony is a very soft, irregularly rounded, inverted saucer shape, 8 cm in diam. and about 1 cm high in the centre. The surface is very smooth and there are no adherent or included foreign bodies. The test is slightly transparent, cloudy and of creamish colour. Zooids open separately to the exterior over the upper surface. The siphons are fairly muscular and there are 12 fine longitudinal muscle bands on the thorax extending along both sides of the abdomen and posterior abdomen. There are 3 rows of stigmata with about 12 stigmata per row. The abdomen is slightly longer than the thorax, although the posterior abdomen is about 3 times the length of the abdomen. The stomach is half way down the abdomen and externally is smooth, although internally there appear to be 4 glandular ridges. There are minute mulberry-like cells in the common test, from 0.01–0.02 mm in diam.

Remarks: It has not been possible to separate the present colony from Pérès' Mediterranean species. The colony form and consistency, the number of stigmata, and the size and shape of both the stomach and of the zooid are identical. *Pseudodistoma aurea* (Brewin 1957) and *P. mauritiana* Vasseur, 1967, both form large fleshy colonies. However, in these forms, the abdomen is very much longer than the thorax and the oesophagus is especially long. *Pseudodistoma fragilis* (Tokioka, 1958) and *P. australis* also form fleshy investing colonies but they are much thinner than the present specimen and have 25 stigmata in each row, distinguishing them from the present specimen which has only 12. The present colony is considerably more extensive than specimens of *P. australis* so far available.

Pseudodistoma cereum Michaelsen, Kott, 1972a: 12 and synonymy.

New Records: Elliston Bay, Waldegrave I., St. Francis I. For *Previous Records, Description*, see Kott 1972a.

FIGS. 21, 22

Remarks: The species is distinguished from other stalked forms by the relatively large number of thoracic muscles (30–40). The stomach is rather capacious and has its internal glandular wall divided into four sections (see Michaelsen 1924). This also helps to distinguish the species from *P. australis* in which the stomach is especially small, shallow and smooth walled.

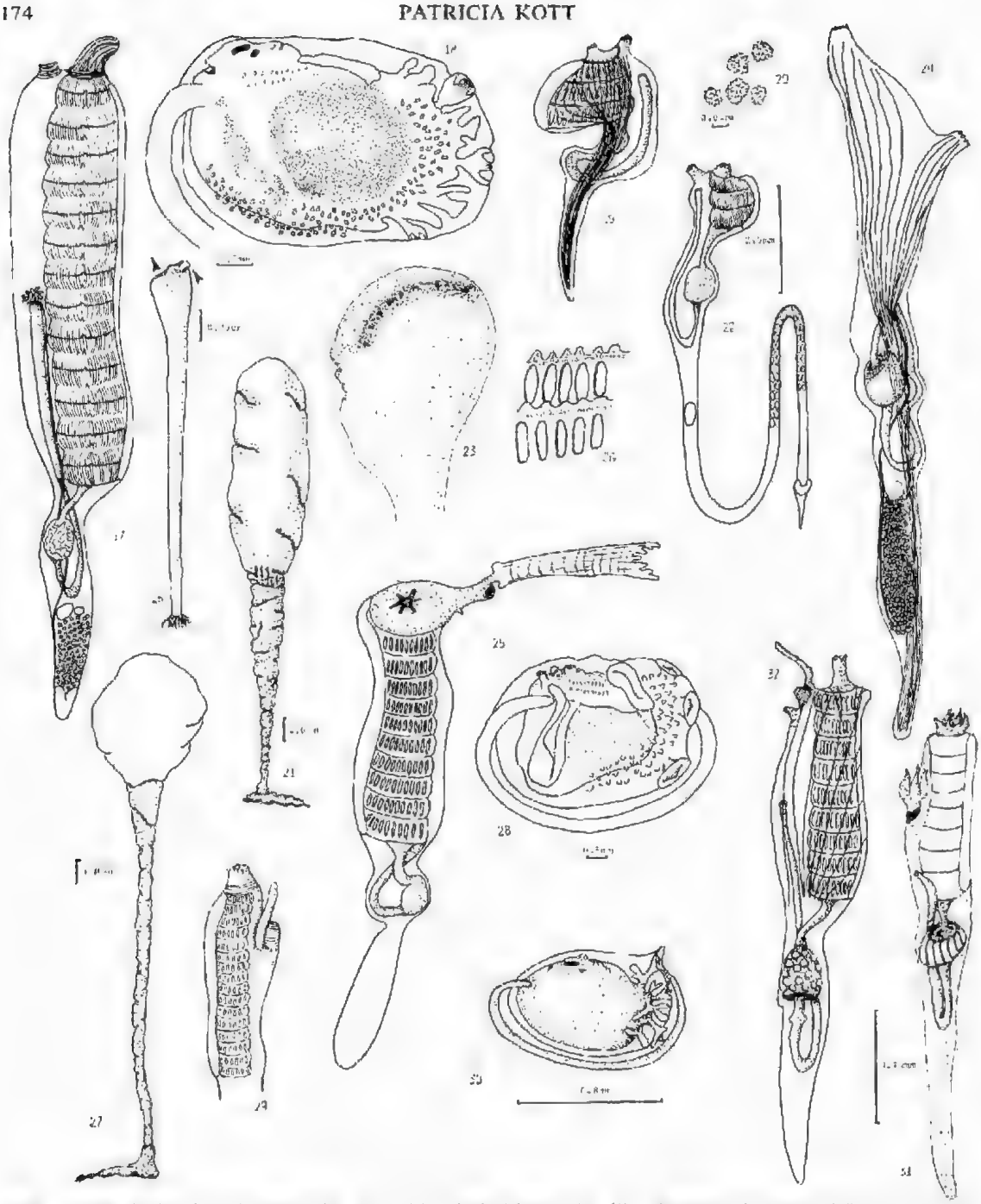
The present colonies from Waldegrave I. are long, with a long stalk and head, while those from Elliston Bay are no more than 2 cm high with a round soft head on a short thick stalk. This range in the form of the colonies has been observed in specimens from New Zealand (see *Sigillinaria novae-zelandiae* Brewin, 1950, a synonym of the present species, and *P. cereum*; Brewin 1958).

Placentela ellistoni n.sp.

Type Locality: Elliston Bay, inside caves, outside bar, 14.v.1971, *Shepherd*. *Holotype*: SAM, E901. *Paratypes*: SAM, E900.

FIGS. 23, 24

Description: The colonies form narrow, fan-shaped lobes, rounded at the free edge and narrowing to the base. The lobes are 5 cm tall



Figs. 16–18. *Eutherdmania australis*. Fig. 16.—Individual. Fig. 17.—Individual removed from test. Fig. 18.—Larva.
Fig. 19. *Pseudodistoma australis*. Zooid.
Fig. 20. *Pseudodistoma cynusense*. Spicules from test.
Figs. 21, 22. *Pseudodistoma cereum*. Fig. 21.—Colony. Fig. 22.—ooid.
Figs. 23, 24. *Placentela ellistoni*. Fig. 23.—Colony. Fig. 24.—Zooid.
Figs. 25, 26. *Polyclinum neptunium*. Fig. 25.—Individual. Fig. 26.—Portion of branchial sac showing papillae produced from transverse vessel.
Figs. 27, 28. *Aplidium colelloides*. Fig. 27.—Colony. Fig. 28—Larva.
Fig. 29. *Aplidium pantherinum*. Thorax.
Fig. 30. *Aplidium flavlineatum*. Larva.
Fig. 31. *Aplidium elatum*. Zooid.
Fig. 32. *Synoicium papilliferum*. Zooid.

and about 2.5 cm broad across the free end, which is the widest part of the colony. There are sand-covered swellings projecting back from the rounded free border of the fan, and overlapping both sides of the colony. The test is very stiff and sandy. Branchial apertures are arranged in an arc protected by the overlap from the rounded free border of the fan. Each aperture is sessile and in a sand-free area of test. The atrial apertures on the opposite side of the colony are in a groove slightly further back than the corresponding arc of branchial apertures. Each atrial aperture is on a small mound and, as with the branchial apertures, is covered by the overlapping rim of the rounded free border of the fan. Zooids are arranged in only a single layer at the top of the colony but as they extend down towards the base, they overlap and cross one another and here the colony is narrower but thicker to accommodate the posterior ends of the zooids. The 6 lobes around both apertures are minute and very pointed. There is a mesh-work of circular and longitudinal muscles on the thorax, extending up around the siphons. There is a wide muscle band on the left side of the abdomen and on the dorsal side of the posterior abdomen, formed by very fine longitudinal bands from the thorax which all cross to the left side of the body across the postero-ventral part of the thorax. There are 17 rows of about 35 rectangular stigmata. The oesophagus is very short and the stomach is smooth and shield-shaped. The abdomen is only about half the length of the thorax. The posterior abdomen is of similar length and contains a large number of male follicles bunched together posterior to the ovary. It appears from the specimens examined that the branchial aperture may be contracted back along the ventral surface of the thorax so that the atrial siphon is terminal. Thus, by virtue of the strong body musculature, the whole top rim of the colony probably moves up and down or from side to side according to whether the arc of branchial apertures or the arc of atrial apertures is to be opened or whether both are simultaneously to be opened or closed.

Remarks: The species is unusual and although the arrangement of zooids within the colony resembles that found in *Ritterella herdmania*, the zooids themselves are distinguished by their strong thoracic musculature, by the smooth stomach (which resembles the type found in the genus *Synoicium*), and by the large number of rows of stigmata.

Subfamily POLYCLININAE

Polyclinum neptunium Hartmeyer, 1912: 331. Kott, 1963: 83 and synonymy.

New Records: Elliston Reef, Elliston Bay. *Previous Records*: W. Aust. (Shark Bay to Albany)—Michaelsen 1930; Kott 1963. S. Aust. (Reevesby I.)—Kott 1963. South Africa—Hartmeyer 1912; Millar 1962.

FIGS. 25, 26

Description: Colonies of large investing sheets or sessile, almost hemispherical, lobes, 4 mm high in thickest part and from 2 cm in diam. There is a dense sandy coat externally, absent only where branchial apertures open to the exterior. The common cloacal apertures are present on the surface, on or at the side of slight rounded elevations. Zooids are in round, to elongate or long, double row systems along either side of shallow, narrow, common cloacal canals. There is no sand in the internal test, which is semi-transparent and soft but tough. There are sometimes, but not always, black spherical pigment cells in the body wall, especially in the atrial languet and around the branchial aperture. There are 6 small, very pointed branchial lobes. The atrial languet, rising from above the sphincter muscle, may be pointed or long and with a flat terminal border fringed with up to 7 minute, pointed, lobes. The shape of the atrial languet is associated with the location of the zooid in relation to the cloacal canals or with the common cloacal openings, and its tip may be incorporated in the border of the opening. There may be a minute papilla from the body wall below the aperture. There are 6 parallel, longitudinal muscle bands in the atrial languet although these may coalesce or divide at any point along their length. These are crossed by very fine traverse muscles. There are 10 longitudinal muscles radiating from the siphons and extending down the thorax, although they may be difficult to detect in the posterior half of the thorax. There are 10 rows of 16 stigmata and a similar number of flat, rounded lobes, confluent at their base, supported along the transverse vessels. The stomach is small and smooth externally but with glandular papillae internally. The posterior abdomen is long and tongue shaped.

Remarks: The relationships of species within this genus have always been difficult to determine, owing to the homogeneity of the zooids and variability of the colony form and atrial languets. The present specimens have been identified by the relatively large number of

branchial papillae, by which the species is distinguished from *P. macrophyllum* (see Michaelsen 1930). There are also fewer rows of stigmata than in *P. macrophyllum*, although the number of stigmata in each row is greater. The internal test is also tougher than is usual for this genus.

Aplidium lobatum Savigny, 1816: 182. Kott, 1963: 97 and synonymy. Tokioka, 1967: 22.

New Record: Elliston Bay. *Previous Records*: see Kott 1963; Van Name 1954.

Description: Specimens are almost spherical and 1 cm in diam. The lower half is sandy and there is a more or less flattened upper surface through which the orange zooids are clearly seen through the transparent test. Sparse sand is present throughout the remainder of the test. The zooids are very small, with a fleshy tripartite atrial languet from the upper border of the opening. There are 6 rows of about 10 stigmata and 5 pronounced stomach folds.

Remarks: The small zooids, the atrial aperture, the small number of stigmata and 5 stomach folds characterise the species.

Aplidium colelloides (Herdman). Kott 1972a: 15 and synonymy.

New Records: off Waldegrave I., Investigator Strait (Stn. Y21). *Previous Records*: see Kott 1972a.

FIGS. 27, 28

Description: There is a rounded, firm, gelatinous head supported by a tough leathery stalk about 17 cm long. Zooids are minute and arranged along both sides of narrow, branching, longitudinal canals. Large common cloacal openings are randomly distributed over the head. The languet from the anterior border of the atrial aperture is very small and pointed. There are 16–18 rows of 10 elliptical stigmata and 15 stomach folds. In the present specimens, there are 2 embryos contained in the posterior part of the peribranchial cavity. One is almost mature while the other is at an early stage of development. This difference in the stage of development of the embryos is observed in all the zooids in which embryos are present.

Larvae: Mature larvae are large, 1.5 mm long. There are small, crowded, epidermal vesicles projecting from the anterior part of the larva around the base of the papillae, and extending along the ventral surface.

Aplidium pantherinum (Sluiter). Kott, 1963: 98 and synonymy.

Psammaplidium pantherinum Sluiter, 1898: 26.

New Record: Elliston Bay. *Previous Records*: W. Aust. (Rottnest I. to Hamelin Bay)—Kott 1963. S. Africa—Sluiter 1898; Millar 1955, 1962.

FIG. 29

Description: The colony is oval in outline, 2 cm thick and 5 cm long. It is fixed by a small part of its base. The base and walls are even and sandy. The surface is marked off into irregularly circular depressed areas that are often free of sand. These are about 5 mm in diam, and are separated from one another by raised sandy ridges about 0.5 cm wide which form a network over the surface and sharply overhang the periphery of the depressed areas. Common cloacal apertures are present in the centre of these depressed areas, and are surrounded by the branchial openings of the zooids. There is sand enclosed throughout the otherwise gelatinous test, thus creating a rather hard colony. Zooids are minute and crowded and radiate down into the base of the colony. The branchial aperture is surrounded by 6 well-defined lobes. The atrial aperture is on a muscular siphon from about half way down the thorax, protected by a long, pointed, lip rising from the body wall anterior to the siphon. The thorax is muscular with a well developed circular sphincter muscle at the base of the branchial aperture. There are about 20 very fine longitudinal muscle bands on the thorax. There are 16 rows of 6 stigmata. The abdomen is about the same length as the thorax, with the small stomach half way down the abdomen. The stomach wall has 5 distinct folds.

Remarks: The form of both colony and zooids is unusual, but does resemble *Aplidium crutiferum* Sluiter, 1909; Van Name, 1918, from the Philippines, which is distinguished however by its 10–12 stomach folds.

Aplidium rubricollum Kott, 1963: 103; 1972a: 15.

New Record: Pearson I. For *Previous Records, Description*, see Kott 1972a.

Aplidium flavolineatum (Sluiter). Kott, 1963: 105 and synonymy.

Amaroucium flavolineatum Sluiter, 1898: 30.

New Records: Elliston Bay, off Waldegrave I. *Previous Records*: W. Aust., S. Aust., Vic., N.S.W.—Kott 1963. S. Africa—Sluiter 1898; Michaelsen 1934; Millar 1955; Tokioka 1959.

FIG. 30

Description: The colonies form low, rounded, cushions about 1 cm high and 1 cm in diam., with a sandy basal half sometimes narrowed to a short thick stalk. In the preserved specimens the zooids are orange, and open onto the transparent upper surface. They are arranged in circular to oval systems of 5–12 zooids. There may be some sand in the surface test between the systems. There are 3 pointed languets from the upper border of the atrial opening. There are about 20 longitudinal muscles on the thorax, continuous along both sides of the abdomen and posterior abdomen. There are 10–15 rows of 12–15 stigmata. The stomach is small and rounded with about 25–30 very narrow folds, slightly oblique and extending anteriorly toward the mid line on both lateral and mesial aspects of the stomach. The abdomen and posterior abdomen are of equal length, although the thorax is smaller. Zooids are very small and usually do not exceed 4 mm.

Larvae: These are present in the peribranchial cavity. They are 0.8 mm long and the tail winds three-quarters of the way around the body. There are median ampullae between the 3 suckers with lateral branches from the base of each median ampulla. The medium ampullae are not always paired as they have been described previously, nor are there posterior vesicles. There has been some variation observed in the form of this larva however (see Kott 1963) and the differences are not thought to be significant.

Aplidium elatum n.sp.

Type Locality: Elliston Bay, outside bar, very strong surge, 17 m, 12.1.1971, *Shepherd*. *Holotype*: SAM E906. *Paratypes*: E905.

FIG. 31

Description: The colonies form tall, undulating, fan-shaped, flattened lamellae and lobes which are sometimes fused. Each lamella is a maximum of 1 cm thick. The maximum height from the base to the free rounded border is 6 cm. The surface is sandy but marked off into slightly prominent, rounded, swellings corresponding to the anterior ends of the minute zooids, which open on both surfaces and on the free edge of the lamellae. The test is sandy throughout and the colony firm and hard. Common cloacal apertures are present from place to place over the surface and zooids are arranged in double rows radiating from them. The zooids and especially the anterior part of the thorax and the endostyle are orange in the preserved specimens. Zooids are about 3 mm long. The thorax and posterior abdomen are of about equal length and slightly longer than the abdomen. The branchial aperture is terminal with 6 sharply pointed lobes. The atrial aperture is opposite the 4th–6th row of stigmata and its anterior lip is produced into 3 almost foliated lips. These are not always of equal size, but they are always very muscular with longitudinal bands extending along their length. There are about 12 fine longitudinal thoracic muscles. There are 8 rows of 8 stigmata. The stomach is very short with about 15 distinct folds.

Remarks: The colonies are very like *Aplidium solidum* (Herdman) (see *A. arboratum* Kott nom. nov. 1963). The species differ however in the number of stomach folds, in the length of the posterior abdomen, and in the length and form of the atrial languets. The colony and the atrial lobes are similar to those of *A. saraxinorum* Millar, 1962, from S. Africa. However, the body musculature and stomach folds differ. *Aplidium multiplicatum* (see Kott 1963) forms jelly-like to firm, investing, colonies and has minute zooids, a branchial sac resembling that of the present species and about the same number of stomach folds. Again, however, the muscular large atrial languet and dense sand inclusion, distinguish the present species.

Synoicium papilliferum (Michaelsen). Kott, 1972a: 16 and synonymy.

New Record: Waldegrave I. *Previous Records*: see Kott 1972a.

FIG. 32

Description: The colony is rounded, lobed and branched. The diameter of a single lobe is about 1.0 cm. The zooids are parallel to one another and at right angles to the surface all around the colony, which does not appear to be fixed. There is a sparse coating of sand grains on the surface and throughout the test. The atrial aperture is on a short muscular siphon and protected by a long pointed lip which is produced from the anterior border of the opening. There is the usual protuberant papilla from the body wall posterior to the atrial siphon. There are 8 fine longitudinal

muscles on the thorax and there are 9 rows of 10 stigmata. The stomach is the usual shield-shape and has mulberry-like glandular swellings.

Remarks: The form of the atrial siphon, the papilla and the stomach with its mulberry-like swellings are characteristic of the species.

Family **DIDEMNIDAE**

Trididemnum cerebriforme Hartmeyer, 1913: 139. Kott, 1962: 275 and synonymy.

New Records: Elliston Bay, Investigator Strait (Stn. X17). *Previous Records*: see Kott 1962.

FIG. 33

Description: There are very extensive posterior abdominal common cloacal cavities and secondary common cloacal canals at the thoracic level. There is a very thin basal layer of test. Zooids are suspended between the basal and surface layer of test by pillar-like strands in which the abdomina are embedded, and through which the thoracic secondary cloacal canals extend. Spicules are sometimes evenly distributed throughout the test although they may be thick in the surface layer but sparse below thoracic level. They are large, 0.03–0.06 mm in diam. with 5–7 conical pointed rays in optical transverse section. Zooids have a minute thorax, with 3 rows of stigmata and a wide atrial opening. There are 7½ coils of the vas deferens around a single testis follicle.

Remarks: The species is identified by the extensive posterior abdominal cloacal system and by the open atrial aperture rather than a posteriorly directed siphon, usually associated with this type of cloacal system.

Trididemnum spiculatum Kott, 1972a: 16.

New Record: Elliston Bay. *Previous Records*: see Kott 1972a.

FIG. 34

Description: The colonies are white and invest stalks and leaves of seaweeds. Deep primary cloacal canals extend around clumps of zooids but the secondary canals remain at thoracic level. There is a long lateral organ. There are 3 rows of stigmata and 5½ coils of the vas deferens around a single testis follicle. The spicules are stellate, with 5–7 rays in optical section, 0.01–0.03 mm in diam.

Remarks: The smaller stellate spicules and the absence of a large posterior abdominal cloacal cavity distinguish the species.

Polysyncraton magnilarvum Millar, 1962: 165. *New Record*: *Investigator Strait* (Stns X15, Y6). *Previous Records*: Natal—Millar, 1962.

