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A REVISION OF QUEENSLAND LITHOPHAGINE MUSSELS 435 (BIVALVIA, MYTILIDAE, LITHOPHAGINAE)

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INTRODUCTION

Among mytilid bivalves, boring in coral or calcareous rocks has evolved as one of the major life styles. Current nomenclature distributes the species of boring mytilids among the "genera" *Lithophaga* Roding, 1798, *Adula* Adams and Adams, 1857, and *Botula* Mörch, 1853, but there is little agreement on the subdivisions and relationships of these major groups.

A preliminary survey shows that there are about a dozen species of *Lithophaga* in the Indo-West Pacific Region but their nomenclature is confused and their distribution uncertain. Data are presented in this paper on the nomenclature, morphology, ecology and distribution of the species of *Lithophaga* found on the Great Barrier Reef.

The work began in September 1970 when I visited Heron I., Michaelmas Cay, Low Isles and other Queensland localities, and continued when I participated in the malacological workshop meeting at Lizard I. in December 1975. The anatomical data are based primarily on specimens collected at Lizard I. except where indicated otherwise. I have also collected these mussels at many other areas of Western Australia, S.E. Asia and the western Pacific and these specimens have provided a helpful source of comparative material. In particular I was able to study in detail the anatomy and ecological distribution of lithophagines at Kendrew I., Dampier Archipelago, during a study of the Crown of Thorns Starfish there in the years 1972-1974, and at Malaupaina I., Solomon Islands while I was the guest of Dr Walter Starck aboard the vessel "El Torito" in October-November, 1975.

MATERIALS AND METHODS

Specimens were studied anatomically either alive or after preservation in 10% formaldehyde. Dissections were done under a binocular microscope and drawings were done free-hand. In the anatomical notes the general organisation of mytilids is assumed to be understood (see List, 1902; Field 1922; White, 1937; Wilson, 1967; Yonge, 1976) and only those characters of interest and significance to the taxonomy of lithophagids in particular are described. The anatomy of *L. teres* is described in most detail. For the other species only those characters considered to differ significantly are indicated; other anatomical characters may be assumed to have been examined and found to be not significantly different to *L. teres*.

Locality records are based principally on the collections of the Western Australian Museum and the Australian Museum, although occasionally adequately illustrated literature records are referred to. All the anatomical material examined is now preserved and catalogued in the Western Australian Museum.

Shell parameters measured are illustrated in Fig. 1.

Abbreviations:

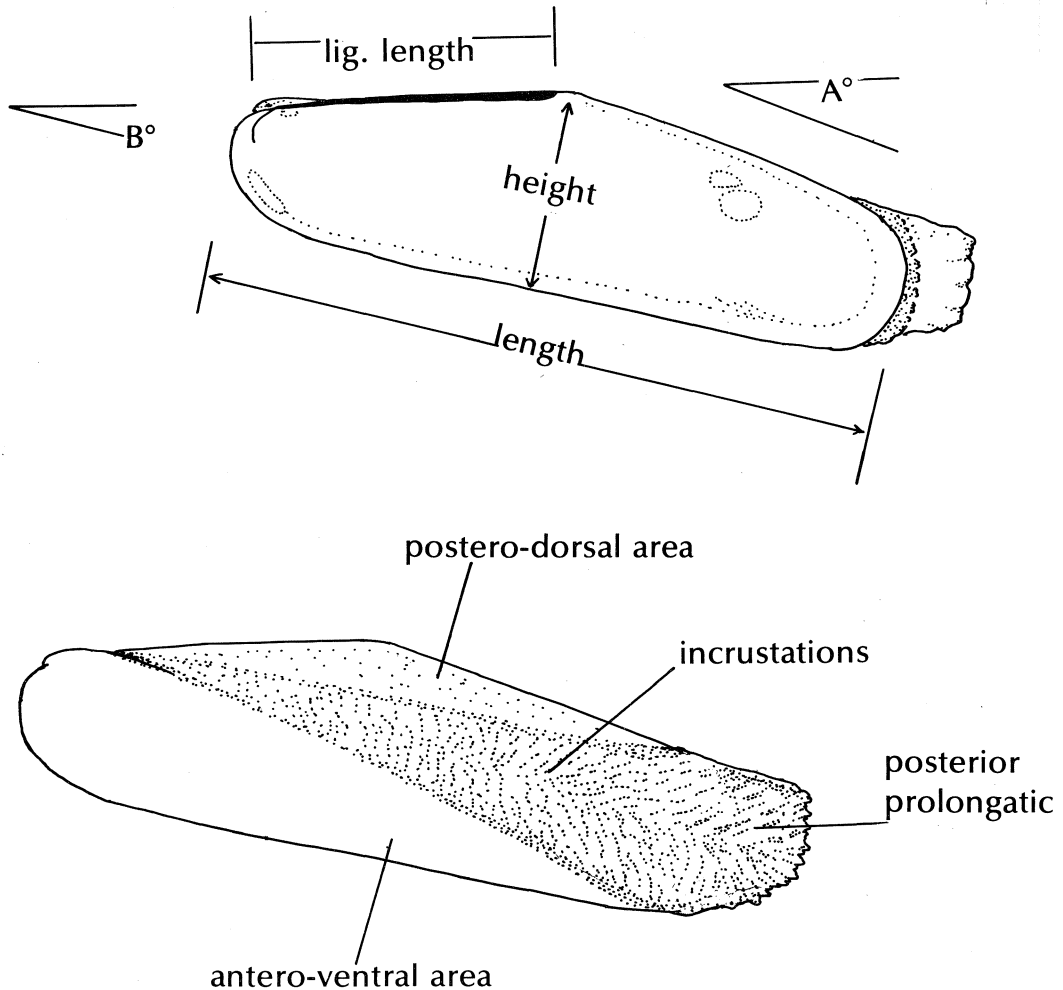
AM	Australian Museum (Sydney)
WAM	Western Australian Museum
BM (NH)	British Museum (Natural History)
MNHN (Paris)	National Museum of Natural History (Paris)
MNHN (Santiago)	Museum National History Natural (Santiago)

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WA	Western Australia
QLD	Queensland
NSW	New South Wales

TAXONOMIC BACKGROUND

Carpenter (1856), Fisher (1886) and Dall (1898, 1916) introduced a series of genus-level names for American lithophagines and these names are in current use (see Turner and Boss, 1962, Soot-Ryen, 1955, 1969, Olsson, 1961). Iredale (1939) reviewed the taxa and their diagnostic characters but ignored the possibility that some of them might also be represented in the Indo-West Pacific region and proposed a new series of sectional names for lithophagines from Queensland.



Figs. 1a & 1b. Diagrammatic illustration of the parts of a lithophagid shell.

Soot-Ryen (1969) attempted to reconcile these two systems. Referring only to shell characters he synonymised all but one of Iredale's "sections" with American counterparts and treated all the senior synonyms as sub-genera of *Lithophaga*. The New Zealand borer *Zelithophaga* Finlay, 1927 and the tropical West Coast American borer *Stumpiella* Soot-Ryen, 1955 were also treated as subgenera of *Lithophaga* by Soot-Ryen. *Adula* was treated as a distinct genus (not represented in the Indo-West Pacific Region) and placed with *Lithophaga* in a subfamily Lithophaginae, Adams and Adams, 1857. Soot-Ryen regarded *Botula* as unrelated and belonging to the subfamily Modiolinae Keen, 1958.

It follows that, according to this system, all the lithophagids of the Indo-West Pacific belong to the genus *Lithophaga*.

The subgenera of *Lithophaga* recognized in the Treatise by Soot-Ryen (1969) may be summarized as follows:

LITHOPHAGA s.s. Röding 1798.

type species: *Mytilus lithophagus* Linné, 1758.

LEIOSOLENUS Carpenter, 1856

type species: *Leiosolenus spatiosus* Carpenter, 1856.

MYOFORCEPS Fisher, 1886.

type species: *Modiola caudigera* Lamarck, 1819.

DIBERUS Dall, 1898.

type species: *Modiola plumula* Hanley, 1843.

= EXODIBERUS Iredale, 1939.

type species: *Lithophaga calcifer* Iredale, 1939.

= SALEBROLABIS Iredale, 1939.

type species: *Lithophaga divaricalx* Iredale, 1939.

LABIS Dall, 1916.

type species: *Modiola attenuata* Deshayes, 1836.

= *Doliolabis* Iredale, 1939.

type species: *Lithophaga laevigata instigans* Iredale, 1939.

MYAPALMULA Iredale, 1939

type species: *Lithophaga dichroa* Iredale, 1939.

STUMPIELLA Soot-Ryen, 1955.

type species: *Lithophagus calyculatus* Carpenter, 1856.

ZELITHOPHAGA Finlay, 1927.

type species: *Lithodomus trunculus* Gray, 1843.

Otter (1937) published a study of the boring molluscs at Low Isles resulting from his work during the 1928-29 Great Barrier Reef Expedition. He described the habitats and burrows of 4 species of *Lithophaga* under the names *teres*, *obesa*, *hanleyana* and *cumingiana*. The first and second of these were correctly identified but under the name *hanleyana* it now appears that Otter confused 4 species and under the name *cumingiana* he confused 2 species. As a consequence his ecological results are now difficult to interpret.