FIG. 35

Description: The colonies are irregularly lobed, large and fleshy, and are supported by a very short and relatively narrow stalk. Each lobe may be up to 2 cm in diam. and a maximum of 2.5 cm in length. There are no spicules. There is a surface layer of bladder cells and beneath this some pigment cells which become less frequent internally although they congregate around inclusions and parasites in the test. The zooids are confined to a thin layer of surface test about 1 mm thick, and the centre of each lobe consists of gelatinous, firm, test without zooids. The consistency of the colonies varies from firm and gelatinous to hard and tough, but it is thought that this may reflect the preservation of the specimens. Common cloacal apertures are randomly placed over the surface and zooids are arranged on either side of long cloacal canals radiating from the apertures. The surface of the colony is marked by these long branching canals in the surface layer of test. The zooids are minute and have a long oesophageal neck. The thorax is especially small, 0.5 mm long. The branchial aperture has the usual 6 pointed lobes and there is a wide, open, atrial aperture. There are 4 rows of 6 stigmata. There are 8 testis follicles with 2¼–5¼ coils of the vas deferens. The ventral surface of each zooid is embedded in the common test so that the surface of the preserved colony is marked into small rounded mounds surrounded by a narrow depression where the thin surface test is depressed over the common cloacal canal to which the atrial apertures are exposed.

Remarks: The species is distinguished by its fleshy colony and by the large number of testis follicles and small number of vas deferens coils. *Polysyncraton aspiculatum* Tokioda, 1949, forms flat investing colonies and is often without spicules, but has a long bilid atrial lip which is absent in the present species.

Polysyncraton paradoxum Nott, 1892: 318.

New Record: Elliston Bay. *Previous Record*: New Zealand—Nott 1892.

Description: The living colonies are brilliant orange but in the preserved specimens only streaks of orange remain on the surface. There

are stellate pigment cells scattered amongst the spicules. There is a surface layer of bladder cells, then a dense layer of spicules which become less dense in the oesophageal region of the zooids and are absent completely from the test at the abdominal level and in the basal test. The common cloacal canals are very shallow and thoracic. There are 8 stigmata per row. There are 5 testis follicles and the vas deferens coils 6½ times around them. The spicules are stellate, 0.01–0.03 mm in diameter.

Remarks: *P. paradoxum* var. *mahenum* Michaelsen, 1920, from the Seychelles probably represents a distinct species since it has only 2½ coils of the vas deferens and the spicules have 24 points in optical section. The shallow thoracic common cloacal system and the arrangement of the spicules beneath the superficial bladder cell layer is characteristic of the present form. Owing to the very shallow thoracic common cloacal space, the colony is especially firm.

Didemnum candidum Savigny, Kott, 1972a: 19 and synonymy.

New Record: Elliston Bay. *Previous Records*: see Kott 1972a.

Description: The present colonies have the usual dark-brown zooids with brownish-black pigment cells. The surface test is thin but the basal test is slightly thicker. The cloacal system is thoracic although the primary canals may extend more deeply. The thorax of each zooid is enclosed in its own test sheath as it crosses the common cloacal space. There is sometimes a lateral organ near the posterior end of the thorax. There are 8½ coils of the vas deferens around the single undivided testis follicle. Dense spicules are present throughout. They are 0.03–0.05 mm in diam. and show the characteristic range from burr-like to stellate. Vesicular cells previously described for *Polysyncraton orbiculum* (see Kott 1972a) are present in circles around the branchial apertures.

Remarks: The pigmented zooids and form of the cloacal cavity, and the single testis follicle with a large number of vas deferens coils around it, have been used to identify this species. The presence of the vesicular cells previously thought to be diagnostic of *P. orbiculum* is puzzling. However, although they have not previously been described for *Didemnum candidum*, they have previously been found randomly distributed over the surface of *Didemnum moseleyi* (see Kott 1972a).

Didemnum moseleyi (Herdman), Kott, 1972a: 19 and synonymy.

New Records: Elliston Bay, Emu Bay (Kangaroo I.), Investigator Strait (Stns. X7, 27, Y?). *Previous Records*: see Kott 1972a.

Description: The colonies are of the usual form with dense white stellate spicules, shallow thoracic common cloacal cavity, and large lateral organs. Living specimens from Waterloo Bay are yellow-orange, encrusting red algae.

Didemnum patulum (Herdman), Kott, 1972a: 18 and synonymy.

New Record: Emu Bay (Kangaroo I.). For *Previous Records*, *Description*, see Kott 1972a.

Remarks: The colony forms a large investing sheet marked with the usual blue grey lines to give a marbled appearance.

Didemnum ternatanum (Gottschaldt), Kott, 1966: 287 and synonymy. Tokioka, 1967: 77.

Didemnoides ternatanum Gottschaldt, 1898: 648.

New Record: Elliston Bay. *Previous Records*: see Kott 1966; Tokioka 1967.

FIG. 36

Description: The living colony is bright orange, although this is lost in preservative. The spicules are small and spherical with many very short conical spines projecting from the surface, 0.02–0.03 mm in diam. and very dense throughout the test. The surface of the colony is raised into mounds and ridges with common cloacal apertures on the apex of the thickenings. The primary cloacal canals extend almost to the basal test and usually are posterior abdominal, while there are thoracic secondary canals. Zooids occur in large clumps anchored to the basal test by solid test material in which the abdomina of the zooids are embedded, while in the thoracic region there are separate test sheaths enclosing each zooid and continuous with the surface test. The surface test is fairly thick. The mounds that are apparent on the surface of the test are therefore created by the great proliferation of zooids in these areas, between the primary cloacal canals. There are 5½ coils of the vas deferens around a single testis follicle. There is a long, oval lateral organ on each side of the thorax. The branchial siphon is fairly long with distinct circular muscles.

Remarks: Although the common cloacal cavity in these specimens is not as well developed

as has been previously described for the species, the small spherical spicules help to distinguish it. Kott (1972b) was not able to identify a "yellow crustose" specimen of the family Didemnidae from West I. (near Penguin Rock). Although the gonads were not mature in the West I. specimen it has been compared with the present colonies from Elliston and is identical in every respect. In particular, the cloacal system and the distribution and form of the spicules are identical.

Leptoclinides reticulatus (Sluiter). Kott, 1972a: 18 and synonymy.

New Record: Investigator Strait (Stn. Y6). *Previous Records*: see Kott 1972a.

Description: Spindle and stellate, purple and orange, pigment cells are present in the surface layer of test. Common cloacal openings are frequently and evenly distributed over the surface. The common cloacal system is extensive at the oesophageal and posterior abdominal level. The zooids are of the usual form with a posteriorly directed atrial siphon.

Leptoclinides fungiformis n.sp.

Type Locality: Outside Pearson I., on gravelly bottom mostly attached to shell or rock fragments, 9.5.1969, 50 m, *Shepherd*. *Holotype and Cotype*: SAM. E911.

FIGS. 37, 38

Description: Two specimens are available from the type locality. They are about 6 cm high with a rounded head. There is a single cloacal aperture terminally. There is a thick dense layer of spicules in the surface test at the level of the branchial siphons. Spicules are less dense elsewhere in the head. In the stalk, the spicules are more evenly and densely distributed throughout. There is no surface layer of bladder cells. The test is firm but not tough. The test in the stalk is similar in consistency but is perforated by longitudinal spaces. The primary cloacal system consists of extensive cavities posterior to the superficial zooid layer surrounding a central core of test. Secondary canals receive the openings of the posteriorly directed atrial siphons and open into the primary cloacal cavity. Zooids open to the surface of the colony by a 6-lobed aperture. The atrial apertures are posteriorly directed from the posterior third of the thorax and have distinct circular muscle bands forming a sphincter. A circular sphincter muscle is present on the branchial siphon, but is not quite so apparent. There are also fine longitudinal muscles on the thorax. There are 4 rows of about 8 stigmata on each side of the thorax. Eggs are large. The testis follicle is apparently undivided and the vas deferens is wound around it. The stomach is small and rounded. The zooids in these colonies are budding from the oesophageal region. Embryos are present in a layer beneath the zooids, but none were sufficiently mature to discern their form. The posteriorly directed atrial siphons open into the secondary cloacal canals rather than directly into the common cloacal chamber.

Remarks: Spicules are stellate and are fairly large. Although closely related to *Leptoclinides kingi* in the development of the cloacal system, the present species is distinguished by its larger spicules and smaller zooids, by the single testis follicle and by the smaller intestinal loop. The present species is further distinguished by its well developed stalk. No other stalked species of *Leptoclinides* has previously been described.

Suborder PHLEBOBRANCHIA

Family ?

Records: As well as the species of this suborder listed below, specimens of an undescribed colonial species have been taken from stations Y18, Y19 and from two other locations, all in Investigator Strait. The species will be described and its phylogeny discussed in a subsequent publication (Kott, in press (*1*)).

Family **ASCIDIIDAE**

Ascidia thompsoni Kott, 1972a: 27.

New Record: Elliston Bay. *Previous Records*: see Kott 1972a.

Description: Individuals are the usual oval, laterally flattened shape, lying mostly on the left side. The body is pinkish and shows through the firm translucent test. There are no muscles on the left side of the body. Body musculature is present as an irregular network on the right or upper side of the body, stopping abruptly at the endostyle, and no muscles were detected on the left side of the body. There is not a row of short parallel bands around the ventral and dorsal border as in *A. sydneyensis*. The peritubercular area is very shallow. The dorsal lamina is double in its anterior part and is ribbed on the left side only. The branchial sac is simply folded between each longitudinal vessel and there are simple papillae at the junction of the longitudinal and transverse vessels.

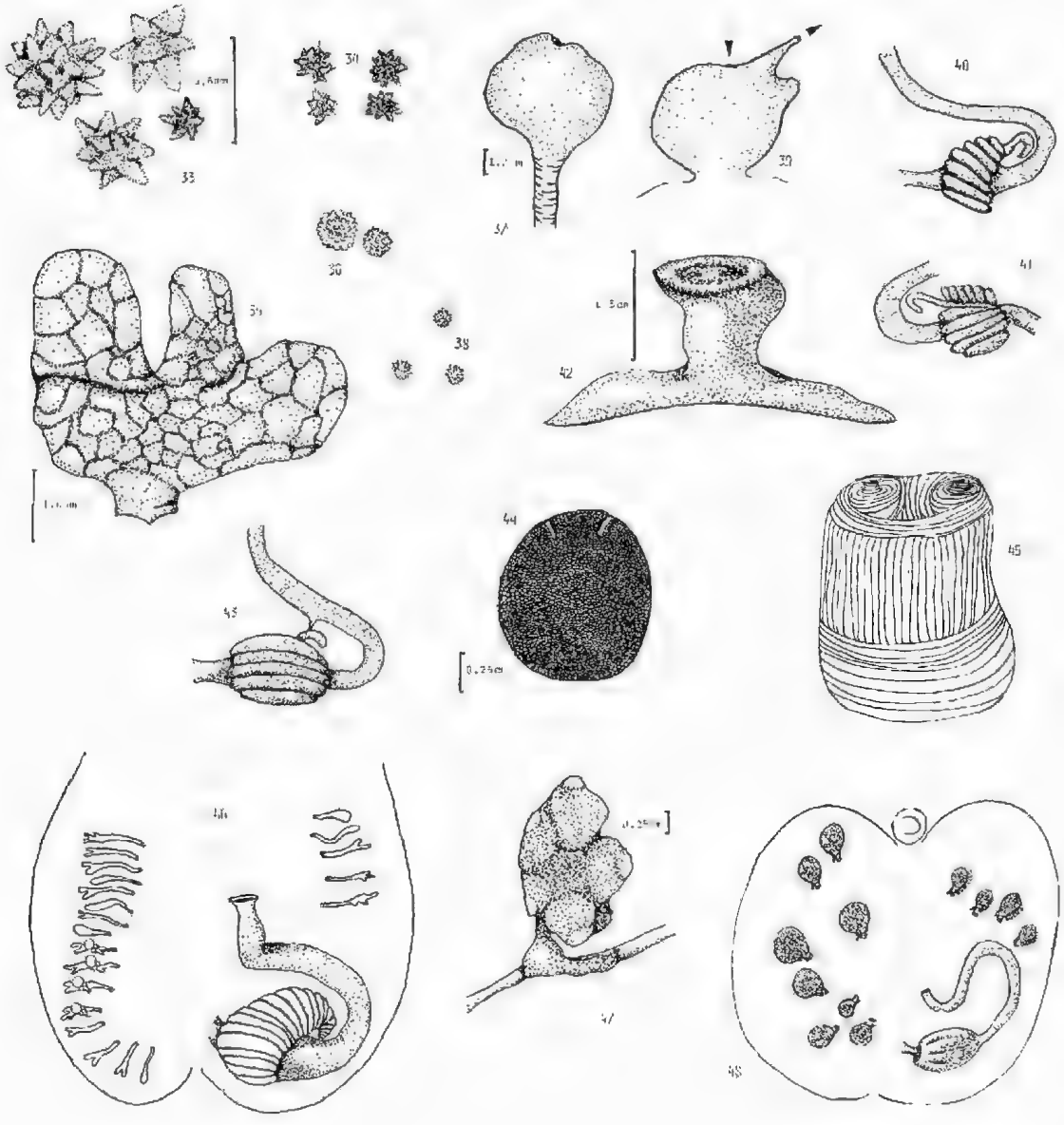


Fig. 33. *Trididemnum cerebriforme*. Spicules.
Fig. 34. *Trididemnum spiculatum*. Spicules.
Fig. 35. *Polysyncraton magnilarvum*. Colony.
Fig. 36. *Didemnum ternatanum*. Spicules.
Figs. 37, 38. *Leptoclinides fungiformis*. Fig. 37.—Colony. Fig. 38.—Spicules.
Figs. 39–41. *Metandrocarpa indica*. Fig. 39.—Individual. Fig. 40—Mesial aspect of stomach. Fig. 41.—Later aspect of stomach.
Fig. 42. *Symplegma arenosa*. Individual.
Fig. 43. *Stolonica australis*. Gut loop and stomach.
Figs. 44–46. *Stolonica truncata*. Fig. 44.—Individual. Fig. 45.—Body removed from test to show body musculature. Fig. 46.—Gut, gonads.
Figs. 47, 48. *Polyandrocarpa simulans*. Fig. 47.—Colony. Fig. 48.—Gut, gonads.

Remarks: The present species is distinguished by the condition of the dorsal lamina and the body musculature.

Ascidia sydneyensis Stimpson. Kott, 1972a: 24 and synonymy.

New Records: Elliston Bay, Investigator Strait (Stn. Y18). For *Previous Records*, *Description*, see Kott 1972a.

Order PLEUROGONA

Suborder STOLIDOBRANCHIA

Family STYELIDAE

Subfamily POLYZOINAE

Metandrocarpa indica n.sp.

Type Location: Investigator Strait (Stn. Y6), 23 m, scattered low reef with shell sand patches and strong surge, *Watson*. *Holotype*: NMV, H159. *Paratype*: NMV, H158.

FIGS. 39–41

Description: The colonies consist of sessile, round, laterally flattened, sandy individuals 5 mm in diam., fixed to a common basal stalk which sometimes expands into a wider membrane. The present colonies invest an algal stem. The zooids are close to one another but each is entire and separate and the tests do not adhere. The test is thin and fairly brittle with embedded sand. Both apertures are anterior and fairly close together. The branchial aperture is sessile and the atrial aperture is on a pointed siphon directed away from the branchial aperture. The body wall is very delicate and closely adherent to the test. It has a fairly close mesh of very fine muscle fibres continuous all over the body. The branchial sac has 4 internal longitudinal vessels on each side with 6–8 stigmata per mesh, crossed by parastigmatic vessels, and there are 9 such rows of stigmata. The gut forms a simple open loop across the posterior end of the body and the rectum is produced anteriorly toward the base of the atrial siphon. The stomach is large and has about 16 conspicuous stomach folds. There is a longitudinal ridge along the lateral aspect of the stomach, which continues to form a long curved caecum in the gut loop. On the posterior side of this longitudinal ridge, the stomach folds are parallel to it. The folds on the anterior aspect of the stomach, however, extend more obliquely and terminate against this caecal ridge so that they do not extend continuously from the pyloric to the cardiac end of the stomach. The anal border is smooth. The dorsal lamina is plain. Unfortunately no gonads were detected.

Remarks: Species of the genus *Metandrocarpa* Michaelsen, 1922, have been described with 5–10 internal longitudinal vessels, and male and female gonads on both sides of the body. Although the present species has only 4 internal longitudinal vessels and the gonads are not developed, its stomach is similar to that found in *M. dura* (Ritter) and *M. michaelseni* (Ritter & Forsyth) both from California (see Van Name 1945). In both these species the stomach has a longitudinal ridge continuous with the pyloric caecum and against which the stomach folds terminate. In other genera of Polyzoinae, e.g., *Allocarpa*, *Theodorella* and *Polyzoa*, although there may sometimes be a small number of internal longitudinal vessels, the stomach is barrel-shaped with parallel longitudinal folds.

Symplegma arenosa n.sp.

Type Location: Off Waldegrave I., *Shepherd*. *Holotype*: SAM, E904. *Paratype*: SAM E985.

FIG. 42

Description: The colonies are formed of sessile, sandy individuals, more or less pillar-shaped but laterally flattened, the zooids taller than their width. They are fairly closely placed but are entirely separate and arise from a sandy basal plate formed of a tangle of basal stolons. Both apertures are close together on the upper free end of the body in a circular, sand-free, area of very thin test. The rest of the test is encrusted with sand. When the zooids are contracted, the stiffer, sand-encrusted, test on either side of the apertures is drawn together across the openings which then appear to be depressed in a longitudinal slit on the upper surface. The body wall has strong muscles around the anterior part of the body, consisting of longitudinal bands radiating from both the siphons and short transverse bands extending across the mid line dorsal and ventral to both of the siphons. These short transverse bands (as in *Agnesia glaciata*: Kott 1969b) are instrumental in drawing together the protective test across the aperture. There are 4 internal longitudinal vessels on each side of the body and 15 rows of stigmata. These are not crossed by parastigmatic vessels. There are 6–8 stigmata in each mesh. The longitudinal muscles extend only about a third of the distance down the

body. The gut forms a very short loop across the posterior end of the body and the rectum is long and extends anteriorly toward the base of the atrial siphon. The stomach is short and barrel-shaped with about 14 longitudinal folds and there is a short straight pyloric caecum connected to the anterior limb of the gut loop by a divided ligament and blood vessels (see *Symplegma oceania* Tokioka, 1961). There is also a connective between the stomach and the intestine. Unfortunately no gonads are developed in the present specimens.

Remarks: Although the present species resembles *Metandrocarpa indica* in the presence of 4 internal longitudinal vessels in the branchial sac and in the shape of the body, it differs in the body apertures, the body musculature, the shape of the stomach and pyloric caecum, and in the length of the gut loop. In the present species, the stomach, as well as the number of internal longitudinal vessels, resemble the condition in the genus *Symplegma*; and in *Symplegma oceania* Tokioka, 1961, from Noumea, the arrangement of the pyloric caecum and its ligaments and the connective between the stomach and the intestine are identical with the present species. Although *Symplegma* spp. are not usually upright as in the present species, they are joined to basal stolons which form a mesh and cross one another and an upright form has been described once previously, viz: *Symplegma viride stolonica* Verrill (see Van Name 1945).

The condition of the apertures is very specialised and the disposition of the body musculature to serve the protective device described above has not previously been recorded in the family Styelidae, although similar mechanisms are developed in the families Agnesidae (see Kott 1969b) and Molgulidae (see Kott 1972b).

Stolonica australis Michaelsen, Kott, 1972a: 28 and synonymy.

New Record: Elliston Bay. *Previous Records*: see Kott 1972a.

FIG. 43

Description: In colonies recently collected from Tiparra Reef (Spencer Gulf), there is a single row of hermaphrodite gonads anteriorly on both sides of the body, but posteriorly there are rather irregular scattered series of simple testis follicles. There is some variation in the apparent shape of the stomach, from pyriform to barrel-shaped depending on the condition of the body wall covering the cardiac end. The caecum is only of moderate size and curved

Stolonica truncata n.sp.

Type Location: 1 km north-west of Waldegrave I. on rocky bottom with sand patches, 23 m, 11.v.1971, *Shepherd*. *Holotype*: SAM, E893. *Paratypes*: SAM E894, E909.

FIGS. 44–46

Description: Colonies comprise rounded, sandy, individuals joined by basal stolons. Each individual is spherical, sessile, and about 1 cm in diam. The apertures are both anterior on the free end of the body, and are present in conspicuous transverse interruptions to the rather solid sand encrusted test, so that each aperture is surrounded by delicate, thin test which can be withdrawn and covered over by protective sand-strengthened lips. The body wall is fairly muscular, with longitudinal bands radiating from both siphons, extending over the rest of the body. There is a broad band of circular fibres around the anterior end of the body and associated with the protective closing mechanism described above. There are also circular fibres around the posterior end of the body. There are 3 branchial folds on the right and 3 on the left, although they all tend to fade out posteriorly, especially the most dorsal folds. The internal longitudinal vessels are arranged according to the following formula:

DL 0(10)5(9)5(6)6 E

There are 1½–2 stigmata per mesh, although these are set slightly obliquely in relation to the internal longitudinal vessels. The gut forms a simple transverse loop with the rectum turning slightly anteriorly. The stomach has a large number of very fine longitudinal folds, and the whole extent of the anterior border of the stomach is produced into a tube of gradually decreasing diameter, lined internally with glandular folds in parallel with those lining the rest of the stomach wall. This tube forms a curve in the gut loop and terminates in a pointed caecum. The anus is bilabiate. On the left hand side of the body, anterior to the gut loop, there may be 5–6 elongate and sometimes branching testis follicles, terminating distally in the long slender duct directed toward the atrial aperture. On the right hand side of the body, there are similar testis follicles arranged around the posterior half of the ventral border and around the posterior border of the body. Some of these testis follicles are also associated with an ovary

of 2–3 eggs, lying on the mesial surface of the distal end of the testis and opening by a short wide oviduct, while the seminal duct curves around and for most of its length lies free in the peribranchial cavity. There are up to 6 hermaphrodite gonads of this type in the centre of the row of gonads on the right side of the body. Larvae are present in the right peribranchial cavity. They have triradiate papillae and appear to be of the type generally associated with the Polyzoinae (see Millar 1960).

Remarks: The most unusual production of the anterior aspect of the stomach to form the long curved caecum in the gut loop is quite distinctive. The long branching testis follicles are also unusual; while externally the highly specialised device to protect the apertures, each located in a transversely oriented strip of unmodified test, by withdrawing them beneath the firm sand-hardened test is unique. Closing mechanisms as described above for *Symplegma arenosa* n.sp., and for species in the families Molgulidae and Agnesiidae, usually involve both apertures simultaneously. The test is black and can be seen through the encrusting sand.

Oculinaria australis Gray. Kott, 1972a: 29 and synonymy.

New Record: Off Waldegrave I., Elliston Bay. For *Previous Records, Description*, see Kott 1972a.

Polyandrocarpa simulans n.sp.

Type Location: Investigator Strait (Stn. Y6, Y19); 23 m, on scattered low-reef with shell sand patches and strong surge, *Watson*. *Further Records*: Investigator Strait (Stn. Y19), Elliston Bay, St. Francis I. *Holotype*: NMV, H162. *Paratypes*: NMV, H160, H161, H163.

FIGS. 47, 48

Description: The colonies form tight aggregates of individuals about 1 cm in diam. The living specimens are reddish brown, tipped with black, although preserved specimens are black. The test is thick with a slight sand encrustation, although this is not present internally where the test of adjacent zooids is confluent. Both apertures are sessile. The branchial aperture is terminal and the atrial aperture anterodorsal. The body wall is very muscular, with almost continuous layers of longitudinal and circular muscle bands. The branchial sac has 4 low folds with crowded, very thick, internal longitudinal vessels. The transverse branchial vessels are also thick so that the branchial sac is a very tough organ in this species. Longitudinal vessels are arranged according to the following formula:

E 1(6)1(9)1(8)1(9)0 DL.

The body musculature is especially thick around the apertures. The gut forms a small closed loop in the posterior end of the body and the rectum extends forward to the atrial aperture to form a secondary loop. A round, flat-topped, entiocarp completely occupies the primary gut loop as in *Polycarpa pedunculata*. The small, pear-shaped stomach has internal glandular folds. The anal border has 4 sometimes indented rounded lobes. The gonads are flat, flask-shaped ovaries opening by a short, wide, oviduct directed towards the atrial aperture and overlying two rows of testis follicles with 5–6 follicles in each row. The ducts of each testis follicle join a common duct that runs along each side of the ovary to join together and open into the peribranchial cavity on the mesial aspect of the short oviduct. The gonads are embedded in thick body wall. There are up to 5 of these gonads on the left side of the body, usually in a single row anterior to the gut loop. On the right, there are up to 9 gonads usually arranged in 2 rather irregular rows.

Remarks: This species is very reminiscent of *Polycarpa pedunculata*. In view of the tight aggregates and confluent test and the absence of sand between adjacent individuals, however, it is clear that colonies form by vegetative reproduction rather than by aggregation of a number of solitary individuals. The process of vegetative budding to form these colonies is probably associated with the small size of the mature individuals, thus limiting the number of internal longitudinal vessels in the branchial sac and the number of gonads on the body wall.

Polyandrocarpa lapidosa (Herdman). Kott, 1952: 250. Millar, 1963: 730.

Cnodsiria lapidosa Herdman, 1899: 99.

New Record: Investigator Strait (Stn. Y19). *Previous Records*: Vic.(Port Phillip Heads, Westernport)—Millar 1963. N.S.W. (Port Jackson)—Herdman 1899; Kott 1952.

Description: The present specimen is a large, sandy, plate-like colony with the upper surface slightly concave, 9 cm in diam, with a maximum thickness of 2 cm, fixed by a large part of the basal surface. The surface of the colony is smooth and sandy without conspicuous

swellings or furrows. The zooids are long, but both openings are on the upper surface. There are 4 long branchial folds of very varying height and internal longitudinal vessels are arranged according to the following formula:

DL (10)1(3)1(7)1(4)1 E

The gut extends in a simple arc from the posterior end of the body to the anterior atrial aperture. There are 12 internal longitudinal stomach folds. The gonads are elongate and arranged along either side of the endostyle.

Subfamily BOTRYLLINAE

Botrylloides leachi (Savigny). Kott, 1972a: 29 and synonymy.

New Records: Elliston Bay, off Waldegrave I. For *Previous Records, Description*, see Kott 1972a.

Botrylloides magnicoecum Hartmeyer. Kott, 1972a: 30 and synonymy.

New Records: Waldegrave I., Pearson I. For *Previous Records, Description* see Kott 1972a.

Botryllus schlosseri (Pallas). Kott, 1972a: 31 and synonymy.

New Record: North of Waldegrave I. For *Previous Records, Description*, see Kott 1972a.

Subfamily STYELINAE

Styela plicata (Lesueur). Kott, 1972b: 239 and synonymy.

Ascidia plicata Lesueur, 1823: 5.

New Record: Coffin Bay. For *Previous Records, Description*, see Kott 1972b.

Styela pedata (Herdman).

Polycarpa pedata Herdman, 1881: 71. Tokioka, 1958: 322 and synonymy. Kott, 1964: 137.

Pandocia pedata Hartmeyer, 1909–11: 1360.

Styela whitelegii Kott, 1952: 213.

Tethyum whitelegii Hartmeyer, 1909–11: 1364.

New Records: Off Waldegrave I., Pearson I.

Previous Records: N.S.W. (Port Jackson, Port Stephens, Port Curtis)—Herdman 1899; Kott 1952. Qld. (Moreton Bay, Great Barrier Reef)—Hastings 1931; Kott 1964. Indonesia—Pizon 1908. Phillipines—Herdman 1881; Van Name 1918. Japan—Tokioka 1958.

FIGS. 49, 50

Description: The preserved specimen is orange, the test is tough and leathery, with longitudinal ridges without any foreign bodies attached. The body is of characteristic shape, expanded postero-dorsally. Both apertures are directed upwards and the branchial aperture, on a siphon continuous with the upright ventral surface, is often recurved. The atrial aperture is also on a short siphon above the postero-dorsal expansion of the body. Basally the test is extended into prop-like roots. The body wall is muscular. The dorsal tubercle is oval with numerous separate circular openings giving it a porous, sponge-like appearance.

Up to 21 internal longitudinal vessels are evenly spaced on the folds, and 3–7 internal longitudinal vessels are present between the folds. There are 6–8 stigmata per mesh. The gut forms a fairly wide loop with tall endocarps enclosed by the loop. The stomach is elliptical with longitudinal internal glandular folds. The anal border is lobed.

There are 3 branched and ramifying gonads on the left above the gut loop and up to 9 on the right. The gonads are embedded in and occupy most of the body wall except where the gut is present on the left. Tall endocarps are present over the body wall between the branches of the gonad. The gonads have testis follicles closely applied to either side of the ovary.

Remarks: The gonads and endocarps of this species are very similar to the much branched and ramifying gonads of *S. ramificata* Kott, 1952, which has also been recorded from Moreton Bay. *S. ramificata* is, however, a very much smaller species heavily encrusted with sand and shell, with a continuous V-shaped opening on the dorsal tubercle, a narrow gut loop and a longer rectum than in the present species. A similar dorsal tubercle is present in *Polycarpa aurata* (Quoy & Gaimard) (see Van Name 1918) which is also similar to the present species in other characters. It is distinguished mainly by its short, typically polycarp gonads in contrast to the long ramifying styelid gonads of the present species. *Styela pedata*, therefore, has a wide distribution from the Phillipines and Japan and around the eastern seaboard of Australia to the Great Australian Bight. It overlaps with *P. aurata* in the Phillipines and on the east coast of Australia.

Polycarpa tinctor (Quoy & Gaimard). Kott, 1964: 134 and synonymy.

Ascidia tinctor Quoy & Gaimard, 1834: 608.

New Record: Off Waldegrave I. *Previous Records*: see Kott 1964.

Description: A single specimen only is available. It is large and slightly damaged. The test, however, has the usual hard, brittle, sand-encrusted form characteristic of the species. The specimen is laterally flattened, with the atrial aperture half way down the dorsum. The apertures are sessile. The dorsal tubercle is large with a complementary slit. The branchial sac has 4 very narrow folds. Gonads were not detected in the present specimen.

Remarks: The present species had not previously been taken further south than Port Jackson. It does occur commonly on the north-west and north-east Australian coast, in the East Indies, and off Japan. The form of the dorsal tubercular slit, broken into several parts, has previously been described in specimens from Japan and the East Indies.

Polycarpa pedunculata Heller. Kott, 1972a: 35 and synonymy.

New Records: Elliston, N-W of Waldegrave I., 22 m off Waldegrave I., Pearson I., Investigator Strait (Stns. X9, 15, 19, 21, 25, 27; Y6, 12, 23; Z9, 11), Emu Bay (Kangaroo I.). For *Previous Records, Description*, see Kott 1972a.

FIG. 51

Remarks: Specimens in this collection demonstrate the full range in external appearance, from sessile to stalked individuals, from brownish to black individuals. In general, the stalk of specimens from Investigator Strait is longer than that found in specimens from St. Vincent Gulf, and many of the specimens are superficially very similar to specimens of *Pyura scoresbiensis* with which they occur, demonstrating convergence in their external appearance related to the environment.

Polycarpa clavata Hartmeyer. Kott, 1972a: 33 and synonymy.

New Records: Waldegrave I., 22 m off Waldegrave I., Pearson I., Investigator Strait (Stn. Y21). For *Previous Records, Description*, see Kott 1972a.

Family **PYURIDAE**

Pyura spinifera (Quoy & Gaimard). Michaelsen, 1922: 390 (part: Port Jackson specimens). Kott, 1952: 269; 1972a: 39.

Ascidia spinifera Quoy & Gaimard, 1834: 617.

Boltenia australiensis Carter, 1885: 197.

Boltenia tuberculata Herdman, 1891: 511; 1899: 17.

Cynthia multiradicata Herdman, 1899: 30.

Boltenia spinifera Michaelsen, 1905: 72 (part: not *B. gibbosa*).

Boltenia spinosa var. intermedia Michaelsen, 1908: 390.

Pyura gibbosa var. intermedia Michaelsen, 1922: 390.

Pyura australiensis f. typica Michaelsen & Hartmeyer, 1928: 410.

New Records: Off Waldegrave I., Investigator Strait (Stns. Y19, Z7). *Previous Records*: W. Aust. (Albany)—Quoy & Gaimard 1834. S. Aust. (St. Vincent Gulf)—Kott 1972a. Vic. (Port Phillip Heads, Portland Harbour, Cape Woolami, Bass Strait)—Carter 1885; Michaelsen 1905. N.S.W. (Port Jackson)—Herdman 1899; Kott 1952.

FIG. 52

Remarks: Minute scale-like spines are present on localised ridges in the branchial siphon. The branched keratose fibres (see Carter 1885) and Michaelsen & Hartmeyer 1928) are present in the body wall and stalk. They are similar to spicules found in *Pyura stolonifera* (see Millar 1962). The specimens are invariably covered with a sponge (*Halisarca*: see Carter 1885).

Pyura australis (Quoy & Gaimard).

Pyura australis subspecies *australis* Kott, 1972a: 39 and synonymy.

Pyura australis var. parvispinatis Kott, 1952: 268.

Boltenia gibbosa Herdman, 1899: 19.

New Records: Off Waldegrave I., N.W. of Waldegrave I., St. Francis I., Pearson I., Investigator Strait (Stns. X27, Y21), Emu Bay (Kangaroo I.). For *Previous Records, Description*, see Kott 1972.

FIG. 53

Remarks: The principal character on which the distinction between the two subspecies, *P. australis typica* and *P. australis parvispinatis*, was based is the condition of the anal border. A careful examination has shown that in this group of species the terminal part of the rectal wall always has flat folds projecting into the

lumen as described for *P. australis parvispinalis* Kott, 1952. These folds are usually extended beyond the anal border into rounded lobes which are often long and finger like and sometimes subdivided. Occasionally, however, they do not extend outside the anal rim. There is no constant condition observed for any group of specimens in regard to the anal border and it is concluded that subspecies are not indicated. The slight difference in the length of the branchial spines (Kott 1952) is not significant. These are conical and only slightly curved and arise from a long oval base. 0.02–0.03 mm long, and their length along the spine is 0.02–0.04 mm. The largest spines are nearest to the apertures. Typical stellate spicules, 0.02 mm in diam. are always present in the test and siphonal lining and distinguish the species.

Pyura pachydermatina (Herdman) s.sp. **draschii** nom. nov.

Boltenia pachydermatina Herdman, 1881: 81. Drasche, 1884: 370. Herdman, 1899: 16. ?Herdman & Riddell, 1913: 875.

Pyura pachydermatina var. gibbosa Kott, 1952: 265.

New Records: Waldegrave I., Elliston Bay. *Previous Records*: W. Aust. (Cottesloe to Albany), Vic. (Julia Percy I., Flinders, Walkerville)—Kott 1952. N.S.W. (Kiama, Port Jackson)—Drasche 1884; further specimens in Australian Museum.

FIGS. 54, 55

Description: Typical specimens with dumb-bell shaped spicules and fringed anal lobes. The siphonal spines are produced into a long pointed base which is distinct from the rounded base in *P. australis*, or the flattened scale-like base in *P. spinifera*. Michaelsen (1905, 1908, 1922) and Michaelsen & Hartmeyer (1928) attempted rationalisation of the relationships of the species *Pyura pachydermatina*, *P. gibbosa* and *P. spinifera* and their synonyms, on the basis of external appearance, condition of the stalk and of the dorsal tubercle, and the presence or absence of spicules. A study of the group in Australia has shown that the form of the spicules and siphonal spines, supported, within certain limits, by the form of the anal border, provides the only reliable character on which to distinguish the species. Michaelsen & Hartmeyer (1928) characterise *P. pachydermatina* by the presence of a smooth anal border, complicated dorsal tubercle, and dumb-bell shaped spicules. This is only true, however, for the New Zealand subspecies *P. pachydermatina typica* since although the dumb-bell shaped spicules are always present, the Australian forms never have a smooth anal border. The dorsal tubercle may be a less complicated double spiral cone. Thus *Pyura gibbosa*; Michaelsen & Hartmeyer 1928 (type specimen: *Cynthia gibbosa* Heller, 1878, from Bass Strait) with anal lobes and dumb-bell shaped spicules falls within the definition of *P. pachydermatina* and Heller's specimen becomes the type of the subspecies *P. pachydermatina gibbosa* (not *P. pachydermatina* var. *gibbosa* Kott, 1952). *Pyura gibbosa intermedia* Michaelsen, 1922 (>*P spinifera intermedia* Michaelsen, 1905) from Backstairs Passage, S. Aust., together with *P. spinifera typica* (part: *P. tuberculata* Herdman) from New South Wales, neither of which have dumb-bell shaped nor stellate spicules, are consequently synonyms of *P. spinifera*, rather than of *P. pachydermatina gibbosa*. *Pyura pachydermatina draschii* is distinguished from *P. pachydermatina gibbosa* (>*P. pachydermatina intermedia*; Kott 1952) (which has shallow anal lobes) by its fringed anal border. *P. Pachydermatina gibbosa* overlaps the present subspecies from Bass Strait to Port Jackson, and extends further to the north. The western limit for *P. pachydermatina draschii* is not at Walkerville, Victoria, as Kott (1952) had suggested, since it extends to Western Australia.

Pyura scoreshiensis Kott 1972a: 36.

New Records: Pearson I., Investigator Strait (Stns. X9, 11, 15, 17, Y14). *Previous Records*: see Kott 1972a.

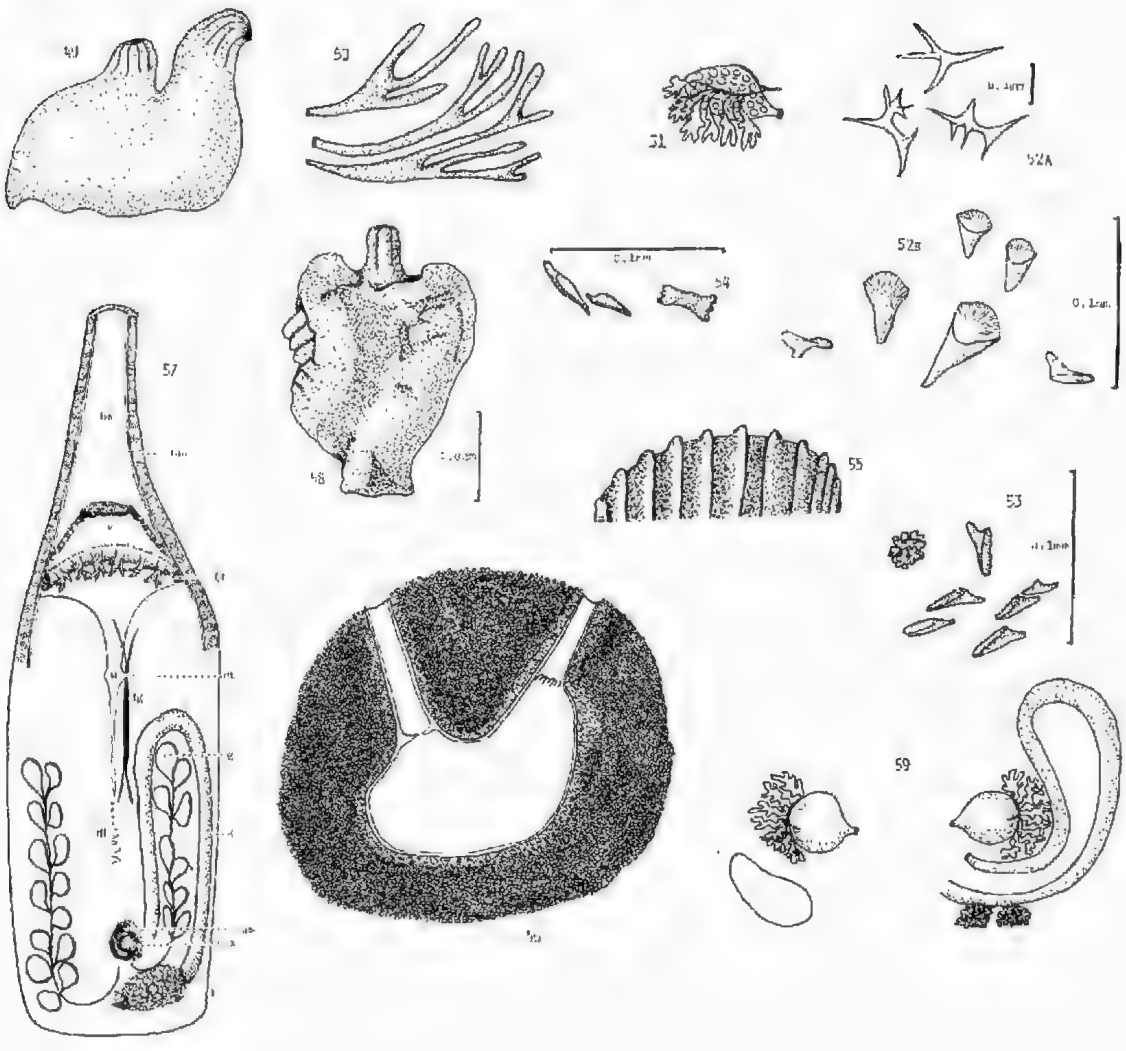
Description: Specimens available show a wide range in the length of stalk and in the development of the rooting processes at the base of the stalk. These sometimes form large sandy lamellae as the roots spread and sand adheres to them. The apertures are always close together on the upper surface, although the pronounced ridge between the apertures previously described (Kott 1972a) is not always present.

Pyura irregularis (Herdman), Kott, 1972a: 38 and synonymy.

New Record: Investigator Strait (Stn. Y6) For *Previous Records*, *Description*, see Kott 1972a.

Pyura tendata n.sp.

Type Location: Investigator Strait (Stn. Y21), 30 m, scattered, low, on pebble reef



Figs. 49–50. *Styela pedata*. Fig. 49.—Individual. Fig. 50—Gonads from left side of body.

Fig. 51. *Polycarpa pedunculata*. Gonad showing flask shaped ovary and testis follicles.

Fig. 52. *Pyura spinifera*. Fig. 52a.—Branching spicules from body wall. Fig. 52b—Branchial spines.

Fig. 53. *Pyura australis*. Spicule and branchial spines.

Figs. 54, 55. *Pyura pachydermatina*. Fig. 54.—Dumbell shaped spicule and branchial spines. Fig. 55. —Anal border showing internal folds from rectal wall.

Figs. 56, 57. *Pyura tendata*. Fig. 56.—Longitudinal section to show sandy coating around body.—Fig. 57.—Body opened around ventral surface, branchial sac removed to show branchial velum, tentacles, dorsal ganglion, gut and gonads: branchial sac (bs); body muscles (bm); branchial velum (v), branchial tentacles (bt); dorsal tubercle (dt); dorsal ganglion (dg); dorsal lamina (dl); intestine (i); gonad (g); base of the atrial siphon (as); anal opening (a).

Fig. 58. *Herdmania momus*. Individual.

Fig. 59. *Molgula ellistoni*. Gonads, gut loop and kidney on inner surface of body wall.

with sand patches. *J. Watson. Holotype*: NMV, H156.