Iredale (1939) published a taxonomic account of the Great Barrier Reef Expedition lithophagid material. He listed the names that had been previously "cited in the Australian connection" but failed to indicate which of these he regarded as representing lithophagids living in Australian waters. Instead he directed his attentions to the Otter material and some other recently collected specimens. As usual his practised eye correctly recognized

Name used here	Iredale	Otter	Gohar and Soliman
<i>hanleyana</i>	<i>laevigata instigans</i>	<i>hanleyana</i> (part)	<i>hanleyana</i>
<i>lessepsiana</i>	<i>simplex</i>	<i>hanleyana</i> (part)*	<i>cumingiana</i>
<i>malaccana</i>	<i>calcifer</i>	<i>hanleyana</i> (part)	<i>laevigata</i>
<i>divaricalx</i>	<i>divaricalx</i>	<i>hanleyana</i> (part)	—
<i>nasuta</i>	<i>dichroa</i> (part)	<i>cumingiana</i> (part)	—
<i>lima</i>	<i>dichroa</i> (part)	<i>cumingiana</i> (part)	<i>lima</i> (?)
<i>teres</i>	<i>teres annectans</i>	<i>teres</i>	—
<i>obesa</i>	<i>obesa suspecta</i>	<i>obesa</i>	—

Table 1. Showing the probable equivalence of names used by Iredale (1939), Otter (1937) and Gohar & Soliman (1969 a & b) with those used in this paper.

most of the species entities involved. He introduced 4 new species names and 3 new subspecies names to account for the 7 species he recognized in the material but failed to indicate clearly how his new names related to Otter's groupings.

In 1970, through the generous help of Mr Ed Kels with his vessel 'Paladin', I visited Low Isles and collected topotypic series of specimens of Iredale's taxa. From these and other Queensland specimens I have concluded that the 7 species entities recognized by Iredale can be substantiated though there was one other in Otter's material which he did not account for. The question of nomenclature is another matter; all but one of Iredale's new names may be relegated to synonymy. Thus there are 8 species of *Lithophaga* at Low Isles, and these appear to be widely distributed in the Indo-west Pacific Region. They comprise the bulk of the Queensland lithophagid fauna. The only addition I am able to make to this list is *L. antillarum*, an uncommon species from the southern part of the Great Barrier Reef. The senior synonyms and their equivalent Iredale and Otter names, as far as I can determine, are given in Table 1.

Gohar and Soliman (1969 a&b) described the habitats, burrows and morphology of 4 species of *Lithophaga* from the Red Sea (plus 1 species of the apparently unrelated genus *Botula*). So that their data may be related to mine I have included their names in Table 1, basing my conclusions solely on my own interpretation of their descriptions.

KEY TO THE SPECIES OF QUEENSLAND LITHOPHAGINES BASED ON SHELL CHARACTERS

1. Shell surface sculptured, lacking superficial calcareous incrustations 2
 Shell surface smooth but may bear superficial calcareous incrustations which may
 be sculptured 3
2. Sculpture of irregular, wavy, near vertical cords confined to antero-ventral
 area *teres*
 Sculpture of irregular, wavy, near vertical cords antero-ventrally plus
 chevron-shaped cords postero-dorsally *antillarum*

3. Shell with thick superficial calcareous incrustations postero-dorsally which project well beyond posterior end..... 4
 Shell without superficial calcareous incrustations postero-dorsally, or if present these are thin and do not project far beyond the posterior end 7
4. Postero-dorsal incrustations smooth, projecting posterior ends squared and chisel-edged*hanleyana*
 Postero-dorsal incrustations strongly sculptured, projecting posterior ends irregular, rounded or dentate 6
6. Postero-dorsal incrustations pitted or irregularly lamellose, postero-dorsal angle low (i.e. 31-35°)*malaccana*
 Postero-dorsal incrustations cast into high chevron-shaped lamellae, postero-dorsal angle high (i.e. 35-40°)*divaricalx*
7. Shell and periostracum uniformly coloured 8
 Shell or periostracum with a conspicuous dark brown or purplish radial ray 9
8. Shell large (to 11cm length), elongate — ovate, antero-ventral area with a continuous smooth or granular superficial calcareous coating.....*obesa*
 Shell small (to 3cm length), elongate — cylindrical, antero-ventral area lacking a superficial calcareous coating.....*lessepsiana*
9. Shell uniform off-white, periostracum light brown with a conspicuous darker brown to purplish radial umbonal ray*nasuta*
 Shell off-white with a conspicuous purple radial umbonal ray visible beneath a uniform olive-brown periostracum.....*lima*

TAXONOMY

Lithophaga teres (Philippi, 1846)
 (Fig. 16 (1-3); text figs. 2-4)

- Modiola teres* Philippi, 1846: 148, pl. 1, fig. 3. Type locality: Pacific Ocean. Type: MNHN, Santiago, Chile (pers. comm. K. Kleeman).
- Modiola malayana* Philippi, 1847a: 117. Type locality: China Sea, Sulu Island etc. Type: MNHN, Santiago, Chile (pers. comm. K. Kleeman).
- Modiola gracilis* Philippi, 1847b: 19. pl. 2, fig. 1. Type locality: China. Type: MNHN, Santiago, Chile (pers. comm. K. Kleeman).
- Dactylus erythraensis* Jousseaume, 1888: 218-219. Type locality: Obock, Red Sea. Syntypes: MNHN (Paris).
- Lithophaga teres annectans* Iredale, 1939: 422, pl. 6, fig. 29. Type locality: Low Isles, Qld. Holotype: AM regn. no. C60406; plus 9 paratypes, AM regn. no. C63285.

DISTRIBUTION: This is one of the most widely distributed species in the genus ranging throughout the tropical Indian and Western Pacific Oceans. In W.A. it penetrates far south into temperate waters being recorded off Albany on the south coast. In Qld. it is known from at least as far south as the Capricorn Group. Queensland localities are: Thursday I., Murray I., Lizard I., Low Isles, Michaelmas Cay, Innisfail, Townsville, Dunk I., Bowen, McKay, Port Curtis, Keppel Is., Lindeman I., Port Molle, Hayman I., Masthead I., Heron I., Swain Reefs.

HABITAT: Bores in dead coral or lithothamnion at depths from the intertidal zone to at least 66 metres. Though sometimes found burrowing in living massive coral heads (e.g. *Favia*) the burrow opening is always located in a position where there are no living polyps.

DESCRIPTION: SHELL: Moderately strong; elongate-elliptical, smooth postero-dorsally but sculptured antero-ventrally by conspicuous, crowded, vertical, parallel cords. Interior iridescent, exterior whitish but covered with a thick, smooth, dark-brown to almost black periostracum. Umbos sub-terminal; anterior and posterior ends rather sharply rounded; ventral margin straight or slightly convex; antero-dorsal margin (hinge-line) almost half the length of the shell, slightly convex; postero-dorsal margin straight; dorsal angle weak and low.

There are no superficial calcareous incrustations but the posterior margins are sometimes thickened and lip-like, presumably forming a plug to block the burrow mouth and serving the same function as the thick posterior accretions of some other species. In older specimens successive phases of thickened posterior margins are often recorded as a series of thick concentric growth ridges.

Dimensions: The largest specimen in the WAM and AM collections is 7.52cm long. Dimensions of Low Is. and Red Sea specimens are given in Table 2.

ANATOMY: (see also Pelseneer, 1911: 20-21, pl. 7, fig. 1)

The anterior adductor muscle is elongate, narrow, and lies along the antero-ventral shell margin. The posterior adductor is small and ovate. Anterior retractors are narrow and attach directly below the umbos; posterior retractors are wide, compressed, undivided and attach above the posterior adductor. The left and right posterior retractors adhere together closely ventrally but diverge dorsally with a deep V-shaped space between them. Small siphonal (pallial) retractors are developed at the ventral margin some distance anterior to the position of the posterior adductor (Fig. 2).

The free edges of the mantle lobes possess inner, middle and outer folds as in other mytilids. The mantle lobes are fused postero-dorsally (i.e. between the postero-dorsal angle and the posterior end of the shell) and antero-ventrally behind the anterior adductor; they are not fused postero-ventrally but are joined together at the posterior end by a muscular membrane, the branchial septum, thus separating the posterior excurrent aperture from the postero-ventral incurrent aperture. In this posterior region the inner folds of the mantle lobes are thickened, muscular and capable of extension to form excurrent (dorsal) and incurrent (ventral) siphons. The dorsal excurrent siphon is tubular; the ventral incurrent siphon is merely a deep fold which gapes ventrally (Fig. 2).

The branchial septum bears a muscular curtain-like partition descending obliquely from its anterior margin to partially occlude the inner end of the incurrent siphon (Figs. 2 & 3). The partition is concave with the concavity facing the rear. Its edge is smooth except in the lateral corners where there are 1-3 small papillae. In addition there are usually 1 or 2 larger simple or branched papillae on the mantle lobes themselves adjacent to the junction of the septal partition (Fig. 3).

Table 2.