FIGS. 56, 57

Description: The species appears to occur in aggregates. The holotype, however, is the only complete specimen available and only small parts of at least two others were obtained when the specimen was broken from its substrate. The outline of the individual is not obvious superficially, since it is completely surrounded by a sandy coat 1 cm or more thick. The test is very thin, without wrinkles, and minute hair-like extensions of the test are seen extending across a narrow space between the sandy coating and the test. It is probably these hairs which enmesh the sand forming the thick coating around the body. The narrow space between the outer surface of the test and the sandy coating is occupied by various commensal worms and echinoderms.

The animal itself consists of a club shaped body narrowing to a long terminal branchial siphon. The atrial siphon is twice the length of the branchial siphon and extends forwards from the dorsal border of the body in the anterior part of the posterior third of the body length and opens level with the branchial opening. Excluding the sandy coat, the body is 1 cm deep from its dorsal border at the base of the atrial siphon to its ventral border. The length of the atrial siphon is 2 cm. Owing to the gradual narrowing of the body to the base of the branchial siphon, the body appears to have two long diverging siphons of equal length.

The body wall is very muscular. Branchial tentacles are present at the base of the branchial siphon half way between the external aperture and the base of the atrial siphon. Just anterior to the ring of branchial tentacles, which are 3 times branched, there is a large muscular velum protuding into the lumen of the branchial siphon. The dorsal tubercle is in the base of a very long narrow perituberc ular area extending half way down the branchial sac. It is a very small, simple U. The elongate dorsal ganglion is associated with the base of the atrial siphon just posterior to the dorsal tubercle. There are 9 branchial folds with internal longitudinal vessels arranged as follows:

E (4)0(7)0(13)1(15)2(16)3(2)1(16)2(13)0(7) DL

The gut forms a simple loop in the posterior end of the body. There are minute, branched, liver tubules in the pyloric region and the body wall covering the distal portion of the rectum is produced into a pronounced non-muscular atrial velum so that the bilabiate anus actually opens into the base of the atrial siphon beyond this velum. The branchial velum has very strong circular muscles in its basal half. The body musculature is very strong, with outer circular bands forming an almost continuous coat external to strong well-spaced longitudinal muscle bands. The gonads consist of about 7 or 8 pairs of polycarp-like sacs either side of central ducts in the gut loop on the left and in a corresponding position on the right side of the body.

Remarks: This quite extraordinarily modified species is in most essential aspects typically pyurid and resembles *Pyura cancellata* Brewin (see Kott 1971) in the thick sandy coating created by sand enmeshed by the long test hairs all around the body. Its most conspicuous character is the very long atrial siphon and the narrowing of the anterior part of the body so that the branchial aperture is also produced upwards to a level with the atrial siphon, so that the incurrent ciliary stream is not obstructed by the sand being accumulated around the body. The thick, sandy coating is so dense and so rigid that it is hard to imagine how the animal is able to increase in size. It is probable, however, that the commensals present between the sandy coating and the test constantly irrigate this area and thus maintain the space into which the animal can expand as it grows. These commensals are therefore probably essential to such sand covered species (see also *Pyura cancellata*; Kott 1971).

Halocynthia hispida (Herdman). Kott 1968: 76 and synonymy; 1972a: 41.

New Record: *Investigator Strait* (Stn. X19). For *Previous Records, Description*, see Kott 1968.

Herdmania momus (Savigny). Kott, 1972a: 41 and synonymy.

New Records: Off Waldegrave I., St. Francis I., Pearson I., Investigator Strait (Stn. X17). Spencer Gulf. For *Previous Records, Description*, see Kott 1972a.

Remarks: There is the usual great range in size of individuals. Smaller specimens are more or less upright with transparent test and short furrowed siphons. Larger specimens become flaccid and opaque.

Ctenicella antipoda Kott, 1972a: 44.

New Record: Investigator Strait (label illegible). For *Previous Records, Description*, see Kott 1972a.

Remarks: The distal part of the gut loop is distended with mud. In one large specimen the gonads on the left side of the body are enclosed in the gut loop. In view of the agreement with the type specimen in all other aspects, this must be regarded as an individual variation.

Molgula ellistoni n.sp.

Type Location: Elliston Bay, in caves outside bar, subject to strong swell, 14.v.1971. *Holotype and Paratypes*: SAM, E907.

FIG. 59

Description: Small sandy spherical individuals were found adhering to *Eutheidmania australis* and sometimes forming aggregates. Both apertures are present fairly close together on the upper surface and are directed away from one another. Very delicate muscles radiate out from the siphons. There are internal circular muscles around the branchial and atrial siphons. There are 7 branchial folds on each side of the body, with 6 meshes along each fold. Each mesh contains a primary spiral infundibulum, which subdivides into two half way up into the fold. There are 3 internal longitudinal vessels arranged along the fold. There is the usual long gut loop open at the pole and a short curved kidney on the right side of the body. The gonads consist of a circular ovary with a short, wide, duct directed dorsally. Testis follicles are present along the proximal border of the ovary and join into a very short vas deferens which opens into the peribranchial cavity on the mesial surface of the ovary. The right gonad is in the middle of the body wall and the left gonad is in the secondary gut loop. The specimens are about 0.5 cm in diam.

Remarks: The position and form of the gonads with the very short vas deferens opening on the surface of the ovary are distinctive. Anural embryos are present in the peribranchial cavity.

Molgula sabulosa Quoy & Gaimard 1834: 613. Kott, 1972b: 248 and synonymy.

New Record: Elliston Bay. For *Previous Records, Description*, see Kott 1972b.

Characteristics of the Fauna

An outstanding feature of the fauna is the large number (23) of species in the relatively primitive Aplousobranchia. Polycitoridae, Clavelininae and Eutheidmaniinae, in which common cloacal systems are not developed. A further 7 species are secondarily colonial species of Styelidae; one is a colonial phlebobranch species; three are aggregated pyurids; and there are two aggregated species of the family Molgulidae. Thus about half of the species present, although colonial in habit, preserve their own independent openings and do not form cloacal systems. They do, however, demonstrate remarkable morphological adaptations in the arrangement, orientation and operation of their apertures to maximise their reactions with the environment. Colonies of *Ritterella heidmania, Placentela ellistoni* n.sp., and the new colonial phlebobranch species are of special interest in that the zooids are arranged in parallel, so that their branchial and atrial apertures are respectively located on different sides or at different ends of the colony. Some benefit can accordingly be derived from mutual reinforcement of feeding currents. One would expect that the exact orientation of these colonies would be such that prevailing currents could also reinforce the incurrent and excurrent ciliary streams.

These species and many of the Clavelininae, together with the new species *Metandrocarpa indica, Symplegma arenosa* and *Stolonica truncata*, all have specially adapted body musculature to operate sophisticated siphonal apparatus. Adaptation of the nervous system to serve the specialised musculature can also be expected. In fact, in both *Pyura tenuata* and in the new colonial phlebobranch species, the neural gland and ganglion are located posteriorly in association with an unusual posterior position of the atrial siphon.

None of the species discussed above are encrusting and most favour habitats under ledges and in crevices or caves. There are only 18 species with highly evolved cloacal systems that have achieved a degree of independence of the environment and, with only 4 exceptions (*Didemnum candidum, D. moseleyi, Trididemnum spiculatum* and *Botryllus schlosseri*), these are also bulky or stalked (rather than encrusting) and favour habitats under ledges or in crevices or caves.

The majority of the solitary stolidobranch species that are present are stalked and able to maximise their reactions with the environment by moving on their stalk with the current. There are only few solitary bottom-living species (*Ascidia spp., Polycarpa tincior, Cnemidocarpa antipoda*) or large fixed species (*Herdmania momus, Styela pedata*).

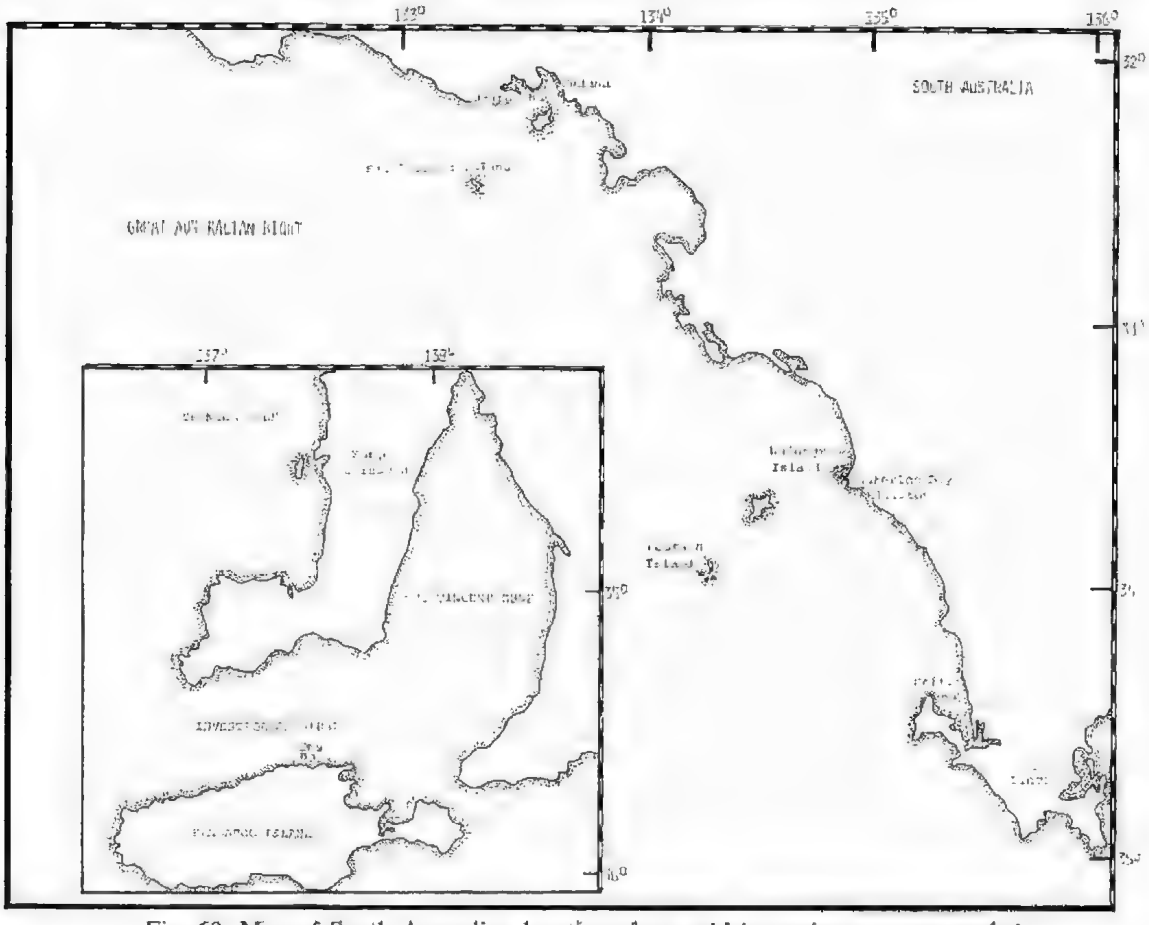


Fig. 60. Map of South Australian locations from which specimens are recorded.

Zoogeography

The known ranges of *Atapozoa marshi* and *Pseudodistoma australis* have been extended from Western Australia to the eastern end of the Great Australian Bight where they overlap with *Distaplia distomoides*, *Eutherdmania australis*, *Pseudodistoma cereum* and *Polyandrocarpa lapidosa*, whose ranges have been similarly extended from the east. The ranges of *Aplidium rubricollum* and *Polyclinum neptunium* from the west, and *Ascidia thompsoni*, *Pyura irregularis* and *P. stolonifera* (see Kott 1952) from the east, are also known to extend into either Spencer Gulf or St. Vincent Gulf. Thus the distribution of these ascidian species across the south coast supports the existence of a marine faunal boundary at the eastern end of the Great Australian Bight, separating the Flindersian marine faunal Province from the Maugean Province to the east (Knox 1963). There is less evidence however for a western boundary of the Flindersian Province further south than Cockburn Sound in Western Australia. It is possible that the 15 new species described herein will subsequently be found to have wider ranges across the Australian coast and provide further data relating to the western boundary of the Flindersian Province to help resolve the question of the existence of a Western Australian Province (Baudinian of Kott, 1952; see Knox 1963).

The ascidian fauna of Gulf waters of South Australia includes only a limited number of the species that occur along the open coast. Of the species discussed above which terminate their range off the eastern South Australian coast, only *Aplidium rubricollum*, *Polyclinum neptunium*, *Ascidia thompsoni*, *Pyura irregularis* and *P. stolonifera* extend into gulf waters. *Podoclavella meridionalis*, *Distaplia stylifera*, *Didemnum ternatanum*, *Styela pedata*, *Polycarpa tinctor*, and *Pyura pachydermatina* are also apparently absent from gulf waters although their geographic range around the Australian coast is wide. It is probable, therefore, that some ecological factor inhibits the

spread of the ascidian fauna from the open coast into gulf waters. It is possibly the same factor that favours the occurrence of *Distaplia viridis, Aplidium pliciferum, Didemnum lambitum, D. pseudodiplosoma, Leptoclinides rufus, L. kingi, Echinoclinum verrilli, Ascidia aclara, Polyzarpa papillata, Pyura cataphracta* and *Microcosmus nicholsi* in St. Vincent Gulf and other embayments to the east and north around the Australian coast, although they have not been recorded from the open coast. The ascidian fauna of gulf waters of South Australia is therefore distinct from that of the adjacent coastal waters and has no special zoogeographic affinity with either the Flindersian or the Maugean Provinces.

There are a further 42 species discussed herein that are recorded from both coastal and gulf waters. The majority of these have a wide cosmopolitan distribution or an extended range from Western Australia to either the boundary of the Maugean marine faunal region in Bass Strait (Hedley 1904, Knox 1963), or further up the eastern Australian coast. Also included in this group of species, however, are *Ctenicella antipoda, Pyura scotesbiensis* and *Atapozoa fantasiana*, previously thought endemic to St. Vincent and Spencer Gulfs, and *Aplidium colelloides* (see Kott 1972a).

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Appendix I—Station List

Stations are listed in the order north to south and west to east.

DENIAL BAY. (Coll. I. Thomas). Lat. 32°13′S; Long. 133°38′E.

Near Ceduna; in *Posidonia* community; depth 10m; 1965.

Atapozoa fantasiana
Sycozon cerebriformis

OFF ST. FRANCIS I. (Coll. S. Shepherd). Lat. 32°31′S; Long. 133°15′E.

Rocky bottom; slight current; depth 55 m; 8.i.1971.

Pseudodistoma cereum
Polyandrocarpa simulans
Pyura australis
Herdmania momus

WALDEGRAVE ISLAND. (Coll. S. Shepherd). Lat. 33°36′S; Long. 134°46′E.

Strong surge; depth 20 m; 17.iv.1970.

Distaplia distomoides
Synoicium papilliferum
Botrylloides magnicoecum
Botryllus schlosseri (22 m)
Pyura australis

Rocky bottom; strong surge; depth 22 m; 23.x.1970.

Eutherdmania australis
Aplidium colelloides
Oculinaria australis
Botrylloides leachi
Styela pedata
Polycarpa tinctor
Pyura australis
Pyura spinifera (covered with sponge)
Pyura pachydermatina
Herdmania momus

1 Km N.W. OF WALDEGRAVE I. (ANXIOUS BAY). Lat. 33°33′S; Long. 134°46′E.

Rocky bottom; slow current; depth 23 m; 11.v.1971.

Clavelina mirabilis (attached to limestone).
Distaplia distomoides
Distaplia stylifera
Symplegma arenosa
Botryllus schlosseri
Stolonica truncata
Holozoinae sp. (growing on red algae)
Polycarpa clavata (growing on brown or red algae: *Sargassum* or *Osmundaria*)
Herdmania momus (with red algae attached)

Rocky bottom with sand patches; slow current; depth 23 m; 11.v.1971.

Podoclavella cylindrica
Synoicium papilliferum
Stolonica truncata
Polycarpa pedunculata
Pyura australis

Rocky bottom; slight surge; depth 22 m; 23.x.1970.

Clavelina nodula
Polycitor giganteum
Pseudodistoma australis
Pseudodistoma cereum
Aplidium flavolineatum
Symplegma arenosa
Polycarpa clavata (attached to rock)
Polycarpa pedunculata

WATERLOO BAY (ELLISTON). (Coll. S. Shepherd). Lat. 33°38′S; Long. 134°51′E.

Roof of caves; strong surge; depth 6 m; 13.v.1971.

Clavelina baudinensis
Podoclavella moluccensis
Distaplia distomoides
Endistoma renieri
Pseudodistoma cereum
Aplidium lobatum
Polysyncraton paradoxum
Didemnum candidum
Didemnum moseleyi
Ascidia thompsoni
Ascidia sydneyensis
Polyandrocarpa simulans (growing on *Ascidia sydneyensis*)

Outside bar; very strong surge; depth 17 m; 12.v.1971.

Sycozoa cerebriformis
Polyclinum neptunium
Aplidium elatum
Oculinaria australis
Pyura pachydermatina

Outside bar, in caves: strong swell; depth 17 m; 14.v.1971.

Pycnoclavella diminuta
Eutherdmania australis
Ritterella herdmania
Placentela ellistoni
Trididemnum cerebriforme (investing *P. diminuta*)
Stolonica australis (around base of *Eutherdmania australis*)
Molgula ellistoni (adhering to *E. Australis*)

Inside bar; depth 6 m; 12.v.1971.
Polycitor giganteum
Pseudodistoma australis
Didemnum moseleyi
Polycarpa pedunculata
Inside bar; strong surge; on vertical face; depth 6 m; 12.v.1971.
Aplidium pantherinum
Near entrance to bay, in caves; depth 3 m; 14.v.1971.
Pseudodistoma cyrnusense
Polyclinum neptunium
Molgula subulosa
Floor of cave; depth 16 m; 12.v.1971.
Atapozoa mirabilis
Centre of bay; depth 11 m; 12.v.1971.
Atapozoa mirabilis
On roof of caves; depth 3–5 m; 14.v.1971.
Aplidium flavolineatum
Elliston Bay
Cystodytes dellechiajei
Trididemnum spiculatum
Didemnum ternatanum
Oculinaria australis (with *E. australis* and *M. ellistoni*)
Botrylloides leachi

PEARSON ISLAND. (Coll. S. Shepherd). Lat. 33°56'S; Long. 134°15'E.
Rough-water coast, 400 m offshore on gravelly bottom, attached to shell or rock fragments; moderate surge; depth 50 m; 9.i.1969.
Leptoclinides fungiformis
Polycarpa clavata
Pyura australis
Herdmania momus
Rough-water coast; in caves; moderate surge; depth 35 m; 10.i.1969.
Podoclavella meridionalis
Aplidium rubricollum
Styela pedata
Polycarpa pedunculata
Herdmania momus
Sandy bottom between Dorothee and Veteran Is. Lat. 34°1'S; Long. 134°15'E. Slight surge; depth 70 m; 11.i.1969.
Polycitor giganteum
Botrylloides magnicoecum
Polycarpa pedunculata
Pyura scoresbiensis
Outside Pearson I; depth 35 m.
Podoclavella meridionalis
Leptoclinides fungiformis
Styela pedata

COFFIN BAY. (Coll. S. Shepherd). Lat. 34°38'S; Long. 135°30' E.
Oyster Trays, at low water; slow currents; no sediments; October 1970.
Styela plicata

SPENCER GULF. (Coll. S. Shepherd). Lat. 34°2'S; Long. 137°23'E, Tipara Reef; depth 11 m; 20.viii.1971.
Pycnoclavella diminuta
Herdmania momus

INVESTIGATOR STRAIT (Coll. J. Watson).
Station X7; depth 30 m; 10.i.1971. Lat. 35°16'S; Long. 137°30'E.
Didemnum moseleyi
Station X9; depth 31 m; 19.i.1971. Lat. 35°17'S; Long. 137°30'E.
Polycarpa pedunculata
Pyura scoresbiensis
Station X11; depth 30 m; 19.i.1971. Lat. 35°19' S; Long. 137°30'E.
Pyura scoresbiensis
Station X15; depth 32 m; 19.i.1971. Lat. 35°23'S; Long. 137°30'E.
Polycitor giganteum
Polysyncraton magnilarvum
Polycarpa pedunculata
Pyura scoresbiensis
Station X?. 19.i.1971.
Polyandrocarpa simulans
Station X17; depth 35 m; 19.i.1971. Lat. 35°24'S; Long. 137°30'E.
Trididemnum cerebriforme
Pyura scoresbiensis
Herdmania momus
Station X19; depth 34 m; 20.i.1971. Lat. 35°26'S; Long. 137°30'E.
Euherdmania australis
Colonial stolidobranch—Gen. and sp.?
Ascidia sydneyensis
Polycarpa pedunculata
Halocynthia hispida
Station X21; depth 34 m; 17.i.1971. Lat. 35°28'S; Long. 137°29'E.
Polycitor giganteum
Polycarpa pedunculata
Station X25; depth 35 m; 17.i.1971. Lat. 35°31'S; Long. 137°29'E.
Polycarpa pedunculata
Station X27; depth 31 m; 17.i.1971. Lat. 35°33'S; Long. 137°29'E.
Didemnum moseleyi
Polycarpa pedunculata
Pyura australis
Station Y6; depth 23 m; 28.i.1971. Lat. 35°17'S; Long. 137°16'E.
Leptoclinides reticulatus
Polysyncraton magnilarvum
Metandrocarpa indica
Polyandrocarpa simulans
Polycarpa pedunculata
Pyura irregularis
Station Y12; depth 33 m; 24.i.1971. Lat. 35°23'S; Long. 137°17'E.
Polycarpa pedunculata
Station Y14; depth 32 m; 23.i.1971. Lat. 35°25'S; Long. 137°17'E.
Atapozoa marshi
Pyura scoresbiensis
Station Y16; depth 35 m; ?.i.1971. Lat. 35°26'S; Long. 137°17'E.
Sycozoa pedunculata
Station Y17; depth 34 m; 20.i.1971. Lat. 35°27'S; Long. 137°18'E.
Atapozoa marshi
Station Y18; depth 31 m; 23.i.1971. Lat. 35°28'S; Long. 137°18'E.
Oxycorynia arenosa
Polycitor obeliscum
Colonial stolidobranch—Gen. & sp.?
Ascidia sydneyensis

Station Y19; depth 33 m; 20.i.1971. Lat. 35°29′S; Long. 137°18′E.
Polyandrocarpa lapidosa
Polyandrocarpa simulans
Pyura spinifera

Station Y21; depth 32 m; 20.i.1971. Lat. 35°32′S; Long. 137°18′E.
Aplidium colelloides
Polycarpa clavata
Pyura australis
Pyura tendata

Station Y23; depth 32 m; 17.i.1971. Lat. 35°33′S; Long. 137°18′E.
Polycarpa pedunculata

Station Y?; 20.i.1971.
Didemnum moseleyi

Station Z?
Colonial stolidobranch—Gen. & sp.?
Pyura spinifera

Stations Z9, 11; depth 38 m; 25.i.1971. Lat. 35°30′S; Long. 137°8′E.
Polycarpa pedunculata
? (Label illegible)
Colonial stolidobranch—Gen. & sp.?
Ctenicella antipoda

KANGAROO ISLAND, (Coll. J. E. Watson). Lat. 35°35′S; Long. 137°31′E. Off Emu Bay, 22.i.1971.
Didemnum moseleyi
Didemnum patulum
Polycarpa pedunculata
Pyura australis

Index to Genera and Species

STRIGEATA (TREMATODA) OF AUSTRALIA BIRDS AND MAMMALS FROM THE HELMINTHOLOGICAL COLLECTION OF THE UNIVERSITY OF ADELAIDE

BY GEORGES DUBOIS AND L. MADELINE ANGEL

Summary

An important collection of Strigeata of birds and mammals has been made by the Department of Zoology of the University of Adelaide.