Dimensions of <i>L. teres</i> (in mm).						
	length	height	width	lig. length	A°	B°
<i>LOW IS.</i> (Type series <i>L. teres annectans</i>)						
Holotype	63.8	17.6	14.9	32.8	18°	12°
Paratypes	62.8	16.3	14.4	—	—	—
	45.7	13.9	11.4	—	—	—
	50.8	12.8	11.1	—	—	—
	40.1	10.9	08.8	—	—	—
	36.8	11.9	10.0	—	—	—
	32.0	09.7	08.3	—	—	—
	27.1	07.8	07.1	—	—	—
	24.5	01.8	06.4	—	—	—
	22.1	06.0	07.1	—	—	—
<i>RED SEA</i>						
(Syntype series	54.2	14.0	11.9	21.4	16°	15°
<i>L. erythraensis</i>)	41.8	11.0	—	16.2	14°	11°
	41.9	11.6	10.5	18.6	13°	11°
	40.8	11.4	11.0	18.4	15°	10°
	59.1	15.5	06.9	21.6	15°	13°
	62.3	16.6	13.1	24.0	16°	9°
	29.2	08.2	06.8	10.8	15°	8°
	29.1	07.0	05.7	12.0	11°	5°
	30.0	07.1	05.9	11.9	11°	6°
	28.5	07.2	06.2	11.1	15°	8°
	23.7	06.3	05.4	11.3	12°	5°
	20.5	05.9	05.1	09.6	15°	6°

A thin but muscular supra-branchial valve or diaphragm is developed at the inner end of the excurrent siphon. When the siphonal structure is retracted (Fig. 2) this forms a "tube within a tube" structure; presumably it is a device for controlling the size of the excurrent aperture and the velocity of water ejection. A thin horizontal membrane connects the muscular branchial septum to the ventral surface of the posterior adductor and the posterior ends of the gill axes attach to this (Fig. 2).

An "acid" gland is situated in the mantle lobes where they fuse antero-ventrally.

(Figured by Pelseneer, 1911, pl. 7 fig. 7.) (See Jaccarini, Bannister & Micallef, 1968 for discussion of the function of this organ.)

The gills are of typical filibranch style with demibranchs of equal length and ascending and descending lamellae of both demibranchs are of equal height. Ciliary food grooves run along the ventral edge of each demibranch. Longitudinal rows of ciliary platelets loosely connect adjacent filaments and simple cross-bars connect the ascending and descending lamellae in the lower $\frac{2}{3}$ of the gill.

Labial palps are of moderate length and strongly plicate. The inner and outer palps are approximately equal in length.

The ventricle is short, wide, quadrate and traversed its entire length by the rectum (for similar condition in *L. lima* see Fig. 12). The auricles are long and in-curved at the posterior end; they adhere closely to the lateral walls of the pericardium and are densely pigmented red-brown. Pericardial glands are not evident on the walls or floor of the pericardium. There is a major anterior artery leading forward dorsal to the rectum but no posterior artery was observed.

There is a dorsal cul-de-sac of the mantle cavity which passes over the posterior retractor and adductor muscles and forward to the posterior wall of the pericardium so that that thin membrane is all that separates pericardial fluids from the water in the mantle cavity. In the roof of the mantle cavity cul-de-sac the mantle lobes contain a rather hard, elongate mass which appears to have no ducts, apertures or internal cavities. Sections are needed to determine the cellular nature of this structure but it has the appearance of glandular tissue.

Left and right kidneys comprise a mass of pale-green tubules which is wide lateral and posterior to the pericardium, and extends some distance anteriorly. There is a wide reno-pericardial aperture in the ventral floor of each antero-lateral corner of the pericardium which opens directly into the lumen of the kidney. The renal apertures are very small and situated on small papillae in the roof of the supra-branchial chambers just lateral to the genital papillae (Fig. 4) and opening directly into the lumen of the kidneys.

When ripe the gonads fill the spaces between and above the posterior retractors, much of the visceral mass beside and below the pericardium, and the mesosoma. There is no gonad tissue in the mantle lobes.

Genital apertures are slits in prominent papillae in the roof of the supra-branchial chambers between the visceral mass and the gill axes immediately below the antero-lateral corners of the pericardium (Fig. 4).

A pair of major anterior genital ducts lay superficially on the visceral mass anterior to the pericardium leading backwards and then downwards to the genital apertures. A major pair of posterior genital ducts lies beneath the pericardium leading forwards to the apertures (see similar condition in *L. lima*, Fig. 12).

Plicate canals or "organs of Sabatier", consisting of thin-walled, transparent lamellae, cross between the visceral mass and the gill axes in the roof of the supra-branchial chambers (see Sabatier, 1877 and Field, 1922 for similar organs in *Mytilus edulis*). Plicate canals are present throughout the length of the supra-branchial chambers but are longest and most crowded posterior to the genital apertures (Fig. 4). There are no comparable structures between the mantle lobes and the gill axes.

Convolute cords (or ducts?) are embedded in the translucent tissue of the gill axes, connecting the outer ends of the plicate canals with loops running inward along them to varying extent (Fig. 4).

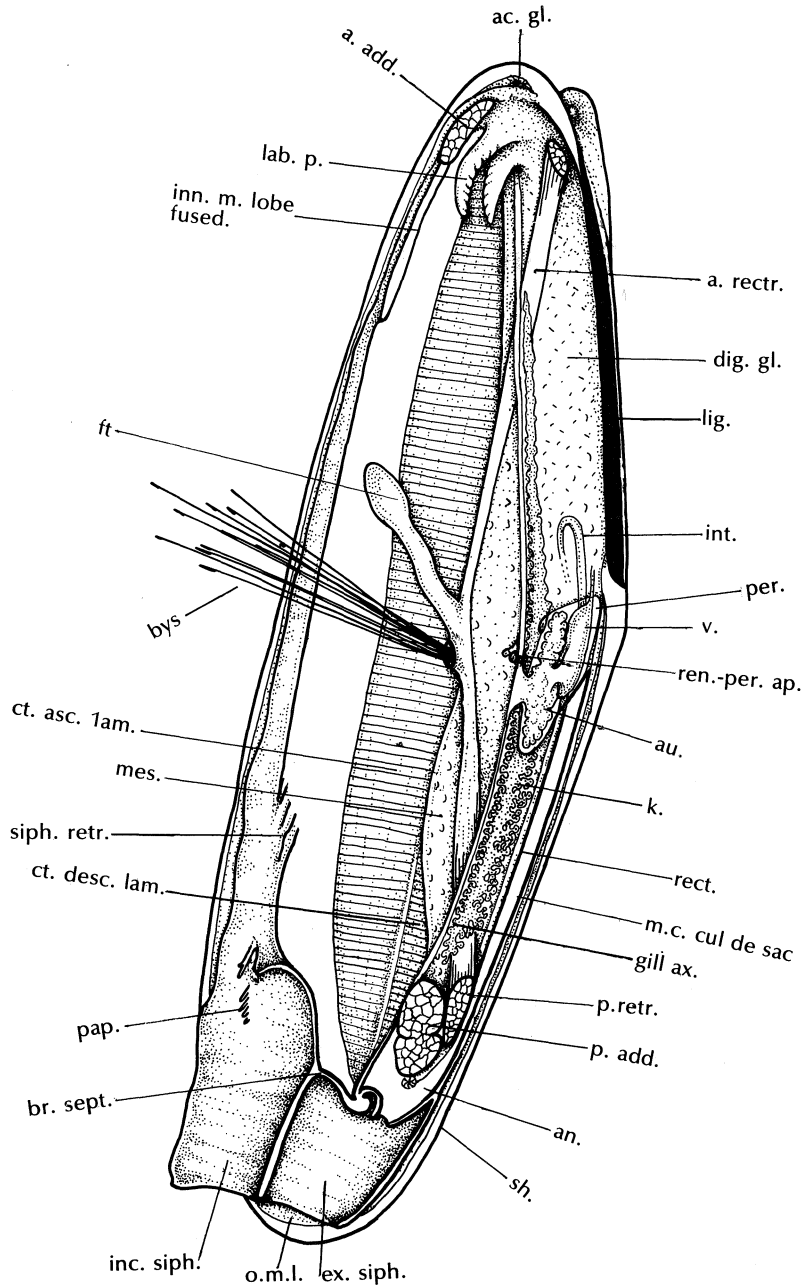


Fig. 2 *Lithophaga teres* (WAM 194-77). Semi-diagrammatic lateral view of soft parts. Siphons partly retracted. Ctenidium and mantle lobe of left side removed and posterior end presented as a saggital section to illustrate details of structure of incurrent and excurrent siphons. Oesophagus, stomach and 1st arm of intestine not shown.

The oesophagus is short. Details of the stomach were not examined. The mid-gut lacks a separate style sac; in fact no style was present in any of the specimens examined which were all preserved in alcohol.

The first turn of the rectum is located immediately below the posterior end of the pericardium some distance in front of the posterior adductor. The second turn or recurrent loop of the rectum is located level with the rear end of the stomach and slightly off-set to the right side.

ANATOMICAL MATERIAL EXAMINED.

Queensland:

Rocky Point, Lizard I., WAM 193-77, from dead coral, 2-5m.

Watson Bay, Lizard I., WAM 195-77, from dead base of living *Favia* colony at 3m.

Lagoon bombies (coral outcrops) Lizard I., WAM 194-77, from dead centre of a large *Porites* "micro-atoll".

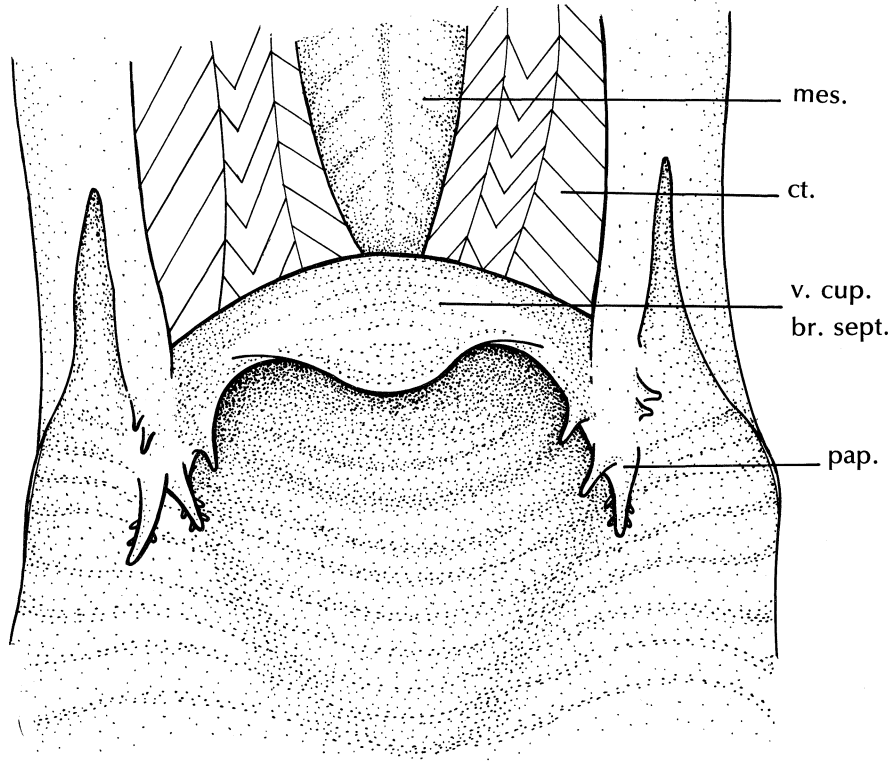


Fig. 3 *Lithophaga teres*. Incurrent siphon opened out and seen from below, illustrating the ventral cup of branchial septum and its papillae. 3a Low Isles, Qld (WAM 190-77).

Western Australia:

Kendrew I., Dampier Arch., WAM 13-76, underside of coral stones, intertidal reef flat.
Kwinana, Cockburn Sound, WAM 83-63, in dead coral at 3m.

Low Is., WAM 190-77, from dead coral, 3m and intertidal.

SE end Heron I. reef, WAM 191-77, from dead coral boulders on reef crest.

South side Heron I. reef, WAM 192-77, from dead coral at 4m.

Solomon Is:

Malaupaina I., WAM 187-77, in dead coral boulder on outer reef slope at 50m.

Caroline Is:

Kapingamarangi Atoll, WAM 202-77, in dead coral on lagoon bombie at 2m.

Malaysia:

Tg. Rhu, Palau Langkawi, WAM 36-73, in dead coral at low tide.

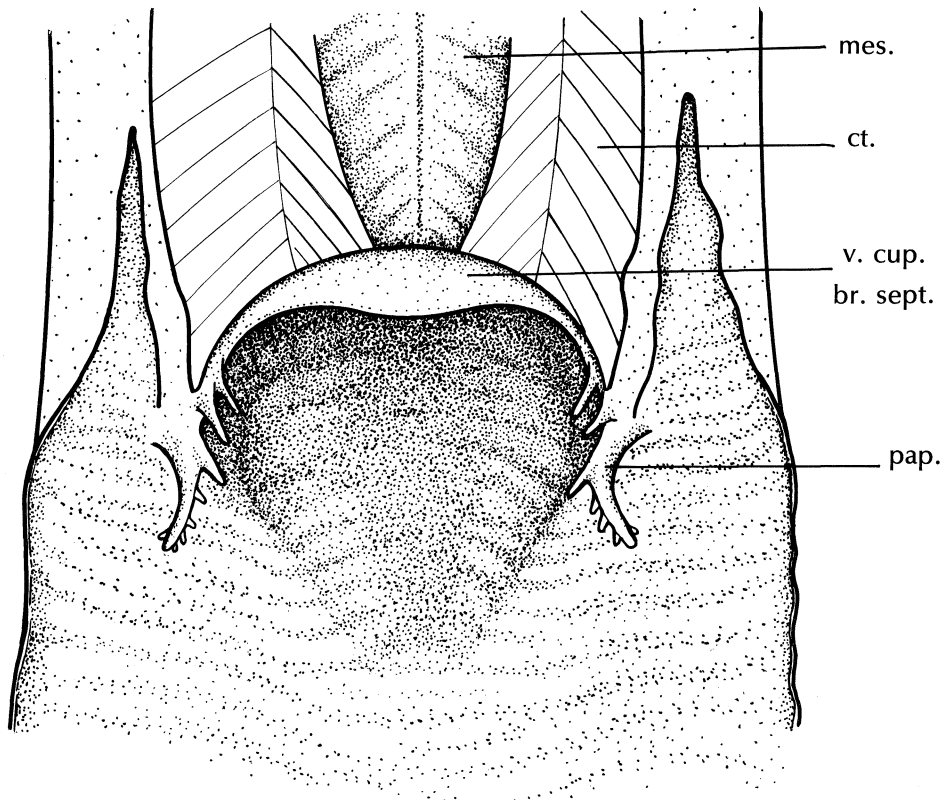


Fig. 3 *Lithophaga teres*. Incurrent siphon opened out and seen from below, illustrating the ventral cup of branchial septum and its papillae. 3b Heron I., Qld (WAM 192-77).

REMARKS: The variability in shell shape in this species is well recognized. Specimens from some localities are long and slender while others are short and stout. Iredale mentioned this and supposed that the species may be polytypic with many subspecies. A major morpho-metric study might demonstrate the existence of distinctive geographic variants but my impressions are that the variation is geographically inconsistent. An exception is to be found in W.A. populations which show an increasing stoutness coming down the coast into southern temperate waters. This trend appears to be clinal.

In view of such variation I cannot agree that sub-species should be recognized and relegate *L. teres annectans* Iredale to synonymy. The most elongate and slender specimens of all are perhaps those in the Red Sea for which Jousseume introduced the name *L. erythraensis*. In the absence of any other distinguishing character I have synonymized that name with *L. teres*. By the same token perhaps one should synonymize *L. teres* and the tropical Atlantic species *L. nigra* (d'Orbigny, 1842) for that species also is

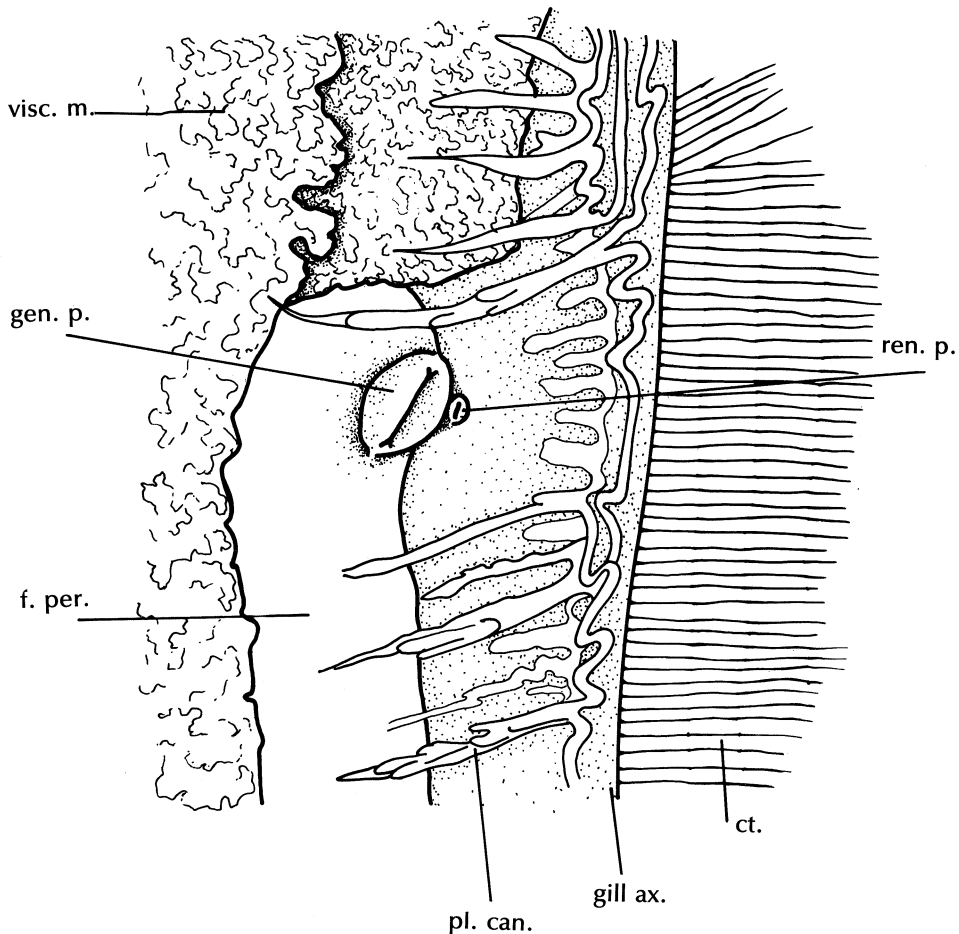


Fig. 4 *Lithophaga teres* (WAM 190-77). Roof of mantle cavity of the right side seen from below illustrating the plicate canals and the location of the renal and genital apertures.

apparently indistinguishable on shell characters (see Turner & Boss, 1962: 98), but I am not brave enough to take that drastic step without a comprehensive morpho-metric study.

Several anatomical characteristics of *L. teres* bear note.