The present work records thirty species, of which seven are new. Descriptions of the new species with additional information on some of the others are given. The new species from birds are: *Apatemon (Apatemon) vitelliresiduus* (from *Biziura lobata), Cardiocephaloides ovicorpus* (from *Phalacrocorax melanoleucos brevirostris and P. varius), Cotylurus (Cotylurus) magniacetubulus* (from *Cygnus atratus), Diplostomum (Diplostomum) parvulum* (from *Hydroprogne caspia and Pelecanus conspicillatus), Neodiplostomum (Neodiplostomum) lanceolaturn* (from *Ninox novaeseelandiue).*

The new species from mammals are: *Neodiplostomum (Triloborchidiplostomum) diaboli* (a new subgenus, for which the diagnosis is given) (from *Sarcophilus harrisii*) and Ph*aryngostomoides dasyuri* (from *Dasyurus viverrinus*).

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The new species from birds are: *Apatemon* (*Apatemon*) *vitelliresiduus* (from *Biziura lobata*), *Cardiocephaloides ovicorpus* (from *Phalacrocorax melanoleucos brevirostris* and *P. varius*), *Cotylurus* (*Cotylurus*) *magniacetubulus* (from *Cygnus atratus*), *Diplostomum* (*Diplostomum*) *parvulum* (from *Hydroprogne caspia* and *Pelecanus conspicillatus*), *Neodiplostomum* (*Neodiplostomum*) *lanceolatum* (from *Ninox novaeseelandiae*).

The new species from mammals are: *Neodiplostomum* (*Triloborchidiplostomum*) *diaboli* (a new subgenus, for which the diagnosis is given) (from *Sarcophilus harrisii*) and *Pharyngostomoides dasyuri* (from *Dasyurus viverrinus*).

Resume

Une importante collection de Strigeata d'Oiseaux et de Mammifères a été constituée au Département de Zoologie de l'Université d'Adelaide.

Le présent travail comprend la description ou la mention de 30 espèces, dont 7 sont nouvelles: *Apatemon* (*Apatemon*) *vitelliresiduus*, *Cardiocephaloides ovicorpus*, *Cotylurus* (*Cotylurus*) *magniacetubulus*, *Diplostomum* (*Diplostomum*) *parvulum*, *Neodiplostomum* (*Neodiplostomum*) *lanceolatum*, *Neodiplostomum* (*Triloborchidiplostomum*) *diaboli* (n. subgen., dont la diagnose est proposée) et *Pharyngostomoides dasyuri*. Ces deux dernières espèces sont parasites de Marsupiaux (Dasyurinés), respectivement de *Sarcophilus harrisii* et de *Dasyurus viverrinus*.

Introduction

An important collection of Strigeata from birds and mammals has been made by the Department of Zoology of the University of Adelaide. It consisted of 92 tubes with spirit specimens, and 3 slides.

Collections and identifications made before August, 1951, are the valuable contribution of the late Professor T. Harvey Johnston, to whose memory this work is dedicated. Since that time Mrs. P. M. Thomas (Patricia M. Mawson) has done most of the collecting. One of us (L.M.A.) collected the remainder. Dr. J. C. Pearson, of the University of Queensland, Brisbane, contributed 5 specimens (*Pharyngostomoides dasyuri*) from Tasmania.

Some of the specimens are valueless, either because of poor preservation or because young stages cannot be identified with adults.

The holotypes of all the new species described in this paper have been deposited in the South Australian Museum (SAM). Paratypes, where available, are in the South Australian Museum, and in the Helminthological Collection of the Institute of Zoology, University of Neuchâtel (G.D.). Preparations of the rest of the material are deposited in the Universities of Adelaide and of Neuchâtel.

The present publication is a continuation of 3 previous accounts of Australian Strigeida (Dubois 1937; Dubois & Pearson 1965, 1967).

Thirty species are described or recorded. Seven, one of which belongs to a new subgenus, are new. Twenty-seven are recorded as avian parasites and the other three are from mammals.

Family **STRIGEIDAE** Railliet

Subfamily STRIGEINAE Railliet

Apharyngostrigea simplex (S. J. Johnston, 1904). Dubois, 1968: 35, figs. 19–21. Dubois & Pearson, 1965: 79, figs. 1–3. S. J. Johnston, 1904: 112, pl. 7, figs. 1–3. *Host and origin*: *Ardea novaehollandiae* Latham, from Tailem Bend, River Murray, S. Aust., 1.v.1940 and 9.xii.1940 (2 specimens); from the Australian Museum, date? (one specimen).

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Habitat: upper intestine.

Description: These specimens, taken from the type-host, measure 2.8–3.0 mm; eggs 92–99 by 61–68 μm.

Parastrigea repens (Chase, 1921), Dubois, 1968: 68, fig. 51. Chase, 1921: 500, fig. 1 and pl. 26, figs. 1–5.

FIGS. 1, 2

Host and origin: *Circus approximans* Peale, from Tailem Bend, S. Aust., 10.iv. 1950 (18 adult and 1 immature specimen) and Dec. 1938 (10 young specimens).

Habitat: duodenum.

Chase (1921) found three specimens of this strigeid in the intestine of *Notophoyx novaehollandiae* (Latham) from Terrigal, N.S.W. The holotype, which is registered in the Australian Museum (W544), was re-examined by Dr. J. C. Pearson (see Dubois 1968, p. 68, footnote 1). On the basis of this examination, the species was removed from the genus *Apharyngostrigea* Ciurea to *Parastrigea* Szidat.

Description: The smallest specimens with few eggs in the uteri measure 1.6–2.2 mm. Fully mature worms are 5–6 mm long. Suckers weakly developed: oral sucker marginal, 60–115 μm in average diameter; ventral sucker 92–165 μm, near oral sucker. Average ratio of the oral to the ventral sucker nearly 2 : 3. Length of forebody from 9–19 (average 14) times that of oral sucker. Proteolytic gland elongated, oval or fusiform, 190–220 by 80–110 μm, composed of closely aggregated lobules and lying between the two concentrations of the vitelline follicles.

Ovary kidney-shaped and testes multi-lobed, occupying second half of the hindbody. Vitellaria of forebody extending dorsally up to ventral sucker, concentrated in lateral semicordiform expansions of dorsal lip of tribocytic organ. (No follicles in ventral lip, which is as long as forebody). Scattered follicles in wall of segment, extending further forward dorsally than ventro-laterally. In hindbody, vitelline follicles concentrated in front of ovary, absent dorsally over the gonads, and extending ventro-laterally to the bursa copulatrix. Ejaculatory duct joining with uterus at entrance to genital cone. Eggs numerous, 90–105 by 60–68 μm.

Relationships: *Parastrigea repens*, *P. intermedia*[1] Tubangui, 1932, and *P. flexilis* (Dubois, 1934) are closely related apharyngeal strigeids; in the absence of pharynx they are distinguishable from all known members of the genus. Their normal hosts are birds of prey (Falconiformes). *P. intermedia* (from the Philippines) differs from *P. repens* in that the small suckers are subequal, and in the size of the eggs (100–112 by 71–79 μm). *P. flexilis* is distinguished from the Australian species by having fewer eggs, and by a geographical distribution restricted to the holarctic zone of Europe and Asia.

Parastrigea sp.

Host and origin: *Threskiornis moluccus* (Cuvier), from Queensland, 26.vi.1911 (4 contracted specimens, collected by A. Breinl).

Habitat: unknown.

Description: Body length 1.4–2.4 mm. Forebody 0.88–1.08 by 0.94–1.15 mm (dorso-ventral diam.), with two well-developed lateral expansions. Hindbody 0.75–1.40 by 0.81–1.05 mm. Bursa copulatrix small.

These worms exhibit a striking similarity to *P. robusta* Szidat.

A specific diagnosis is reserved until better specimens are obtained.

Strigea baylisi Dubois, 1937: 1968: 82, figs. 60–61.

Hosts and origin: *Threskiornis moluccus* (Cuvier), from Tailem Bend, S. Aust., 28.iii.1942 (one specimen), *Platalea flavipes* Gould, from Tailem Bend, 24.ii.1943 (23 specimens) and 10.xii.1947 (6 specimens).

Habitat: intestine.

Relationships: *Strigea baylisi*, which appears to be a parasite of Plataleidae, is distinguishable from *S. promiscua* Nicoll by its smaller size, the smallness and the weakness of the pharynx (50–60 by 37–47 μm), the extension of the vitellaria to nearly as far as the posterior extremity, and the absence of follicles from the ventral wall of the anterior segment.

Strigea glandulosa Dubois, 1937: 244, fig. 9; 1968: 101, figs. 82–84. Dubois & Pearson, 1965: 82, figs. 4–5.

Strigea falconis Dubois, 1937: 247, fig. 10 (not Szidat, 1928).

Hosts and origin: *Circus approximans* Peale, from Tailem Bend, S. Aust., 15.xii.1938 (2 young specimens). *Haliastur sphenurus* (Vieillot), from Tailem Bend, Dec. 1938, (1

[1] One of us (G.D.), having examined three syntypes of *P. intermedia*, has not found any trace of a pharynx.

specimen) and 18.vi.1941 (2 macerated specimens). *Falco subniger* Gray from Meningie, S. Aust., 6.v.1945 (4 specimens). *Habitat*: intestine.

Description: Body up to 2.8 mm in length (when extended). The smallest specimen, with eggs in the uterus, measures only 1.4 mm. Oral sucker terminal, often prominent, 120–140 by 90–125 μm; pharynx rounded, very muscular, 95–105 by 90–105 μm; ventral sucker 160–190 by 150–175 μm; proteolytic gland well developed, oval, strongly lobulated, 145–210 by 170–250 μm, lying at base of forebody.

Ovary reniform. Mehlis' gland intertesticular, well developed. Eggs 89–102 by 57–69 μm, very numerous in mature specimens, in which the uterus may be distended into sinuous or tortuous curves and even into loops.

Relationships: *Strigea glandulosa* differs from *S. falconis* Szidat in its small size and in the great development of the proteolytic gland relative to the length of the body.

Strigea nicolli (Dubois, 1937). Dubois, 1968: 114, figs. 101–102.

Strigea suttoni Dubois, 1937: 237, figs. 5–7.

Host and origin: *Gymnorhina tibicen* (Latham) from Canberra, A.C.T., April 1969 (4 specimens) and 27.vii.1960 (1 specimen; collected by R. Mykytowycz).

Habitat: duodenum and intestine.

Description: Length 1.40–1.62 mm. Oral sucker 120–162 by 155–177 μm; pharynx 85–105 by 75–90 μm; ventral sucker 190–230 by 215–230 μm. Eggs 108–115 by 65–72 μm.

Relationships: *Strigea nicolli* resembles *S. baylisi* Dubois in general anatomy, but differs in the sizes of the suckers and the pharynx, which are definitely larger, and in the minor development of the atrial ring-shaped musculature.

Strigea promiscua Nicoll, 1914: 347; Dubois, 1968: 119, figs. 107–108. Dubois & Pearson, 1967: 186.

Hosts and origin: *Ninox novaeseelandiae* (Gmelin) (syn. *N. boobook*) from Yalkuri, S. Aust., 24.viii.1957 (1 specimen, described below). *N. strenua* (Gould) from Eidsvold, Qld., 1.vi.1919 (22 specimens, very contracted; collected by M. J. Bancroft).

Habitat: intestine.

On June 9, 1965, Dr. J. C. Pearson collected the species from the small intestine of *Ninox novaeseelandiae* in Brisbane, Qld. The species has now been found four times, always from the same host genus.

Description: Length 2 mm. Body very contractile, nearly as wide as long when strongly contracted (as in 1.vi.1919 material). Oral sucker 160 by 185 μm, pharynx 115 by 105 μm, ventral sucker 230 by 210 μm; proteolytic gland 190 by 215 μm, multilobed.

Ovary reniform, 170 by 260 μm. Testes roughly lobed, the anterior measuring 285 by 390 μm, the posterior 320 by 400 μm. Vitellaria extending from cephalic margin to level of equator of genital cone. The latter is robust, well differentiated, larger than the ovary, 260 μm in diam. when retracted. Genital atrium spacious, 180 to 240 μm in depth, with ring-shaped musculature well developed. Eggs 104–115 by 75–80 μm, 6 in number.

As at present known, it seems that *Strigea promiscua* is restricted to the Strigiformes, especially to the oriental type *Ninox*.

Apatemon (Apatemon) vitelliresiduus n.sp.

FIG. 3

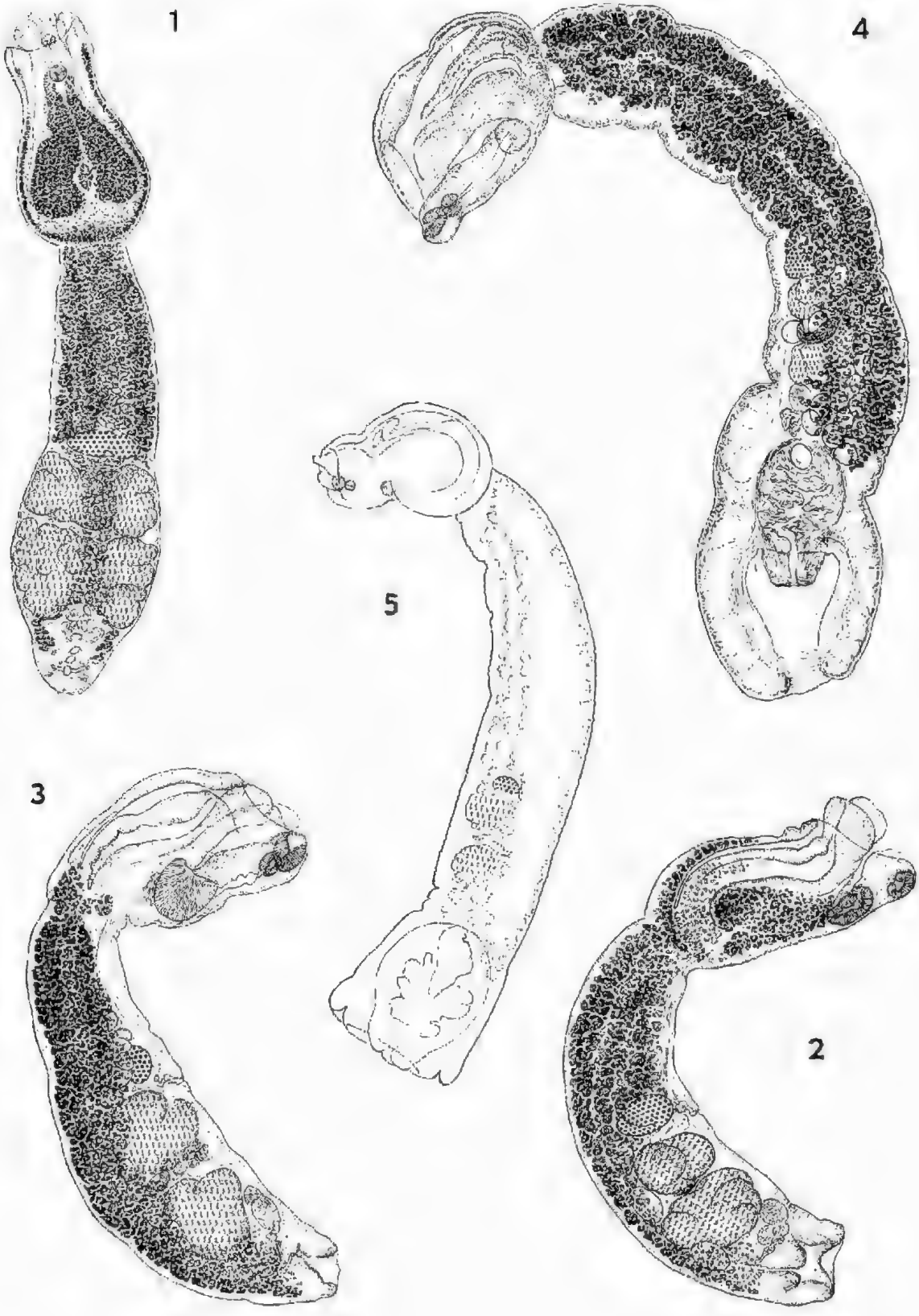
Host and origin: *Biziura lobata* (Shaw) from Tailem Bend, S. Aust., 10.xii.1937 and 9.xii.1940 (35 specimens); Sandgate, Qld., 22.ix.1918 (1 specimen); Purnong and Caloot, R. Murray, S. Aust., 20.vi.1958 (10 specimens, obtained from two hosts) (type material).

Habitat: intestine.

Holotype: length 2.6 mm, SAM, E927 (with 3 paratypes, E928, on same slide).

Description: Body cambered dorsally, 2.2–2.6 mm long. Forebody ovoid or cup-shaped, 0.71–0.90 mm in length by 0.51–0.64 mm in dorsoventral diam., delimited by constriction from hindbody. Hindbody twice as long, banana-shaped, with small bursal region slightly delineated, 1.48–1.70 mm long by 0.50–0.56 mm in diam. at the level of the testes. Ratio of hindbody to forebody ranging from 1.9–2.1. Oral sucker 115–160 by 110–127 μm, terminal in position; pharynx smaller, 85–93 by 70–75 μm; ventral sucker postequatorial, relatively large, 190–210 by 165–180 μm. Proteolytic gland small, rounded and lobed, situated dorsally near base of forebody, 65–80 by 60–70 μm.

Ovary 140–150 μm long, 180–190 μm thick, located at anterior third (27–36/100, average 33/100) of hindbody. Testes large, approximately equal in size (first, 260–330 by 240–300 μm, second 300–370 by 260–300 μm), ovoid, roughly lobed, obliquely orientated with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lobes directed forward. Vitellaria are confined ventrally in hindbody, especially well developed in front of gonads, extending to near posterior extremity of worm, but not masking bursa copulatrix laterally; erratic follicles extend more or less far into ventral wall of forebody, but do not go beyond acetabular level. Vitelline reservoir lies in intertesticular space. Mehlis' gland is situated dorsally and a little anteriorly. Genital cone of medium size, 190–200 by 150–180 μm, not well differentiated. Vesicula seminalis S-shaped and voluminous, lying posterodorsal to second testis. Sinuous ejaculatory duct opens into terminal part of uterus at entrance to cone, to form a rectilinear, not pleated, hermaphroditic canal. Eggs 87–95 by 58–67 μm, average 92 by 63 μm.

Relationships: This new species closely resembles *Apatemon* (*A.*) *fuligulae* Yamaguti, 1933, in general morphology, but differs essentially in the presence of erratic vitelline follicles in the ventral wall of the anterior segment. This remnant appears to constitute an archaic character. In *A. fuligulae*, the eggs are larger (100–120 by 60–66 μm).

Apatemon (Australapatemon) intermedius (S. J. Johnston, 1904). S. J. Johnston, 1904: 109, pl. v, figs. 7–10. Dubois, 1968: 169, figs. 162–164. Dubois & Pearson, 1965: 85, figs. 6–7. Johnston & Angel, 1951: 66, figs. 1–28.

Hosts and origin: *Oxyura australis* Gould, from Tailem Bend, S. Aust., 15.i.1941 and 28.i.1941 (11 specimens), *Accipiter fasciatus* Vigors & Horsfield from Mallala, S. Aust., March 1965 (20 small ovigerous specimens). (Johnston & Angel (1951) found this species in 5 of 11 *Cygnus atratus* (Latham) from Tailem Bend).