The ctenidia are quite like those of *Mytilus* in that the inter-lamellar connections are simple tissue bars. "Plicate canals" in the supra-branchial chambers between the visceral mass and the gill axis resemble the structures described by Sabatier (1877) and Field (1922) in *Mytilus edulis*, although in that mussel the lamellae are present on both sides of the gill axes. Field (1922: 166) described the plicate canals of *Mytilus edulis* as "composed of two thin membranes of fibrillar tissue united to each other by strands of the same kind of tissue, which form a regular spongy reticulum in the cavity. The space between them is a blood channel which connects the veins of the mantle with the blood vessels of the kidney and with the longitudinal vein". Field (1922: 168) claimed that the plicate canals have a supplementary respiratory function, especially when the mantle lobes are distended with gonad tissue. At that time the plicate canals "become enlarged and well filled with blood which flows through them from the mantle to the kidney and longitudinal vein". He proposed that they might well be termed "the accessory gills". It is here supposed that the lamellae between the visceral mass and the gill axes in *L. teres* may be homologous and have a similar function, although the nature and function of the convoluted tubes they contain is problematical.

Pericardial glands in *L. teres* are probably represented by the heavy pigmentation of the auricle walls. In *Mytilus edulis* pericardial glands "invest the outer walls of the auricles" (Field, 1922: 168).

Unlike *Mytilus edulis* the mantle lobes of *L. teres* are thin and not invaded by gonad tubules. Gonad tissue is confined to the visceral mass.

Although I have not been able to examine in detail well preserved specimens of *Lithophaga lithophaga*, descriptions and illustration by List (1902), and cursory examination of indifferently preserved specimens in the WAM collections, indicate that this species shares these anatomical characteristic with *L. teres*.

***Lithophaga antillarum* (d'Orbigny, 1842)**

(Fig. 16 (4))

Lithodomus antillarum d'Orbigny (in) Sagra, 1842: pl. 28, figs. 12-13. Type locality: Guantánamo, Oriente, Cuba (restricted thus by Turner & Boss 1962: 101). Type: B M (NH) regn. no. 54.10.4.605.

Modiola corrugata Philippi, 1846: 147, pl. 1, fig. 1. Type locality unknown. Type not located.

DISTRIBUTION: This species is uncommon but apparently widely distributed in the Indo-West Pacific Region and in the tropical Western Atlantic. Museum and literature records are as follows:

Western Atlantic: "from Miami, Florida south through the West Indies and in Central America from Veracruz, Mexico south to British Honduras" (Turner and Boss, 1962).

Indo-West Pacific: Mauritius (AM regn. no. C74661, identity uncertain); Madras, India (Ummerkutty, 1960); Gulf of Siam (Lyngé, 1909); southern Japan (Okada, 1960); New Caledonia (Lamy, 1937; AM regn. no. C3929); Fiji (AM regn. no. C56414).

Queensland: Mast Head I. (Hedley, 1906), Low Isles (AM regn. no. C89643), Fairfax I, Bunker Group (AM regn. no. C69053), Heron I. (WAM 30-73).

Dr K. Kleeman (pers. comm.) has informed me that the records from Madras, Gulf of Siam and southern Japan "are probably not representing *L. antillarum*".

HABITAT: Data on habitat are inadequate. Turner and Boss (1962) state that *L. antillarum* burrows in both living and dead coral in the Western Atlantic. At Heron I. I found one juvenile specimen burrowing in a coral boulder in the boulder tract of the outer reef flat.

DESCRIPTION: SHELL: Moderately thin; elongate-elliptical, rather attenuate anteriorly. Sculptured antero-ventrally by fine, crowded cords which are more-or-less parallel and vertical near the anterior end but become curved centrally; posteriorly and postero-dorsally the cords are irregularly radiating or chevron-shaped. Interior shiny white, sometimes slightly iridescent; exterior uniformly white covered by a thin, smooth pale yellow or yellow-brown periostracum. Umbos sub-terminal; anterior end narrowly rounded, posterior end broadly rounded; dorsal margin (hinge-line) rather short and slightly convex; ventral margin slightly convex; postero-dorsal margin straight or slightly convex; dorsal angle low and poorly defined.

There are no superficial calcareous incrustations but the posterior ends of the valves may be thickened and lip-like as in *L. teres*.

Turner & Boss (1962) give 10.9cm as the maximum recorded length for Western Atlantic specimens. The largest specimen recorded from Indo-West Pacific localities is 14.5cm long (Heron I., Qld, pers. comm. K. Kleeman). Dimensions of the available Qld material are given in Table 3.

ANATOMY: The only preserved specimen available to me is an indifferently preserved juvenile from Heron I. which is adequate to determine only the following facts.

The musculature is essentially the same as in *L. teres* except that there are several thin strands arising from the pedal-byssal complex anterior to the origin of the posterior retractors.

Descending ventrally from the anterior edge of the branchial septum is a fairly thick, cup-shaped partition like that of *L. teres*. Its margin is smooth but there are 2 small papillae at each lateral corner, and another actually on the adjacent mantle lobe of each side.

The gills in this juvenile specimen are unlike those of *L. teres* in that there are no inter-lamellar bars. Instead there are entire septa in the lower parts of the demibranchs, spaced at intervals of about 5-8 filaments and rising to about 1/5 of the gill height.

The heart is like that of *L. teres* with thickly pigmented auricles. A dorsal cul-de-sac of the mantle cavity passes over the posterior retractor and adductor muscles and reaches the posterior wall of the pericardium as in *L. teres*. There is also a hard, amorphous mass in the mantle lobes above the dorsal cul-de-sac like that described in *L. teres*.

The kidneys are thin-walled and colourless and it was not possible to determine their extent along the gill axes or the details of their connections to the pericardium. The renal apertures are small thin slits in the inner sides of the gill axes as in *L. teres*.

Though the specimen is juvenile there are white (male?) gonad follicles in the visceral mass anterior to and below the pericardium but there are none in the mantle lobes which are very thin and transparent. A mesosoma is not developed. The genital apertures are slits on papillae adjacent to the renal apertures as in *L. teres*.

Structures resembling small plicate canals are present between the gill axes and the mantle lobes but on the inner sides between the gill axes and the visceral mass there are

Table 3

Dimensions of *L. antillarum* (in mm).

<i>Atlantic</i> (Turner & Boss, 1962)	length	height	width	lig length	A°	B°
Florida, U.S.A.	109.5	25.0	—	—	—	—
Florida, U.S.A.	101.0	26.5	—	—	—	—
Florida, U.S.A.	83.5	23.5	—	—	—	—
Santo Domingo	44.0	12.5	—	—	—	—
<i>Pacific</i>						
Fiji (AM C56414)	89.4	26.7	20.4	—	—	—
New Caledonia (AM C3929)	89.0	22.9	17.6	—	—	—
Fairfax I., Qld (AM C69053)	100.3	26.0	20.6	—	—	—
Low Is, Qld (AM C89643)	27.5	07.6	06.4	—	—	—
Heron I, Qld (WAM 30-73)	47.4	12.3	09.5	19.2	16°	11°

only a few low ridges with small depressions between them, anterior to the renal and genital apertures.

REMARKS: The shell of *L. antillarum* most closely resembles that of *L. teres* being sculptured and lacking any secondary calcareous incrustations but is easily distinguished by the presence of radiating or chevron-like sculpture on the postero-dorsal surface. It is also rather more slender than *L. teres* and the periostracum is usually yellow-brown and not chocolate brown to black as it is in that species.

Anatomically *L. antillarum* also resembles *L. teres*. It appears that gonad follicles do not invest the mantle lobes though mature specimens are needed to confirm this. The structure of the branchial septum is like that of *L. teres* with small lateral papillae on the lateral corners of the ventral cup-shaped partition and on the adjacent mantle lobes. Another structure peculiar to these two species is the hard, amorphous mass in the dorsal mantle lobes behind the pericardium and lining the roof of the dorsal cul-de-sac of the mantle cavity. The function of this structure is unknown.

Genital and renal apertures are situated like those of *L. teres* and not in a deep supra-branchial pocket like those of the other Qld lithophagines. But anterior to them there are neither plicate canals nor a series of supra-branchial pockets. This may also be because of the immature nature of the specimen.

Perhaps the most remarkable thing about *L. antillarum* is its distribution. Turner & Boss (1962) have shown the lack of morphological characters distinguishing Western Atlantic and Indo-West Pacific shells and there is no option but to regard these widely separated populations as belonging to the same species.

Lithophaga lessepsiana (Vaillant, 1865)

(Fig. 18 (6-10); text figs. 5-8)

Lithodomus lessepsiana Vaillant, 1865: 115 and 123; figured Savigny, 1817: pl. 11, fig. 1. Type locality: Suez. Syntypes: MNHN (Paris), 2 broken specimens.

Lithophaga simplex Iredale, 1939: 421, pl. 6, fig. 25. Type locality: Low Isles, Qld. Holotype: AM regn. no. C60403.

DISTRIBUTION: Arnaud & Thomassin (1976; table 3) list the following localities for *L. lessepsiana* burrowing in the solitary coral *Heteropsammia michelini*: Red Sea, Madagascar, Zanzibar, Seychelle Is., Maldive Is., Eniwetok Atoll, Chinese Sea, Lizard I. and Port Curtis, Qld.

From AM and WAM collections I can add the following localities for *L. lessepsiana* burrowing in various colonial corals: Malaupaina I. (Solomons), Darwin (Northern Territory), Kendrew and Rosemary Is., Dampier Archipelago (W.A.), Lizard I., Low Isles, Michaelmas Cay, Heron I., North West I., Moreton Bay (QLD).

Thus it is apparent that *L. lessepsiana* is widely distributed in the tropical Indo-West Pacific Region.

HABITAT: This is one of the few lithophagids which habitually burrows in living corals. The entrance of the burrow is always located among living polyps and never in dead parts of the corallum.

Iredale (1939) reported that this species "is only found in living *Porites* and *Symphyllia*", but it is in fact commonly found burrowing in several kinds of branching corals. I have found it abundantly in *Acropora palifera* and *Pocillopora eydouxi* at Heron I. (Qld.), Dampier Archipelago (W.A.) and the Solomon Is. (but not in the more common species *Pocillopora damicornis* living adjacent). Vaillant (1865) and Fishelson (1973) report it from the Red Sea in *Stylophora pistillata*. Soliman & Gohar (1963a) report it from the red Sea in *Sytlophora? flabellata*. At Heron I. I found it boring in prostrate forms of *Acropora palifera* growing in exposed positions on the reef flat but I have not seen it in the branching ("staghorn") species of *Acropora*. At Lizard I., Low Isles, Dampier Archipelago and the Solomon Is. *L. lessepsiana* is also common, boring in massive corals of the genera *Porites* and *Favia* but I have not been able to determine which species.

Arnaud and Thomassin (1976) describe the geographical and ecological distribution and the burrows of *L. lessepsiana* in the free living scleractinian coral *Heteropsammia michelini* living on soft substrates in lagoon or reef-slope situations. Significantly they did not find the lithophagine in other solitary corals (e.g. *Heterocyathus aequicostatus* and *H. rousseauanus*) living in the same or similar biotopes.

DESCRIPTION: SHELL: Smooth, very thin and fragile. Iridescent internally, with a shiny yellow-green periostracum. Moderately elongate and cylindrical; umbos terminal or sub-terminal; anterior end deep and rounded, posterior end broadly rounded. Ventral margin only slightly convex; hinge-line and postero-dorsal margin almost straight; dorsal angle relatively low. Calcareous incrustations over the periostracum thin and poorly developed. Antero-dorsally there is a loose pasty covering of calcareous particles and mucus.

Ventrally and posteriorly there is a very thin discontinuous crusty, calcareous layer which may be smooth or cast into divaricating threads or a reticulate pattern of intersecting

concentric and radial threads. There may be thick, dentate terminal accretions posteriorly extending beyond the end of the valves.

The nature of the superficial calcareous incrustations was observed to vary according to the identity of the host coral at Lizard I. Shells from *Favia* are generally smooth and terminal thickenings are small or lacking (Fig. 18(8)). Shells from *Acropora* and *Pocillopora* usually have a weak reticulate pattern on the postero-dorsal area and small terminal thickenings (Fig. 18(10)). Shells from *Porites* are more strongly encrusted with a reticulate or divaricate pattern and the terminal thickenings are relatively heavy, projecting, and dentate on their inner surfaces (Fig. 18(9)). Specimens burrowing in *Favia* sgem also to reach a greater size than those burrowing in other corals.

DIMENSIONS: The syntypes of *L. lessepsiana* and the holotype of *L. simplex* are all broken and a full set of measurements of these specimens is not possible. Data for series from Low Isles and Lizard I. populations are given in Table 4.

ANATOMY: Though similar in basic arrangement the structural detail of the branchial septum in *L. lessepsiana* differs from that of *L. teres* (compare Figs. 2 and 5). The antero-ventral extension is much shorter and the diaphragm-like membrane across the inner end of the excurrent siphon is a simple, thin structure with a narrow horizontal slit across the centre.

The ventral partition of the branchial septum is strongly papillate along its margin (Figs. 5 and 6). There is a large, compressed and digitate central lappet with 3-9 branches. It is flanked on each side by 1-3 small simple papillae and a lateral papilla in the corners by the mantle lobes bearing 2-3 branches.

The outer surface of the incurrent siphon is cream or fawn with a wide brown band a short distance forward from the posterior margin; bands of left and right sides meet dorsally and encircle the excurrent aperture. Internally the incurrent siphon is fawn near the posterior margin but elsewhere brown flecked with white except for two fawn lines which begin at the corners of the branchial siphon and converge dorsally at immediately below the margin of the excurrent aperture.

The first loop of the rectum lays on the dorsal surface of the posterior adductor.

Table 4

Dimensions of *L. lessepsiana* (in mm)

Topotypic series *L. simplex*,

Low Is, Qld.	length	height	width	lig length	A°	B°
WAM 178-77	30.1	10.2	07.8	11.6	23°	16°
WAM 178-77	27.0	10.5	11.2	08.9	28°	17°
WAM 178-77	29.1	09.9	08.6	11.0	25°	18°
WAM 35-73	27.0	08.8	07.4	12.9	22°	15°
WAM 35-73	22.1	08.5	06.4	08.8	30°	18°
WAM 35-73	30.1	08.1	06.0	10.2	15°	13°
WAM 35-73	15.3	05.9	04.8	06.0	27°	15°

The auricles are thin, transparent and lack pigmentation. Otherwise the heart is like that of *L. teres* and *L. lima* (see Fig. 10).

An "acid" gland was not located.

Instead of plicate canals in the supra-branchial chamber between the visceral mass and the gill axis there is a single axial series of 6 or 7 deep rounded pockets in the roof of the supra-branchial chamber anterior to the pericardium (Fig. 7). The pockets are separated from each other by broad transverse bars of transparent tissue which may be homologous with the plicate canals of *L. teres*.

The largest of these supra-branchial pockets are the most posterior pair, located directly below the antero-lateral corners of the pericardium. They possess anterior extensions or diverticulæ which form small compressed chambers deep within the body of the visceral mass, lined by a thin epithelium. These diverticulæ appear to have no ducts or apertures to the exterior, pericardium or any other organ except for the wide gape opening into the large supra-branchial pockets.

Kidney tissue is visible in the rooves of the supra-branchial pockets along their gill axis (lateral) sides; the inner sides of the pockets are walled by gonad (the large posterior pocket) or digestive gland (the anterior pockets).

Posterior to the supra-branchial chamber there are no such pockets. In the roof of the chamber in that region the ventral wall of the kidney is visible along the outer (lateral) side and the ventral pericardial wall is visible along the inner side. Only the thin, nearly transparent wall of the pericardium separates pericardial fluids from water in the supra-branchial chamber.

Between the gill axis and the mantle lobe there are short transverse, transparent strands apparently equivalent to the plicate glands of other mytilids.

Genital and renal apertures are located on papillae on the lateral wall of the large posterior supra-branchial pocket immediately below the antero-lateral corners of the pericardium. The genital papillae are prominent; the renal papillae are smaller but easily visible under moderate magnification adjacent and lateral to the genital papillae (Fig. 7).

Gonad tubules, when in ripe condition, spread superficially over the dorsal surface of the digestive gland anterior to the pericardium, fill the small mesosoma and the space between the diverging posterior retractors, and also fill the mantle lobes which are consequently thick and opaque. Ovary is purplish brown; testis is white.

Anterior and posterior genital ducts are present in the visceral mass as in *L. teres* but there is also a dendritic system of ducts ramifying through the mantle lobes, connecting to the primary anterior visceral ducts just in front of the genital papillae.

The kidneys comprise massed, green, thin-walled tubules lying above and along the whole length of the gill axis. The kidney mass is wide and strongly diverticulate posteriorly, narrow and less diverticulate in front of the pericardium. The renopericardial apertures are broad ventral slits in the antero-lateral corners of the pericardium opening directly into the kidney lumen (Fig. 5).

Inner and outer lamellae of the ctenidial demibranchs are held together by inter-lamellar membranes instead of inter-lamellar bars as in *L. teres*. The membranes occur every few filaments along the demibranchs; they are entire and rise to a height equal to about $\frac{1}{3}$ of the height of the outer lamellae. Labial palps are approximately equal in size (Fig. 8).