Habitat: unknown.

Description: Body length 1.5–2.8 mm (specimens from *Oxyura australis*). This species is characterised by the structure and size of the genital cone; this organ measures 240–320 by 160–200 μm when retracted, thus being about one fifth the total length of worm. A wide strongly folded hermaphrodite duct passes through the cone. Laurer's canal descends from oviduct where the latter leaves the ovary, and reaches the dorsal surface on a level with anterior testis. Eggs 94–99 by 60–68 μm.

The specimens from *Accipiter fasciatus* (possibly an abnormal host) measure 1.2 to 1.9 mm. Eggs 90–95 by 55–63 μm.

Cardiocephaloides hilli (S. J. Johnston, 1904). Dubois, 1968: 180, figs. 175, 176; 1970: 722. S. J. Johnston, 1904: 110, pl. VI, figs. 1–8.

FIGS. 4, 6

Host and origin: *Larus novaehollandiae* Stephens, from Glenelg, S. Aust., 2.iii.1939 (20 specimens, from 2 hosts); West I., S. Aust., 14.vi.1968 (4 specimens); St. Kilda, S. Aust., 5–19.ix.1951 (2 specimens, from intestinal residues of four birds).

Habitat: duodenum, intestine.

The only previous record of this strigeid is that of S. J. Johnston (1904) who described it from the Australian gull, *Larus novaehollandiae* from Jervis Bay, N.S.W. There is only one syntype (deposited in the Helminthological Collection of the London School of Hygiene and Tropical Medicine (No. 244)) known. The following description is based on the examination of 15 specimens, slightly smaller than those of Johnston, from the Glenelg material.

Description: Body length 3.5–6.2 mm (6.9–8.2 mm according to Johnston). Forebody ovoid in lateral view, subcordiform in ventral view, with feebly developed lateral expansions, 0.74–1.12 mm long, 0.55–0.70 mm thick. Hindbody elongated, cylindrical and usually flexed dorsally, with bursal region set off from remainder by a more or less definite constriction, 2.80–3.18 mm long, 0.52–0.80 mm in diam. at level of testes, 0.65–0.76 mm in bursal zone. Ratio of hindbody to forebody ranging from 2.9–3.8, averaging 3.4. Oral sucker terminal or subterminal, of medium size, 95–117 by 85–106 μm; pharynx smaller, spherical, 80–95 by 75–95 μm; caeca extending back close to genital cone (fig. 6); ventral sucker, 95–130 by 115–145 μm, lying usually just in front of middle of forebody.

Figs. 1, 2. *Parastrigea repens*, from *Circus approximans*. Fig. 1.—Length 5.5 mm, flattened mature specimen. Fig. 2.—Length 1.8 mm, young specimen with two eggs.

Fig. 3 *Apatemon* (*Apatemon*) *vitelliresiduus* n.sp., from *Biziura lobata*. Holotype: length 2.6 mm.

Fig. 4. *Cardiocephaloides hilli*, from *Larus novae-hollandiae*. Length 3.64 mm.

Fig. 5. *Cardiocephaloides musculosus*, from *Hydroprogne caspia*. Outline. Length 6.6 mm. Neuch. Univ. (G.D.) No. V17.

Ovary, 130–150 by 190–200 μm, situated at about mid-length of hindbody, in front of relatively small testes (160–190 by 210–250 μm), which are ovoid and roughly lobed. Vitellaria confined to this segment, where they appear profusely developed up to gonads, then restricted to ventro-lateral field; they do not penetrate bursa copulatrix. Vitelline reservoir lies in intertesticular space. Dilatable bursa copulatrix large, quite often larger than forebody; occupying last third or quarter of hindbody, and enclosing powerfully built genital cone, which measures 520–740 by 340–500 μm; inner wall of cone, when retracted, thrown into a number of folds delimiting sinuous spaces. Uterus and muscular ejaculatory duct, the walls of which are 5–10 μm thick, enter the cone, proceed side by side and unite to form a very short hermaphroditic canal which discharges into large genital atrium. There are two sphincters, one at orifice of cone, the other surrounding aperture of bursa. The numerous eggs measure 115–125 by 75–84 μm, average 119 by 80 μm; shell thin (3–4 μm).

Cardiocephaloides musculosus (S. J. Johnston, 1904). S. J. Johnston, 1904: 112, pl. VII, figs. 4–9. Dubois, 1968: 188, fig. 185.

FIGS. 5, 7

Hosts and origin: *Chlidonias hybrida* (Pallas), from Tailem Bend, S. Aust., 27.x.1948 (6 specimens). *Hydroprogne caspia* (Pallas), from Townsville, Qld., 20.viii.1968 (1 specimen).

Habitat: small intestine.

The only Australian record of this strigeid is that of S. J. Johnston (1904), who described it from the crested tern, *Sterna bergii* Lichtenstein, from Broken Bay, N.S.W. The type material collected by Dr. J. P. Hill cannot be found. As a result of the examination of these new specimens, some additional structures have been seen.

Description: Body up to 6.8 mm long. Forebody short and cordiform, or pear-shaped (seen side view), with large lateral expansions in last two thirds, 1.43–1.57 mm long, 1.60–1.65 mm wide, 0.69–0.87 mm thick across the cephalic cupule, 0.95–1.15 mm at level of expansions. Hindbody elongated, subcylindrical and slightly flexed dorsally, gradually increasing in diam. towards posterior end where it is truncated, especially just in front of bursa copulatrix, 4.4–5.2 mm long, 0.72–0.87 mm in diam. anteriorly, 1.05–1.25 mm posteriorly. Ratio of hindbody to forebody from 3–3.5. Oral sucker spherical, of medium size, measuring 130–160 μm in diam.; pharynx smaller, 125 μm; ventral sucker, 130–140 μm, lying much in front of middle of forebody (about at one-third its length), where latter begins to dilate. Caeca extending laterally to level of genital atrium.

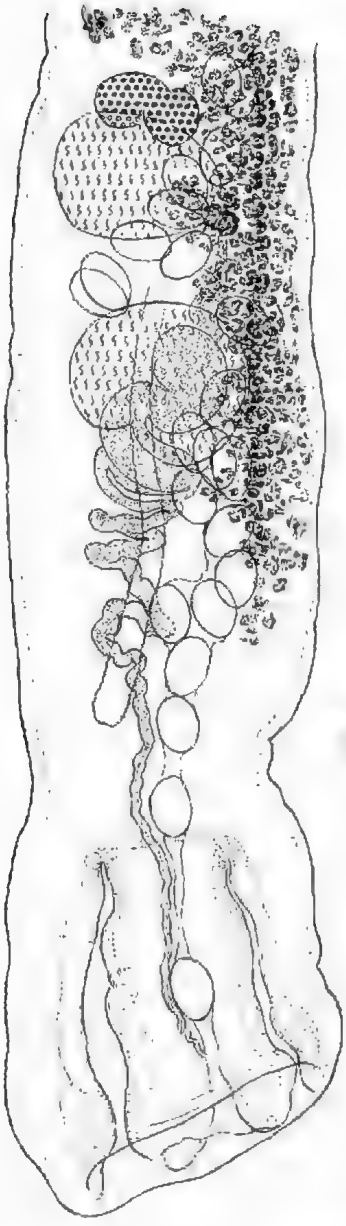
The ovary and the testes—the latter lobed and approximately equal in size (300–350 μm long, and wider than long)—occupy about the middle third or third quarter of the hindbody. Vitellaria confined to hindbody, profusely developed in small follicles, obscuring the contents, down to the gonads, then restricted to two ventro-lateral fields, and extending down to cap of the genital cone, laterally beyond its equator. Vitelline reservoir between testes. Large bursa copulatrix a truncated cone, occupying a little less than last quarter of hindbody, delineated by a slight constriction, gradually increasing in diam., with wide open terminal aperture; enclosing a powerfully built ovoid genital cone, 1250–1600 by 950–1060 μm, clearly defined by its own musculature. When withdrawn, its walls are thrown into a number of folds surrounded by parenchyma and muscle fibres, and delimiting sinuous spaces. A slack sphincter surrounds orifice of cone. Uterus entering cone anteriorly and connecting with ejaculatory duct. Eggs, numerous in both ascending and descending limbs of uterus, measure 110–122 by 73–80 μm; shell thin (3–4 μm).

Relationships: *Cardiocephaloides musculosus* differs from *C. hilli* (Johnston) in the strongly muscular nature and bulk of the genital cone, and in the presence of "very strong bands of longitudinal muscle" in the hindbody (S. J.

Fig. 6. *Cardiocephaloides hilli*, from *Larus novaehollandiae*. Second half (measuring 2.1 mm) of posterior segment.

Fig. 7. *Cardiocephaloides musculosus*, from *Chlidonias hybrida*. Length 6.3 mm, ventral view.

Figs. 8–11. *Cardiocephaloides ovicorpus* n.sp. Fig. 8.—From an unknown host. Holotype: length 5.4 mm, ventral view. Fig. 9.—Sketch of an unmounted specimen, from *Phalacrocorax varius*. Length 3.6 mm, dorsal view. Fig. 10.—Sketch of an unmounted specimen from an unknown host. Paratype: length 6.7 mm, lateral view. Fig. 11.—From an unknown host. Sagittal section of posterior region of a paratype.



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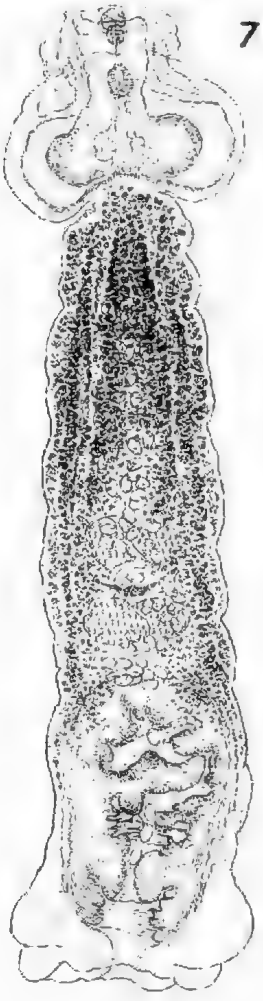

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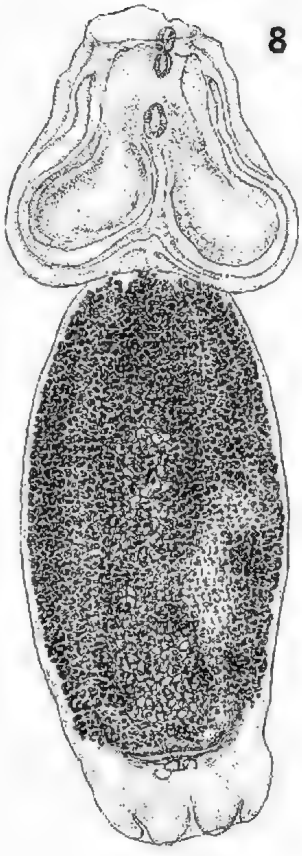

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Johnston 1904, p. 714). Ratio of length of posterior segment/genital cone = 3.0–3.7 in *C. musculosus* (average 3.3) and 4.0–5.3 in *C. hilli* (average 4.8). The two species occur in Laridiformes, the first in terns, the second in gulls.

Cardiocephaloides ovicorpus n.sp.

FIGS. 8–11

Hosts and origin: *Phalacrocorax melanoleucos brevirostris* Gould, from Dunedin, New Zealand, 20.ii.1940 (6 specimens, collected by Miss M. Fyfe, Otago University). *P. varius* (Gmelin), from Port Gawler, S. Aust., 29.vi.1938 (several specimens, from two birds). Unknown host (18 attached and free specimens) (type material).
Habitat: intestine.
Holotype: length 5.4 mm, SAM, E929.
Paratypes: E930. (Sections in Neuchâtel University and Adelaide University collections).

Description: Body medium-sized, divided into distinct anterior and posterior segments. Total length 2–7.6 mm. Specimens which have recently begun egg production 2.5–3 mm long. Anterior segment, 0.98–2.40 by 1.40–2.80 mm, comprising from three-tenths to four-tenths of the body length, subcordiform, with two dilated and dorsally incurved lateral expansions in its second half, which appear with their ventral connection like a reniform collar surrounding base of cephalic cupule; latter spherical or a truncated cone. Posterior segment 1.5–5.4 by 1.0–2.6 mm, ovoid to spindle-shaped, sometimes cylindrical (fixed in extended state), often slightly arched, dumpy, massive in contracted state (greatest diam. at level of testes), narrower in atrial zone of bursa (0.74–1.75 mm) which is delineated by a more or less definite constriction at the last fifth, sixth or seventh of the segment. Ratio of hindbody to forebody ranging from 1.4–2.5, averaging 1.96. Oral sucker (marginal), pharynx and ventral sucker all small; ventral sucker a little larger than oral, situated at mid-length of forebody or in front of it (42–45/100). Oral sucker 140–200 by 110–200 μm, pharynx 85–180 by 75–127 μm and ventral sucker 180–210 by 120–200 μm. Caeca enclosed in muscular, ventro-lateral bundles and extending as far as equator of genital cone, i.e. posterior limit of vitellaria. Tribocytic organ well developed, often protruding anterior to margin of forebody, and penetrating into the lateral expansions. A layer of large cells delimits the whole active surface of this organ. Proteolytic glands distributed in numerous small, relatively scattered bunches, as shown by Baer (1969, fig. 41).

Ovary ovoid, 320 by 230 μm, situated dorsally between 27th and 31st hundredths of length of hindbody. Testes multilobed, the mass of which measures 2100 by 1300 μm. Vitellaria are confined to hindbody, profusely developed and obscuring its contents; lying in a large field along ventro-lateral surface up to constriction delineating genital atrium. (Last follicles 420–890 μm distant from posterior end, having their limit between 77th and 85th hundredths of this part of body.) Field widest anterior to gonads, where follicles extend towards dorsal surface. Vitelline reservoir intertesticular. Mehlis' gland well developed, lateral and posterior to ovary. Bursa copulatrix enclosing a genital cone, 450–980 by 420–920 μm (320–1000 μm in diam. inside the atrium). Central part of this cone appears less muscular, but more spongy and coloured; its inner wall thrown into a few folds delimiting sinuous spaces. Uterus extending into first third of hindbody, where it develops several convolutions, then descends ventrally; behind seminal vesicle, it makes a conspicuous right angled bend to open into genital cone. Sinuous ductus ejaculatorius, wall of which is 5–16 μm thick, opens near entrance of uterus to genital cone. Eggs very numerous, 120–130 by 78–94 μm (thickness of shell 4–5 μm, up to 8 μm at the non-operculate pole).

Relationships: The new species resembles *C. physalis* (Lutz, 1926) [syn. *C. szidati* (Hartwich, 1954)], as figured by Dubois (1968, figs. 187–188) and rediscovered by Baer (1969) in the intestine of a cormorant from Peru (Guañape Islands), but *C. physalis* differs from it in having a much bigger bursa copulatrix, eggs with very thick shell and vitellaria extending only as far as the beginning of the bursa, and in the geographic distribution.

Cotylurus (Cotylurus) magniacetabulus n.sp.

FIG. 12

Host and origin: *Cygnus atratus* (Latham), from Tailem Bend, S. Aust., 25.x.1945 (16 specimens).
Habitat: lower intestine.
Holotype: Length 2 mm, SAM, E931 (with 5 paratypes, E932, on same slide; and a second slide, E932).

Description: Body very muscular, with meridian muscles in walls of forebody and circular fibres surrounding the oblique open-

ing; at beginning of hindbody are longitudinal muscles dorsally, gathered into several bundles which spread out at level of reproductive organs, dorsal one reaching posterior end of worm.

Body 2.0–2.6 mm long. Forebody cupuliform, hemispherical to spheroidal, obliquely truncated in front, with ventral border nearly rectilinear and shorter than strongly incurved dorsal border, 0.60–0.71 by 0.74–0.86 mm, well marked off from the gradually attenuated cucumiform hindbody, 1.34–1.65 by 0.53–0.67 mm, which is eccentrically fastened to the former. Ratio of hindbody to forebody from 2–2.6. Oral sucker 105–127 by 130–155 μm; ventral sucker much larger, cupuliform in profile, 180–240 by 160–190 μm (ratio of the average diams. of the latter to the former 1.35–1.74, average 1.47); pharynx feebly muscular, 80–95 by 64–75 μm.

Ovary reniform, 130–160 by 175–210 μm, situated between 17th and 24th hundredths of hindbody. Testes trilobate, with lobes directed posteriorly, the first measuring 210–350 by 275–320 μm, the second a little smaller, 210–320 by 265–300 μm. Vitellaria very profuse through hindbody, and extending anteriorly into the two lips of tribocytic organ (erratic follicles); vitelline reservoir and Mehlis' gland intertesticular. Seminal vesicle lying dorsally; ejaculatory duct and uterus (which extends to intersegmental constriction) uniting and opening through a short common duct (length 70–80 μm) into atrium. Genital bulb, 140–170 μm in diam., provided with a conspicuous muscular thickening at its base, on the dorsal side. Eggs from 30 to 60 in the uterus, 84–99 by 58–72 μm (average 89 by 63 μm).

Relationships: This new species closely resembles *C. strigeoides* Dubois, 1958, but differs from it in the larger size of the acetabulum, relative to the oral sucker (ratio of the average diams. 1.10–1.13 in *C. strigeoides*), in the ovary being more distant from the beginning of the hindbody (7–8/100 in *C. strigeoides*), and in the geographic locality.

Schwartzitrema pandubi (Pande, 1939). Dubois, 1968: 248, figs. 257–260. Dubois & Pearson, 1965: 90, figs. 8, 9; 1967: 190. Pande, 1939: 26, figs. 3, 4.

FIGS. 13, 14

Hosts and origin: *Phalacrocorax carbo* (Linn.), from Tailem Bend, S. Aust., 21.iv.1941 (4 specimens), *P. sulcirostris* (Brandt), from Tailem Bend, 15.i.1941 (16 specimens, of which 10 ovigerous), 15.i.1941 and 26.iii.1943 (numerous cysts, some excysting, from stomach, along with fish remains), *P. melanoleucos* (Vieillot), from Tailem Bend, 25.x.1945 (14 immature specimens), 30.iii.1938 and 24.ii.1943 (24 specimens) and 6.vi.1945 (40 specimens). *Habitat*: intestine.

Description: Body length 0.7–1.4 mm (ovigerous specimens).

Remarks: This parasite appears to be common in cormorants at Tailem Bend (cf. Dubois & Pearson 1965, 1967).

The tetracotyles found in the stomach of *P. sulcirostris* were both encysted and encapsulated. The cysts are dark, strong, ovoid, helmet-shaped, with a subconical pole and a circular opposite aperture. They measure 400–450 by 320–360 μm (230–320 μm at the level of the opening). The cyst wall varies from 40–90 μm in thickness (70–130 μm at the pole). At this stage the structures in the forebody of the tetracotyle are clearly differentiated, and the conical hindbody is separated by a marked constriction. The characteristic processes of the pseudo-suckers are in a conspicuous position (Fig. 13). The cysts are often surrounded by a thin layer of hyaline secretion (5–18 μm in thickness, 8–24 μm at the pole).

The cysts were also found free in the stomach and proventriculus of grebes, *Podiceps novaehollandiae* Stephens (24.ii.1943 and 14.iv.1943), *P. poliocephalus* Jardine & Selby (14.iv.1943) and *P. cristatus* (Linn.) (24.xi.1947), all from Tailem Bend; from the stomach of *Pelecanus conspicillatus* (Temminck) along with fish and the crustacean, *Cherax destructor* (27.i.1942, 25.v.1942, 17.iv.1944), from Tailem Bend; in the stomach of *Platalea flavipes* Gould, along with fish (24.ii.1943), from Tailem Bend; and from fish remains, with escaping metacercariae, in *Botaurus poiciloptilus* (Wagler) (20.vi.1949) from Mannum, River Murray, S. Aust.

Family **DIPLOSTOMIDAE** Poirier

Subfamily DIPLOSTOMINAE Monticelli

Bolbophorus confusus (Krause). Dubois, 1970: 266, figs. 272–276, 278 (metacercaria). Dubois & Pearson, 1965: 95, fig. 13.

Host and origin: *Pelecanus conspicillatus* (Temminck) from Tailem Bend, S. Aust., April 1938, Dec. 1938, 27.i.1942, 25.v.1942, 23.xi.1942, 17.iv.1944, 20.iii.1950 (40

mature specimens, and 20 metacercariae and young specimens).

Habitat: stomach and intestines.

Description: Body length 1.5–2.2 mm.

Remarks: The first Australian record of this cosmopolitan species is that of Dubois & Pearson (1965), who observed an acetabulum measuring 42–65 by 48–92 μm. In the mature specimens of the present collection, this organ is smaller, 32–40 by 42–50 μm.

?Diplostomum (Diplostomum) amygdalum

Dubois & Pearson, 1965: 90, figs. 10–11.
Dubois, 1970: 300, figs. 297–298.

Host and origin: *Nycticorax caledonicus* (Gmelin), from Tailem Bend, S. Aust., 1.vi.1940 (9 immature specimens).

Habitat: unknown.

Description: Body length 0.55–0.66 mm. The vitellaria are not yet developed. This species, adapted to the Ardeidae, commonly occurs in Brisbane, Qld. (Botanical Gardens).

Diplostomum (Diplostomum) parvulum n.sp.