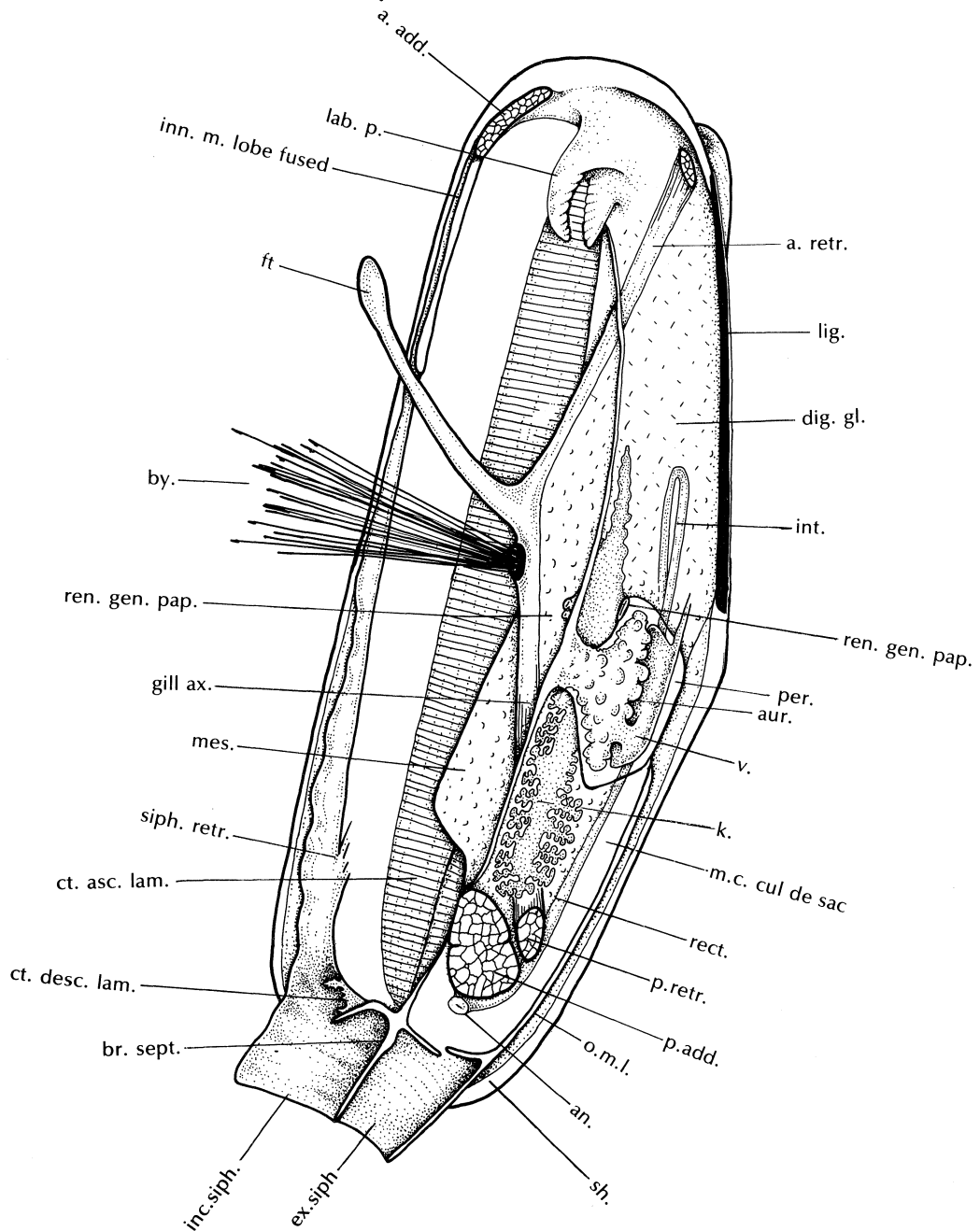


Fig. 5 *Lithophaga lessepsiana* (WAM 153-77). Semi-diagrammatic lateral view of soft parts. Siphons extended. Ctenidium and mantle lobe of left side removed and posterior end presented as a saggital section to illustrate details of structure of the incurrent and excurrent siphons. Oesophagus, stomach and 1st arm of intestine not shown.

ANATOMICAL MATERIAL EXAMINED.

Queensland:

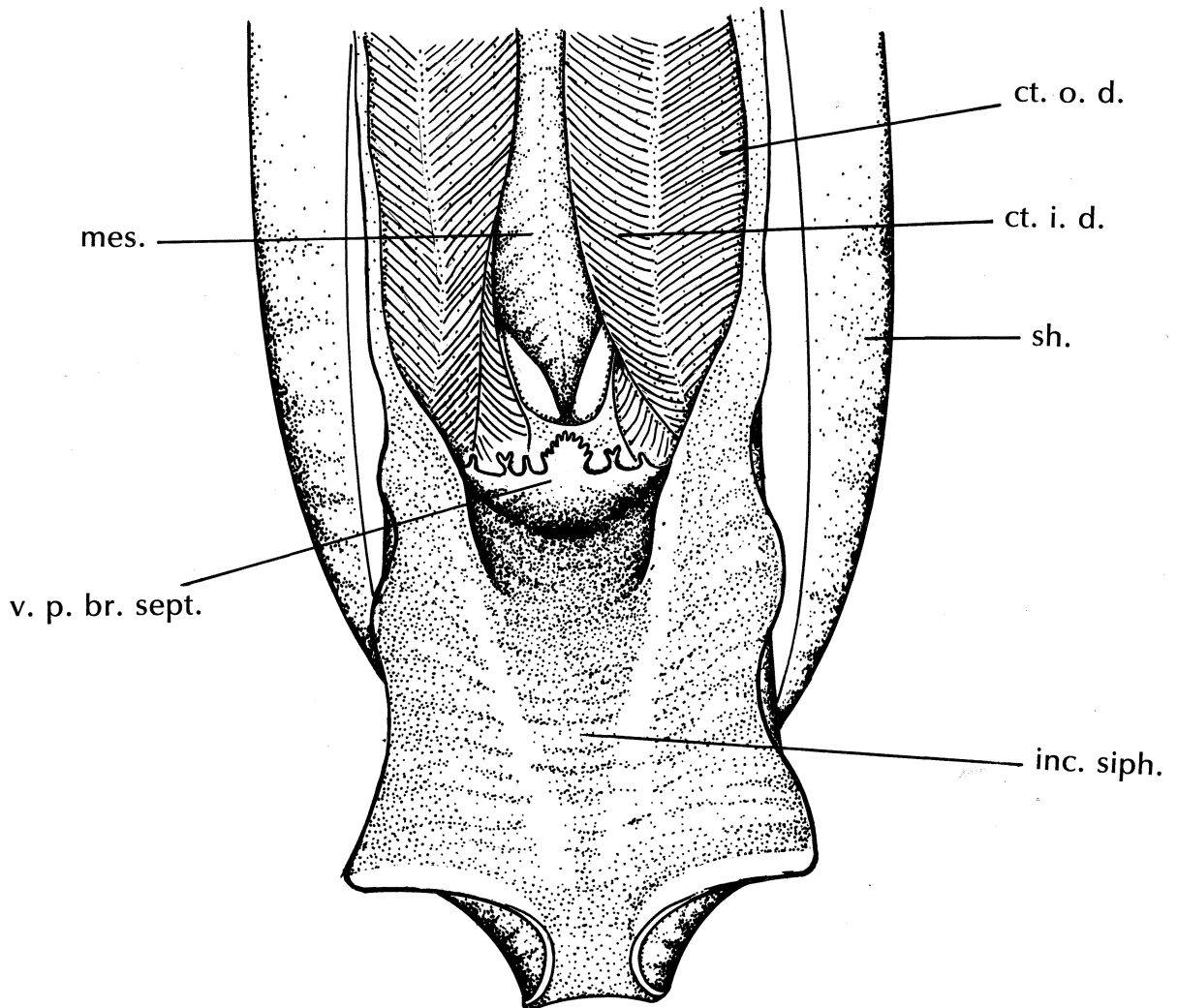
Rocky Point, Lizard I., WAM 179-77, 154-77, 153-77, in *Porites*.Watson Bay, Lizard I., WAM 173-77, 177-77, in *Favia*.Lagoon, Lizard I., WAM 158-77, in *Pocillopora*.Casuarina Beach at low tide, Lizard I., WAM 176-77, in *Favia*.Low Isles, WAM 161-77, 35-77, in *Porites*.

Fig. 6 *Lithophaga lessepsiana* (WAM 33-73). Incurrent siphon opened out and seen from below, illustrating the ventral partition of the branchial septum and its papillae.

Low Isles, WAM 178-77, in *Favia*.

Michaelmas Cay, WAM 175-77, in *Favia*.

Lagoon, Heron I., WAM 33-73, in *Pocillopora eydouxi*;

Reef flat at low tide, Heron I., WAM 172-77, 171-77, in *Acropora* sp.;

Lagoon, Heron I., WAM 164-77, 165-77, in *Acropora palifera*.

Western Australia:

Kendrew I., Dampier Archipelago, WAM 174-77, 167-77, in *Pocillopora eydouxi*;

Solomon Is:

Malaupaina I., WAM 166-77, in *Pocillopora eydouxi*.

REMARKS: Having compared the types of *L. lessepsiana* and *L. simplex* I am satisfied that they belong to the one species in spite of the geographic distance between the type localities.

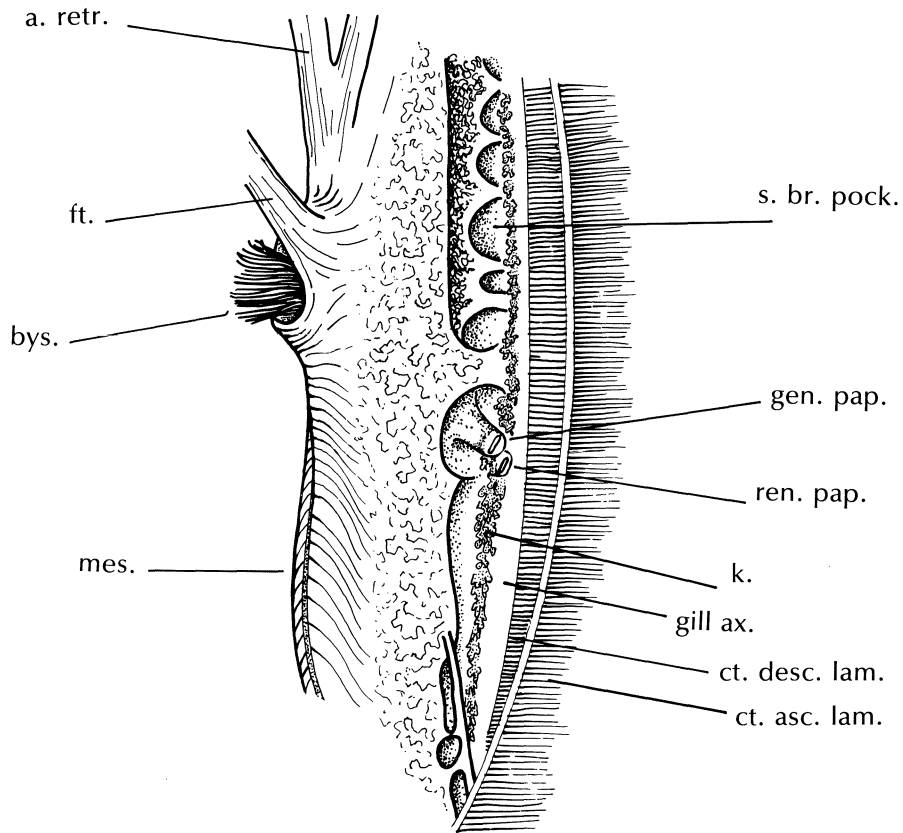


Fig. 7 *Lithophaga lessepsiana* (WAM 153-77). Roof of mantle cavity of the right side illustrating the series of supra-branchial pockets and the location of the renal and genital apertures.