FIGS. 15, 16

Hosts and origin: *Hydroprogne caspia* (Pallas), from Tailem Bend, S. Aust., Dec. 1939 (Type material: 5 specimens). *Pelecanus conspicillatus* (Temminck) from Tailem Bend, date? (4 specimens).

Habitat: intestine.

Holotype: length 0.56 mm. SAM. E933, with 2 or 3 (?) paratypes (E934) on same slide.

The type-material was obtained from a Caspian tern at Tailem Bend. Another collection has been found in a pelican from the same place: this is probably a case of erratic parasitism, the worms being mixed with metacercariae of *Bolbophorus confusus* (Krause).

Description: Body 0.42–0.87 mm long, more or less distinctly divided in two segments. Forebody 0.25–0.53 by 0.24–0.34 mm, oval in outline, foliiform, spoon-shaped with posterior margin curved ventrally. Hindbody ovoid, bent dorsally, 0.16–0.34 by 0.21–0.27 mm (dorso-ventral diam. 0.21–0.32 mm). Ratio of length of second segment to first from 0.62–0.75 (average 0.67). Oral sucker rounded, prominent, 50–62 by 52–63 μm; ventral sucker almost equal in size to the oral or smaller, broader than long, 45–52 by 55–63 μm; pharynx elongated, 50–52 by 24–30 μm (its antero-posterior diam. is often equal to that of oral sucker); oesophagus short, 15–25 μm; intestinal caeca narrow (5–10 μm), conspicuous in forebody and entering hindbody to terminate not far from posterior end. Pseudo-suckers semilunar or kidney-shaped, thicker anteriorly, 73–90 by by 37–60 μm. Tribocytic organ approximately circular, with a median cleft, 75–100 by 75–120 μm; proteolytic gland bilobed, with massive bean-shaped lobes, lying transversely at base of anterior segment.

Ovary submedian, situated at beginning of hindbody, 35 by 60 μm. Anterior testis asymmetrical, 45–55 by 130–170 μm; posterior testis bilobed, 60–75 by 220–250 μm. Vitellaria extending from posterior margin of ventral sucker or front of tribocytic organ to caudal extremity of body, with the greater density in pretesticular zone, reducing beyond to two medio-ventral sowings of follicles at level of testes, and abutting against the rather compact latero-terminal accumulations behind these; vitelline reservoir intertesticular. Bursa copulatrix small, the pore being dorsal and subterminal (at 50–65 μm from posterior extremity); genital cone absent. Eggs few in number (1–3), 89–95 by 55–65 μm.

Relationships: This diplostome is characterized by its very small size, being the smallest of those described in the subgenus *Diplostomum*. It closely resembles the South American species *D. minutum* Szidat, from *Larus dominicanus* Lichtenstein, but differs from it in the size of the eggs and in the relative diameters of the oral and ventral suckers. (In the latter, the eggs measure 110 by 70 μm, and the ventral sucker is larger than the oral.)

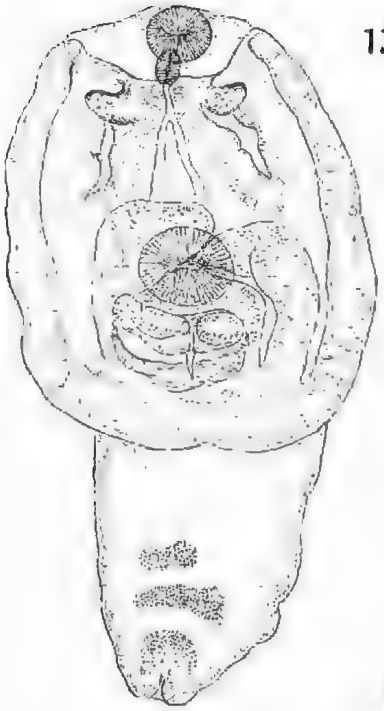
There were yet larger diplostomes in the collection from *Hydroprogne caspia*. They measure 0.7 to 1.0 mm in the contracted state.

Fig. 12. *Cotylurus* (*Cotylurus*) *magniacetabulus* n.sp., from *Cygnus atratus*. Holotype: length 2 mm.

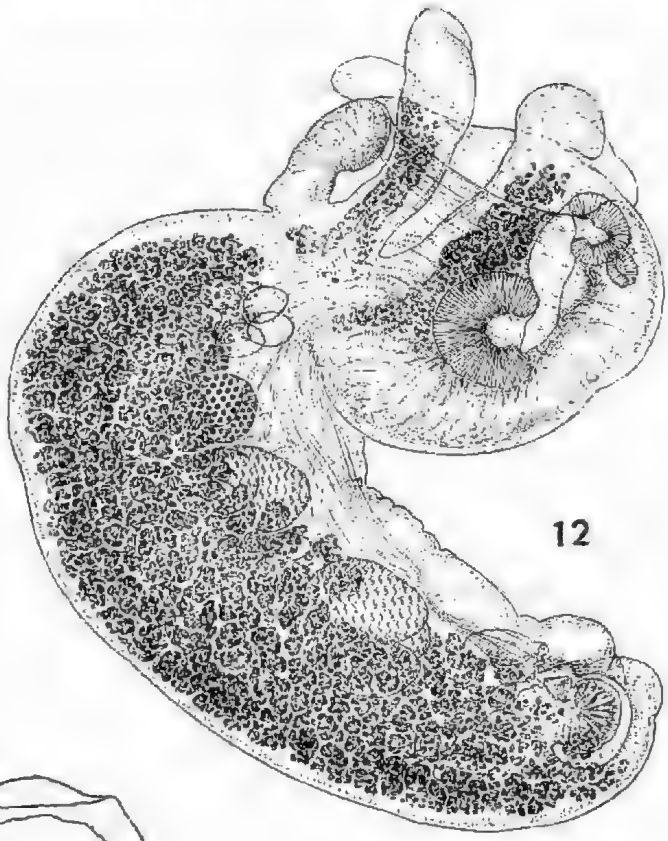
Figs. 13, 14. *Schwartzitrema pandubi*. Fig. 13.—Excysted tetracotyle, from *Phalacrocorax melanoleucos*. Length 0.67 mm. Fig. 14.—Cyst, from stomach of *P. sulcirostris*; 420 by 320 μm.

Figs. 15, 16. *Diplostomum* (*Diplostomum*) *parvulum* n.sp. Fig. 15.—From *Hydroprogne caspia*. Holotype: length 0.56 mm, ventral view. Fig. 16.—From *Pelecanus conspicillatus*. Length 0.42 mm., dorsal view.

Fig. 17. *Diplostomum* (*Diplostomum*) *spathaceum murrayense*, from *Larus novaehollandiae*. Length 1.7 mm, ventral view.



13



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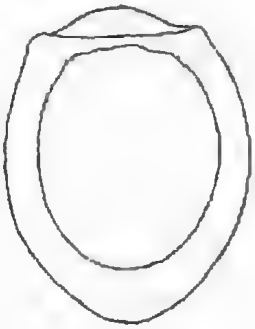
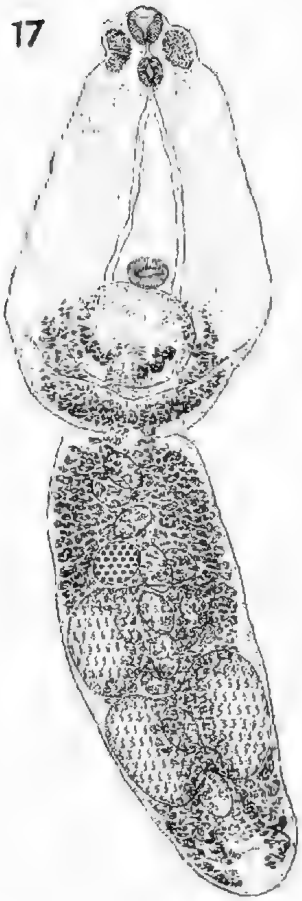
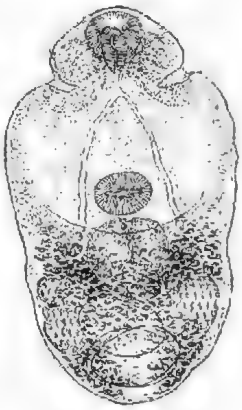
14



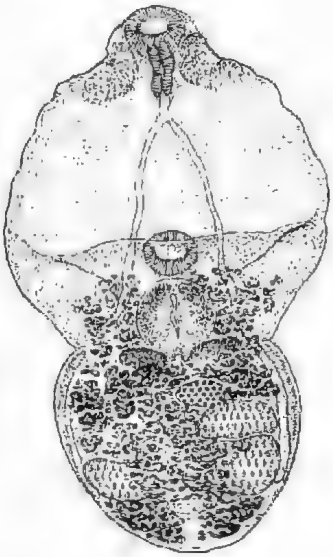
17



16



15



Ratio of massive hindbody to forebody from 0.91–1.25 (average 1.02). We would have difficulty in describing them. Perhaps they belong to the former species, but the pharynx is obviously larger (60–70 by 47–52 μm), and the ventral sucker (89 by 65 μm) is greater than the oral sucker (68–75 by 57–65 μm).

Diplostomum (Diplostomum) spathaceum murrayense (Johnston & Cleland, 1938). Johnston & Cleland, 1938: 127, figs. 1–10 (cercaria). Dubois, 1966a: 40; 1970: 341, fig. 355, Dubois & Pearson, 1965: 93, fig. 12. Johnston & Angel, 1941: 140, figs. 1–10 (life cycle). Johnston & Simpson, 1939: 230, figs. 1–6 (diplostomulum).

FIG. 17

Host and origin: *Larus novaehollandiae* Stephens, from Swan Reach, River Murray, S. Aust., 14.xii.1937 (12 specimens); Tailem Bend, S. Aust., 8.iii.1940 (8 specimens), 19.iii.1941 (12 specimens), 19.v.1941 (20 specimens), 27.i.1942 (3 specimens) and 28.iii.1942 (13 specimens); Yalkuri, S. Aust., 24.viii.1957 (one specimen).

Habitat: intestine.

Remarks: Johnston & Simpson (1939) believed that the adult would be found in lariform birds, most probably in the silver gull, *Larus novaehollandiae*. However, Johnston & Angel (1941) reported having found young and adult diplostomes in the marsh tern, *Chlidonias hybrida* (Pallas) [*C. leucopareia*], and successfully infected *Limnaea lessoni* Deshayes with eggs from the adult flukes, later recovering cercariae (*Cercaria murrayensis*) from this snail. From the occurrences recorded above, it seems that the silver gull is an equally, if not more important, definitive host for this parasite.

Diplostomum (Tylodelphys) podicipinum podicipinum Kozicka & Niewiadomska, 1960. Dubois, 1970: 388, figs. 420–421.

FIG. 18

Host and origin: *Podiceps cristatus* (Linn.) from Tailem Bend, S. Aust., 24.xi.1947 (16 specimens).

Habitat: unknown.

Description: Body length 1.32 mm.

Remarks: This is the first Australian record of this parasite originally described from Poland, collected from Slovakia and U.S.S.R., and characterized by the great relative diameter of the acetabulum (90 by 95 μm, equal to a quarter of the body breadth), elongate pseudo-suckers (170 μm), the ratio of length of body to pseudo-sucker (7.7), and the presence of a conspicuous atrial sphincter.

Hysteromorpha platalea Dubinin & Dubinina, 1940. Dubois, 1970: 397, figs. 430–435. *Diplostomum ardeiformium* Odening, 1962.

FIG. 19

Host and origin: *Threskiornis molucca* (Cuvier), from Qld., 26.vi.1911 (18 specimens: Coll. A. Breinl).

Habitat: unknown.

In 1940 this minute trematode was described by Dubinin & Dubinina from the intestine of a spoonbill, *Platalea leucoradia* L., in U.S.S.R. (the Volga delta). Its presence in India was reported by Odening (1962), who considered it as a new species designated by the name of *Diplostomum ardeiformium*, from *Pseudibis papillosa* (Temm.). The present record is the first Australian reference to this parasite.

Description: Body length 0.58–0.76 mm. Forebody 0.33–0.40 by 0.36–0.51 mm. Hindbody shortly ovoid, 0.23–0.37 by 0.34–0.44 mm, scarcely demarcated from forebody by a weak constriction. Ratio of hindbody to forebody 0.66–0.94. Oral sucker 52–68 by 57–75 μm; pharynx 42–52 by 40–45 μm; ventral sucker small, almost equal in size to pharynx, 42–47 by 47–50 μm, masked by a well-developed tribocytic organ, 210–265 by 170–225 μm. Proteolytic gland oval in outline, crescent-shaped, strongly lobulated, 95–125 by 110–125 μm.

Ovary 45–55 by 95–135 μm, situated at intersegmental level. Anterior testis asymmetrical, 70–105 by 150–210 μm; posterior testis bilobed, 80–125 by 290–390 μm. Vitellaria well developed throughout most of body; follicles distributed in the folliceous forebody, especially at its base, and in tribocytic organ, where they are arranged in the form of a semicircle; restricted in hindbody to a medio-ventral field, which widens out to constitute two latero-terminal clusters. Vitelline reservoir intertesticular. Mehlis' gland lateral, opposite anterior testis. Eggs, from 3–10 in the uterus, 95–112 by 58–68 μm (average 103 by 62 μm).

Relationships: *Hysteromorpha platalea* shows a close resemblance to *H. triloba* (Rud.), but the latter appears to be bigger (up to 2.2 mm) whereas its eggs are smaller (75–99 by 48–75 μm) and more numerous. The acetabulum of *H. triloba* is always larger than the oral sucker, and the hosts are various species of cormorants.

Hysteromorpha triloba (Rudolphi, 1819). Dubois, 1970: 400, figs. 436–439, and 440 (cercaria). T. H. Johnston, 1942: 238, *Diplostomulum cortii* Hughes, 1929 (metacercaria).

Diplostomum granulosum Goss, 1941.

Parastrigea slovacica Rysavy, 1958

Host and origin: *Phalacrocorax melanoleucos* (Vieillot), from Tailem Bend, S. Aust., date? (7 specimens).

Habitat: unknown.

The first record of this cosmopolitan parasite is that of Miss O. M. Goss (1941) who described it as *Diplostomum granulosum*, from *Phalacrocorax sulcirostrix* (Brandt) [= *P. ater*] from Perth, W. Aust. T. H. Johnston (1942) recorded it from various cormorants, especially from Tailem Bend.

Description: Body 1.03–1.18 by 0.56–0.67 mm. Ventral sucker 90–92 by 94–98 μm; oral sucker 70–73 by 83–84 μm; pharynx 50 by 47 μm. Eggs 92–95 by 63–68 μm. Tribocytic organ rounded, funnel-shaped when protruded. Proteolytic gland bilobed and trapezoidal.

Neodiplostomum (Conodiplostomum) brachyurum (Nicoll, 1914). Nicoll, 1914: 346, pl. 24, fig. 9. Dubois, 1937: 333, figs. 11–12; 1970: 418, figs. 451–452.

Hosts and origin: *Ninox novaeseelandiae* (Gmelin), from Yalkuri, S. Aust., 24.viii.1957 (18 specimens, collected by W. H. Ewers). *Tyto alba* (Scopoli), from Point Turton, Yorke Peninsula, S. Aust., 12.ix.1970 (3 specimens).

Habitat: intestine.

Description: Body length 1.5–3 mm.

Remarks: This species is characterized by the large size of the ventral sucker, 72–105 by 73–110 μm (average 87 by 90 μm), and by the fact that it occurs in the Strigiformes. The testes are large and symmetrically developed. The vitelline follicles have their maximum density in the forebody, where they quite often reach to the level of the intestinal bifurcation.

Neodiplostomum (Conodiplostomum) spathula australiense Dubois, 1937: 337, figs. 13–14; 1970: 428, figs. 465–468. Dubois & Pearson, 1967: 196, fig. 7.

Hosts and origin: *Circus approximans* Peale, from Tailem Bend, S. Aust., Dec. 1938 (3 specimens). *Haliæetus leucogaster* (Gmelin), from Wauraltee, Yorke Pen., S. Aust., 21.viii.1960 (3 specimens). *Falco peregrinus* Tunstall, from Naracoorte, S. Aust., 12.vi.1956 (24 specimens). *F. subniger* Gray, from Meningie, S. Aust., 6.v.1945 (19 specimens). *Accipiter cirrocephalus* (Vieillot), from Townsville, Qld., 1911 (one specimen, collected by T. H. Johnston).

Habitat: duodenum and intestine.

Description: Body length 1.0–1.75 mm. Vitellaria densest in forebody, sometimes reaching the intestinal bifurcation.

Relationships: The size of the ventral sucker (45–68 by 57–75 μm, average 57 by 67 μm) constitutes a useful specific character. In this respect *Neodiplostomum spathula* is distinguishable from *N. brachyurum* (Nicoll).

Neodiplostomum (Neodiplostomum) lanceolatum n.sp.

FIGS. 20, 21

Host and origin: *Ninox novaeseelandiae* (Gmelin) from Adelaide, S. Aust., April, 1959 (14 specimens).

Habitat: intestine.

Holotype: length 1.25 mm. SAM, E935 with 4 paratypes, E936, and another slide, E936.

Description: Body distinctly bisegmented, 1.25–1.52 mm long. Forebody flattened, lanceolate, 0.79–1.01 by 0.29–0.38 mm, with posterior border, where it is wider, curved ventrally. Hindbody subcylindrical to claviform, always shorter than forebody, 0.40–0.61 by 0.18–0.21 mm. Ratio of hindbody to forebody from 0.50–0.68, averaging 0.56. Oral sucker 38–47 by 42–50 μm; ventral sucker slightly larger, 36–52 by 47–57 μm, situated between the 50th and 55th hundredths of length of forebody. Short prepharynx (10–15 μm); pharynx ellipsoidal and muscular, 37–45 by 26–32 μm; oesophagus reaching length of 40–52 μm; caeca narrow (about 5–10 μm) in their visible section. Tribocytic organ narrowly ellipsoidal or almond-shaped, 150–210 by 80–125 μm.

Ovary oval or rounded, submedian, located at beginning of hindbody between 16th and 21st hundredths, 55–63 by 63–75 μm. First testis appears asymmetrically developed, 80–110 by 120–140 μm; second testis clearly bilobed (with a posterior median indentation), 80–110 by 150–185 μm. Vitelline follicles very conspicuous, with a maximum density at base of forebody; from thence invading tribocytic organ and, separated in longitudinal bands, extending beyond ventral sucker, with their limit on median line between the 24th and 48th hundredths of this part of body; densely

distributed on each side at beginning of hindbody; then receding from dorsal area to become a wide ventral ribbon which ends in two latero-terminal or subterminal accumulations. Vitelline reservoir situated at mid-length of hindbody. Mehlis' gland lateral, on level with second half of first testis. Hermaphrodite canal, which prolongs the incurved uterus, does not traverse a genital cone. Genital pore dorsal and subterminal, at 65–100 μm from posterior extremity of body. Eggs few in number (up to 13), 94–115 by 63–72 μm (average 104 by 66 μm).

Relationships: Five species of the subgenus *Neodiplostomum* are parasites of night-birds and have vitellaria passing beyond the ventral sucker; *N. americanum* Chandler & Rausch, *N. canaliculatum* (Nicoll), *N. japonicum* Dubois, *N. rousseloti* Dubois and *N. travassosi* Dubois. Among them, only the first has an ellipsoidal tribocytic organ, but the ovary is situated at the junction of the two segments of the body, and the ventral sucker is located between one third and two fifths of the forebody. This American species reaches 2.9 mm.

Neodiplostomum (Neodiplostomum) subaequipartitum Dubois & Pearson, 1967: 199, fig. 8; Dubois, 1970: 484, fig. 555.

FIG. 22

Host and origin: *Haliastur sphenurus* (Vieillot), from Tailem Bend, S. Aust., Dec. 1938 (22 specimens), 18.vi.1941 (young specimens).

Habitat: intestine.

Description: Body 1.16–1.30 mm long, divided into two nearly equal segments. Forebody 0.61–0.68 by 0.36–0.49 mm; hindbody 0.55–0.63 by 0.38–0.43 mm. Ratio of the hindbody to forebody from 0.89–1.02 (average 0.93). Oral sucker 47–55 by 45–52 μm; pharynx 45–52 by 36–52 μm; ventral sucker a little larger than oral, 52–65 by 54–68 μm, situated between 45th and 50th hundredths of length of forebody; tribocytic organ 170–240 by 160–210 μm.

Ovary ovoid or ellipsoidal, lying at beginning of hindbody, 95–110 by 130–170 μm. Anterior testis lateral, asymmetrical, cuneiform or ovoid, 125–150 by 140–210 μm; posterior testis bilobed, dumb-bell-shaped, 120–150 by 260–320 μm, with greater lobe obliquely opposite first testis. Eggs few in number (one to four), 84–92 by 58–65 μm.

Neodiplostomum (Triloborchidiplostomum) diaboli n. subgen., n.sp.

FIGS. 23, 24

Host and origin: *Sarcophilus harrisii* (Boitard), from Tasmania, Oct. 1969 (2 specimens).

Habitat: unknown.

Holotype: length 2.05 mm, SAM, B937. Paratype in Neuchâtel University.

Description: Body 1.95–2.05 mm long, divided by a constriction into anterior and posterior segments. Forebody broadly elliptical, spatheshaped, 0.90–0.93 by 0.70–0.73 mm, deeply concave posteriorly, with lateral edges obliquely curled ventrad and continuous with each other behind tribocytic organ. Hindbody long ovoid or conical, 1.05–1.12 by 0.45–0.56 mm, widest at testicular level. Ratio of hindbody to forebody, 1.2. Oral sucker spheroidal, 90–92 by 93–95 μm; pharynx elliptical in outline, much larger than oral sucker and very muscular, 122–130 by 118 μm. Ratio of lengths: oral sucker + pharynx/forebody, 0.20. Caeca terminating in front of genital atrium, i.e. to posterior limit of vitellaria. Ventral sucker (ca. 75 μm) masked by large tribocytic organ, 460–480 by 500–525 μm, irregularly rounded, with a very narrow slit; its frontal border situated between one sixth and one tenth of the length of the forebody, more or less overlapping the pharynx.

Fig. 18. *Diplostomum (Tylodelphys) podicipinum podicipinum*, from *Podiceps cristatus*. Posterior end with atrial sphincter.

Fig. 19. *Hysteromorpha platalea*, from *Threskiornis molucca*. Length 0.64 mm, dorsal view.

Figs. 20, 21. *Neodiplostomum (Neodiplostomum) lanceolatum* n.sp., from *Ninox novaeseelandiae*. Fig. 20.—Holotype: length 1.25 mm, dorsal view. Fig. 21.— Lateral view of hindbody.

Fig. 22. *Neodiplostomum (Neodiplostomum) subaequipartitum*. Outline of posterior extremity of body.

Figs. 23, 24. *Neodiplostomum (Triloborchidiplostomum) diaboli* n.sp., from *Sarcophilus harrisii*. Fig. 23. Holotype: length 2.05 mm, ventral view. Fig. 24.—Morphology and topography of genital glands of holotype, dorsal view.

Fig. 25. *Pharyngostomoides dasyuri* n.sp. from *Dasyurus viverrinus* (Shaw). Holotype: length 0.62 mm, dorsal view.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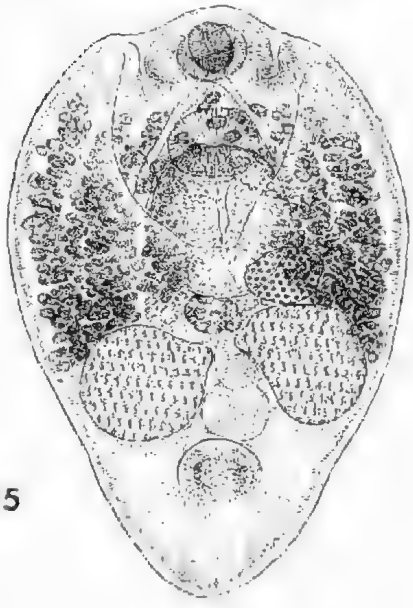
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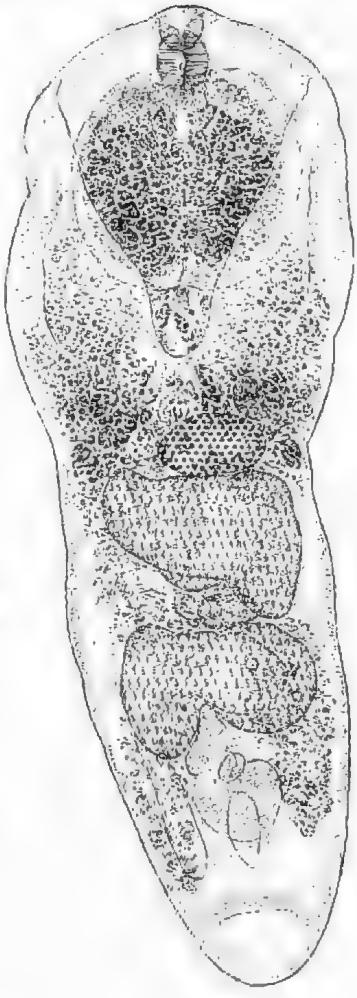
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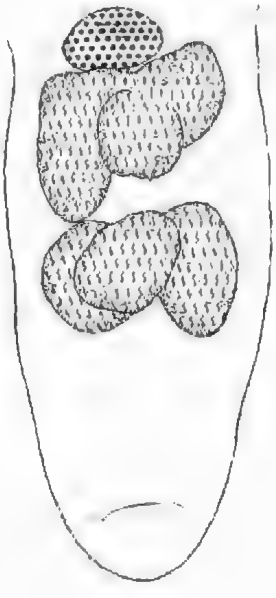
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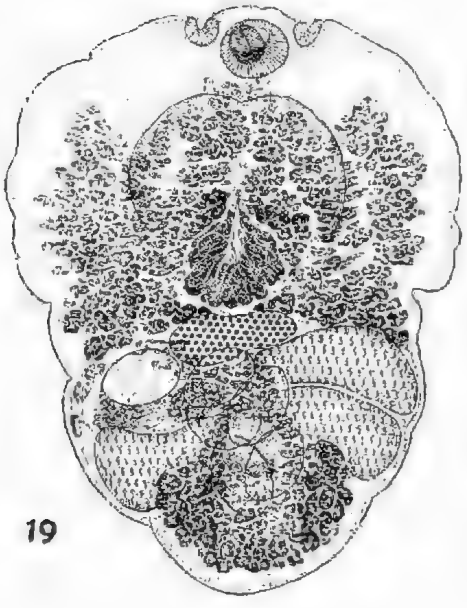
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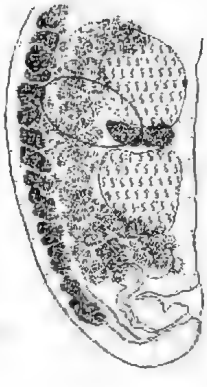
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Ovary ovoid, transversely elongate, median or submedian, 130–140 by 180–220 μm, lying at junction of forebody and hindbody. Testes trilobate (with one dorsal lobe and two latero-ventral lobes), occupying with ovary, first three fifths of segment: anterior testis contiguous with ovary, asymmetrical, 140–200 μm on left, 240–320 μm on right, and 350–430 μm in transverse dimension. Second testis 200–230 μm and 275–280 μm on two of its lobes, and 330–410 μm transversely; posterior border of this testis situated between 56th and 63rd hundredths of length of hindbody. Seminal vesicle well developed, posttesticular. Vitelline follicles having their maximum density at junction of two segments and in second half of forebody, penetrating tribocytic organ and extending forward to level of posterior border of pharynx; from beginning of hindbody less abundant, covering ventral face in form of two submedian fields which widen slightly at level of seminal vesicle (distance from last follicles to posterior end of the body is 200–270 μm). The anterior border of the bursa copulatrix is found between the 87th and the 90th hundredths of length of hindbody. The collapsed eggs of the paratype measure approx. 125 by 70 μm.

Relationships: This parasite from the Tasmanian devil is readily distinguished from all other species of the genus *Neodiplostomum* by the trilobate shape of the testis[2], with the exception of *Neodiplostomum tamarini* Dubois, 1966, of which the posterior testis also develops three lobes (two latero-ventral and one medio-dorsal). This morphological character justifies the establishment of a new subgenus for which we propose the name *Triloborchidiplostomum*, with the type species *N (T.) diaboli n.sp.*[3] A second character common to the two species is the ratio of the lengths of oral sucker + pharynx/forebody, which varies between 0.20 and 0.25.

TRILOBORCHIDIPLOSTOMUM n. subgen.

Diagnosis: *Neodiplostomum* with the two testes or only the second testis trilobate. Complex of oral sucker and pharynx usually between one-fifth and one-quarter of length of forebody. Tribocytic organ tending to hypertrophy. Intestinal parasites of mammals.

Type species: *N. (T.) diaboli* n.sp., in *Sarcophilus harrisii* (Boitard), from Tasmania.

Consubgeneric species: *N. (T.) tamarini* Dubois, 1966 in *Leontocebus nigricollis* (Spix), from South America.

Neodiplostomulum sp.

Hosts and origin: *Notechis scutatus* (Peters) [Ophidia], from Tailem Bend, S. Aust., 1.v.1940 (8 specimens and 2 cysts), *Pseudechis porphyriacus* (Shaw) [Ophidia], from Adelaide Zoo, 5.xi.1957 (5 specimens).

Habitat: digestive tract, and subperitoneum.

Description: Body oval, 255–475 by 210–285 μm. Caeca gradually and irregularly distended, filled with a yellowish substance. Cysts oval, 350–380 by 300–320 μm. Cyst wall fibrous, 15–40 μm thick.

Remarks: One specimen only of this metacercaria (335 by 245 μm) was found in the intestine of *Grallina cyanoleuca* (Latham) [Passeriformes] from Tailem Bend, 22.iii.1943.

Posthodiplostomum australe Dubois, 1937: 1970: 510, figs. 585–588; Dubois & Pearson, 1967: 201, fig. 9.

Hosts and origin: *Phalacrocorax sulcirostris* (Brandt), from Tailem Bend, S. Aust., 26.iii.1943 (2 specimens), *P. melanoleucos* (Vieillot), from Tailem Bend, 6.vi.1945, 31.iii.1948, Oct. 1960 (27 specimens) and 25.x.1945 (4 young specimens). *Pelecanus conspicillatus* (Temminck), from Tailem Bend, date? (7 specimens). *Hydroprogne caspia* (Pallas) from Tailem Bend, Dec. 1939 (2 specimens). *Egretta alba* (Linn.), from Tailem Bend, June 1937 (one specimen). *Ardea novaehollandiae* Latham, from Tailem Bend, 1.v.1940, 24.ii.1943, 6.vi.1945 and 31.v.1949 (19 specimens); Swan Reach, S. Aust., 15.xii.1937 (14 specimens); Tailem Bend, May 1938, 1.v.1940, 24.ii.1943 (27 young specimens escaping and escaped from cysts). *Nycticorax caledonicus* (Gmelin) from Mary River, Northern Territory, May 1962 (17 specimens).

Habitat: Stomach and intestine.

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[2] As in several species of the subgenus *Paralaria* Krause, in particular *Alaria (Paralaria) pseudoclathrata* Krause, *A. (P.) mustelae mustelae* Bosma, and especially *A. (P.) mustelae canadensis* Webster and Wolfgang (cf. Dubois 1970, figs. 699-700).

[3] In *Fibricola sarcophila* Sandars, 1957, the posterior testis is "characteristically bilobed". The forebody is "typically" longer than the hindbody, and the tribocytic organ "is usually between one-quarter and one-third of the length of the anterior segment".

Description: This common species is characterized by its small size: the ovigerous specimens measure 0.42–0.98 mm (one to nine eggs in uterus). In life, there is "orange colour around midsucker". Oral sucker 28–31 by 30–37 μm; pharynx 26–30 by 19–25 μm; ventral sucker 42–68 by 45–68 μm.

Ovary situated at beginning of posterior segment. First testis asymmetrically developed; second testis bilobed, sub-cordiform, with an anterior concavity. Vitellaria very dense at base of forebody, extending anteriorly beyond ventral sucker, in some specimens to a level about equidistant from ventral and oral suckers; in hindbody, extending on ventral side to posterior border of second testis, or only to intertesticular region. Uterus ventral, bending dorsad until it arrives anterior to the bursa copulatrix, and then enters genital cone. Eggs 73–94 by 48–63 μm (average 82 by 54 μm).

Cyst transparent, ellipsoidal, 340 by 220 μm, having a thin wall (6 to 8 μm in thickness).

Subfamily ALARINAE Hall & Wigdor

Fibricola intermedius (Pearson, 1959). Pearson, 1959: 111, figs. 1–8; Dubois, 1970: 637, fig. 729.

Host and origin: *Hydromys chrysogaster* Geoffroy, from River Torrens, Adelaide, S. Aust., July 1923 (21 specimens, some of which have one egg in the uterus).

Habitat: intestine.

Description: Body length 0.75–0.98 mm.

Relationships: This species, the type-host of which is *Rattus assimilis*, was found in the water rat, *Hydromys chrysogaster*, by Pearson (1961). It differs from *F. minor* Dubois (also from *H. chrysogaster*) in having erratic vitelline follicles in the hindbody: they form two distinct lateral bands which extend as far as the zone of the second testis, and even beyond.

Pharyngostomoides dasyuri n.sp.

FIG. 25

Host and origin: *Dasyurus viverrinus* (Shaw) from Icena Estate, Tas., 9.xi.1966 (5 specimens).

Habitat: small intestine.

Holotype: length 0.62 mm, SAM, E938, paratypes (3 slides) E939.

Description: Body oval, indistinctly bisegmented, 0.58–0.67 mm long. Forebody marsupiform, 0.33–0.40 by 0.45–0.48 mm (when contracted), with lateral and posterior margins folded ventrally. Hindbody more or less conical, 0.23–0.27 by 0.35–0.41 mm (when contracted). Oral sucker subterminal, 63–78 by 75–94 μm; pharynx ellipsoidal, more muscular but smaller than oral sucker, 57–63 by 40–48 μm; ventral sucker bigger, elliptical in outline, 58–78 by 95–110 μm, usually partially covered by tribocytic organ; oesophagus short. Pseudosuckers cupuliform, 68–75 by 60–63 μm. Tribocytic organ well developed, elliptical in outline, 155–195 by 125–150 μm, with longitudinal slit-like opening.

Ovary ovoid, 50–75 by 85–110 μm, submedian, located dorsally at base of forebody. Testes rounded or ovoid, approximately equal in size, 100–140 by 130–180 μm, situated side by side in anterior part of hindbody, close together. Seminal vesicle well developed, posttesticular. Vitelline follicles confined to forebody, with a dense distribution from level of anterior margins of testes, gradually decreasing forwards, penetrating tribocytic organ and extending medially almost to bifurcation of oesophagus, laterally to level of ventral sucker. Vitelline reservoir pretesticular, median or submedian, at junction of anterior and posterior segments. Eggs 115–118 by 60–63 μm. Fresh material is needed for a description of the bursa copulatrix.

Addendum. On 23rd June, 1972, Dr. G. Gregory collected 64 uncontracted specimens from the intestine of *Dasyurus maculatus* (Kerr), at Ben Nevis, Tasmania. These are described below.

Body length 1.22–1.53 mm. Forebody cochleariform 0.68–0.90 by 0.73–0.95 mm. Hindbody conical, rounded at extremity, 0.52–0.71 by 0.50–0.71 mm at level of testes. Ventral sucker 75–104 by 95–117 μm (average 90 by 130 μm), subequal to or larger than oral sucker, 65–95 by 85–115 μm (average 80 by 95 μm), but more muscular. Pseudo-suckers cupuliform, with prosdetic glands well developed. Tribocytic organ 300–340 by 210–300 μm (230–350 by 265–430 μm when completely protruded). Pharynx small, 55–73 by 52–65 μm.

Ovary submedian, 110–135 by 120–160 μm. Testes spherical or ovoid, situated side by side, 180–255 by 200–300 μm. Seminal vesicle inter- and post-testicular, discharging through muscular ejaculatory duct (ejaculatory pouch absent), which unites with descending limb of uterus. (Ascending limb of latter reaching mid-portion of tribocytic organ.) Vitelline follicles confined to forebody, distributed in two

lateral masses confluent anteriorly at acetabular level, divergent backwards where they terminate in contact with the testes, extending medially to level of intestinal bifurcation (just posterior to pharynx). In the triangular space between these two masses are the longitudinal aperture of tribocytic organ, the ovary and the vitelline reservoir (median and pretesticular). Bursa copulatrix muscular, rounded, 220–300 μm in diam., occupying second half of posterior segment, with dorsal, subterminal aperture and deep genital atrium. Eggs 1 to 15, 110–130 by 65–78 μm (largest 130 by 78 μm), average 118 by 71 μm.

Relationships: *Pharyngostomoides dasyuri* n.sp. seems to be closely related to *P. procyonis* Harkema, 1942, but differs in the smaller body, the inequality of the suckers, the position of the ovary, the absence of ejaculatory pouch, the extension of the vitellaria up to level of intestinal bifurcation, the greater dimensions of the eggs, and the geographic distribution. It is probably identical with *Pharyngostomoides* sp. of Sandars (1957, p. 263), recovered from the intestine of a Tasmanian tiger cat, *Dasyurus maculatus* (Kerr).

Family **PROHEMISTOMIDAE** (Dubois, 1938) Sudarikov, 1941

Subfamily PROHEMISTOMINAE Lutz

Mesostephanus haliasturis[4] Tubangui & Masiluñgan, 1941: 138, pl. 3, fig. 3; Dubois & Pearson, 1965: 96, fig. 14 (from *Haliastur*); 1967: 202 (from *Pelecanus*).

Mesostephanus minor Dubois & Pearson, 1965.

Host and origin: *Pelecanus conspicillatus* (Temminck), from Tailem Bend, S. Aust., date? (24 macerated specimens).

Habitat: unknown.

Tubangui & Masiluñgan recorded this species from the small intestine of *Haliastur intermedius* Blyth from the Pampanga Province (Luzon: Philippines). Dubois & Pearson (1965) redescribed it by the name of *Mesostephanus minor* from *Haliastur sphenurus* (Vieillot) from Brisbane, Qld., and subsequently (1967) from *Pelecanus conspicillatus* (Temminck) and *Anhinga novaehollandiae* (Gould), from Mackay and Kola, Qld. The fishing-kite is probably an occasional host.

Description: Body oval, with small caudal appendix, 0.9–1.5 mm long by 0.3–0.5 mm in maximum width; anterior part well expanded, slightly concave ventrally, with lateral borders more or less rolled up into a gutter and meeting posteriorly. Oral sucker 38–52 μm; ventral sucker slightly larger, 37–55 by 40–60 μm, situated between the 40th and 45th hundredths of the length of the body; pharynx ellipsoidal, 32–50 by 24–40 μm; oesophagus 47–52 μm long. Tribocytic organ oval in shape, 200–210 by 150–160 μm, with a longitudinal slit.

Ovary globular, 60–80 μm, level with second half of anterior testis, slightly to one side of median line, opposite cirrus sac. Testes subglobular to ovoid, close behind one another, 110–190 by 90–150 μm. Vitellaria composed of fairly large follicles disposed in an eccentric wreath (diameter 300–520 μm) around tribocytic organ. The two characteristics of the species are that vitellaria (1) do not reach acetabular level (limit 44th to 50th hundredths of length of body, i.e. distant 28–35 μm from posterior border of ventral sucker), and (2) overlap only first half of posterior testis. Ratio of the length of the body to the diam. of the vitelline wreath ranging from 2.7–3.2 (average 3). Cirrus sac well developed, elongated, club-shaped, 310–530 by 50–100 μm, extending forwards to zone of first testis or even beyond. Uterus short, with vaginal sphincter conspicuous, 20–40 by 29–55 μm. Eggs one to six in number, 90–99 by 65–73 μm.

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[4] Incorrect original spelling *haliasturus*.

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OBITURARY: KEITH RODNEY MILES

Summary

Keith Rodney Miles died on 25th March 1972 after an illness which took him intermittently from duty over the previous six months. He was born in Western Australia on 8th April, 1915.

KEITH RODNEY MILES,
D.SC., F.G.S.

OBITUARY

KEITH RODNEY MILES, D.Sc., F.G.S.

Keith Rodney Miles died on 25th March, 1972 after an illness which took him intermittently from duty over the previous six months. He was born in Western Australia on 8th April, 1915.

He completed his formal education in Perth, graduating B.Sc. in 1937 from the University of Western Australia, with Honours in Economic Geology. He was also at this time lecturing in the School of Geology.

The next six years was spent on the staff of the Geological Survey of Western Australia, during which time he completed a thesis for the degree of Doctor of Science, to which he was admitted in 1942. His thesis covered the jasper bars and banded iron formations of Western Australia.

Miles joined the Geological Survey of South Australia in 1944. This was the beginning of the period of growth and development of the Survey under S. B. Dickinson, and Miles was the first of a group of new appointees comprising in addition T. A. Barnes, R. C. Sprigg, and the present writer.

He spent some ten years with the South Australian Survey at this stage and left in 1954, firstly to accept an appointment as Deputy Chief Geologist with Australasian Oil Exploration Limited and subsequently for private practice as a consultant. He rejoined the Department of Mines in 1963 as Chief Geologist, became Deputy Director in 1970 and at the time of his death was Acting Director of Mines.

Miles' professional career took him through a very wide range of geological interests. His first project—the ironstones—led him later to a detailed study of the Middleback Ranges, followed by a Bulletin on this subject. He undertook many hard-rock mineral exploration projects, several major dam site studies, and geohydrology investigations. He travelled widely throughout Australia and New Zealand and undertook an extensive overseas assignment for the Government in 1970.

Miles was responsible for some sixty published works, including three major Bulletins of the Geological Survey of South Australia, and a great many unpublished reports. A selected bibliography is given below.

Miles was a conscientious member of many professional organisations and made a contribution at Committee and executive level whenever called upon to do so. He was a Fellow of the Geological Society of London, a Member of the Geological Society of America, a Member of the Society of Economic Geologists, a Member of The Australasian Institute of Mining and Metallurgy and a past Chairman of the Adelaide Branch, a member of the Geological Society of Australia, a member of the Professional Division of the Australian Petroleum Exploration Association. He was a Fellow (Life Member) of the Royal Society of South Australia and served as a Council member from 1963-66, Vice President 1966-67 and 1968-69, and President 1967-68.

So much is the official record.

As a colleague, close friend and confidant of nearly thirty years, Keith Miles' death is a personal loss. Much more than this however, is the loss of his experience and judgement at the moment when he was in a position to offer these to greatest effects at both administrative and scientific levels. Keith was fiercely loyal to his colleagues and staff and took great care to ensure that those for whom he was responsible had every opportunity for scientific development.

He was jealous for the status of the profession of Geology and set the highest standards of probity and workmanship in all that he undertook and in his dealings with his fellows.

A geological family becomes accustomed over the years to frequent and sometimes long periods of separation. We offer to his wife and daughter sincerest sympathy for this the longest and most difficult separation of all.

L. W. Parkin.

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