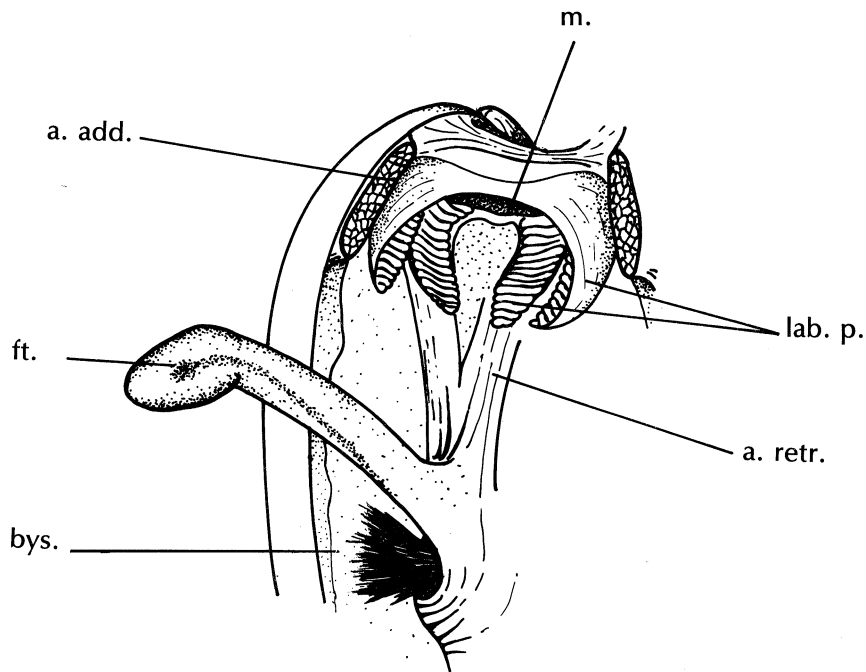


Fig. 8 *Lithophaga lessepsiana* (WAM 153-77). Diagram illustrating the mouth and labial palps as seen from below. Ctenidia excluded.

Gohar & Soliman (1963a) described the anatomy, shell and burrow of this species in the Red Sea under the name *L. cumingiana* Dunker. This name is actually attributable to Reeve (1857) who indicated that it was a Dunker manuscript name. I have examined Reeve's type and agree with Olsson (1961) that it belongs to the American species *L. peruviana* d'Orbigny (1846). The confusion was compounded when Dunker (1882) used the name himself but giving the type locality as New Holland. I have been unable to locate any specimens which could be regarded as the types of *cumingiana* Dunker (1882) other than those described by Reeve, and consider that this name should henceforth be regarded as a junior objective synonym of *cumingiana* 'Dunker' Reeve (1857).

The description of *L. lessepsiana* and its habitat given by Gohar & Soliman (1963a) leaves no doubt about the conspecificity of their material from the Red Sea with mine from Australian and Solomon Is. localities.

Some of the anatomical features differentiating *L. lessepsiana* from *L. teres* appear to have major significance, viz: the lack of pigmentation on the auricle walls, the absence of plicate canals between the visceral mass and the gill axis, and the presence of supra-branchial pockets, the presence of gonad tissue in the mantle lobes, and the presence of inter-lamellar membranes instead of bars in the ctenidia.

Of special interest are the supra-branchial pockets and the deep visceral diverticulae of the most posterior pair, and the exposure of the pericardial wall in the roof of the supra-branchial chamber. No explanation of these structures can be offered except that it is likely they may be involved with respiration and ionic balance and thus have similar function to that assumed for the plicate canals of *L. teres* and *Mytilus edulis*.

The differences in the nature of the superficial incrustations between shells taken from different host coral genera are noteworthy. I could find no evidence of corresponding anatomical differences and conclude that a single species is involved and that the form taken by the incrustations is influenced by the form or biology of the host.

Lithophaga nasuta (Philippi, 1846)

(Fig. 17 (2); text fig. 9)

1846 (Oct.) *Modiola nasuta* Philippi, *Abbildungen und Beschreibungen neuer oder wenig gekannter Conchylien*, 3: 149, pl. 1, fig. 2 (Pacific Ocean). Type: MNHN, Santiago, Chile (pers. comm. K. Kleeman).

1939 *Lithophaga dichroa* Iredale, *Scient. Rep. Gt. Barrier Reef Exped.*, 5 (6): 421, pl. 6, fig. 31. (Low Isles, Qld). Holotype: AM regn. no. C60404.

DISTRIBUTION: The whole range is uncertain but *L. nasuta* is common at least throughout the south-western Pacific, northern Australia and the Indo-Malay Archipelago. Prashad (1932) records it from Sulawesi, Ambon and Sulu Archipelago. Adam & Leloup (1939) record it from Misool. I have collected it in the Solomon Islands, north-western Malaysia, Fiji, and Dampier Archipelago in northern W.A. In the WAM and AM there are specimens from the following Qld. localities: Lizard I., Low Is., Lindeman I., Heron I., Moreton Bay.

HABITAT: *L. nasuta* is principally an intertidal species (though occasionally found in the shallow sublittoral) and bores in any calcareous rocks. It is often abundant in sloping calcareous beachrock platforms high in the intertidal zone and must play an important role in the break up of these sediments. Its burrows are a conspicuous feature of the beachrocks at Heron, Lizard and Low Is and have been described in detail by Otter (1937) under the name *L. cumingiana* (see remarks for *L. lessepsiana* for comments on this name). In this situation it is usually accompanied by the mussel *Botulopa silicula* (Lamarck) (= *Modiolus cinnamomeus* of Otter).

DESCRIPTION: SHELL: Smooth, moderately thin. Interior iridescent, often bluish. Exterior uniformly pale brown, periostracum light brown antero-ventrally and below the hinge, dark purple — brown in a broad radial umbonal ray. Cylindrical; umbos terminal; anterior end curved but sloping making the shell appear to be leaning forward, posterior end broad and bluntly rounded. Ventral margin slightly convex; dorsal margin (hinge-line) straight; postero-dorsal margin straight; dorsal angle low.

Below the umbonal ray there is a continuous smooth and hard chalky layer; over and above the umbonal ray there is little if any superficial incrustation; posteriorly there are thick but smooth deposits which project only a little beyond the ends of the valves.

Dimensions of a topotypic series of *L. dichroa* are given in Table 5.

Table 5

	Dimensions of <i>L. nasuta</i> (in mm)					
	length	height	width	lig length	A°	B°
Holotype <i>L. dichroa</i> (AM C60404)	57.7	17.7	14.2	24.4	19°	11°
Topotypic series <i>L. dichroa</i> Low Is (WAM 86-77)	57.9	19.2	14.2	22.6	20°	17°
	62.6	18.0	14.1	26.4	19°	14°
	51.0	17.8	13.9	20.8	22°	10°
	51.1	16.4	12.1	23.4	17°	10°
	50.1	16.2	12.3	20.3	18°	11°
	50.1	16.5	13.4	21.4	23°	14°
	47.5	16.0	11.8	20.0	22°	12°
	40.5	13.6	10.3	14.0	21°	10°
	39.7	14.2	11.1	18.8	25°	15°

ANATOMY: The ventral partition of the branchial septum has prominent branching papillae along its edge (Fig. 9). There is a large, compressed, multi-digitate one at the centre, a smaller multi-digitate papillum in each corner, and one or more small digits in between which may be simple or have two branches.

Inner and outer surfaces of the siphons and the branchial septum are brown flecked with white patches except as follows. At the posterior edges there is a pale brown or buff band. On the upper inner wall of the incurrent siphon there is a pair of conspicuous white pathways which arise laterally where the partition of the branchial septum joins the mantle wall, and pass upwards and backwards close to the medial line to a position at the posterior edge of the siphon below the excurrent aperture. Application of indian ink to living specimens showed these pathways to be strongly ciliated rejection tracts along which unwanted particles are carried from the mantle cavity to an ejection point at the base of the excurrent siphon.

Digestive gland is dull olive-green.

The first loop of the rectum turns just before reaching the posterior adductor.

Auricles are thick and pigmented (orange).

Plicate canals are lacking between the visceral mass and the gill axes but axial series of deep supra-branchial pockets are present there. The largest pair of these is located below the antero-lateral corners of the pericardium and possesses a deep anterior-dorsal extension into the visceral mass. Supra-branchial pockets occur both anterior and posterior to this large central (cf. *L. lima*) one although the posterior pockets are quite small.

Genital and renal apertures are located on small papillae in the large central supra-branchial pockets as in *L. lessepsiana*.

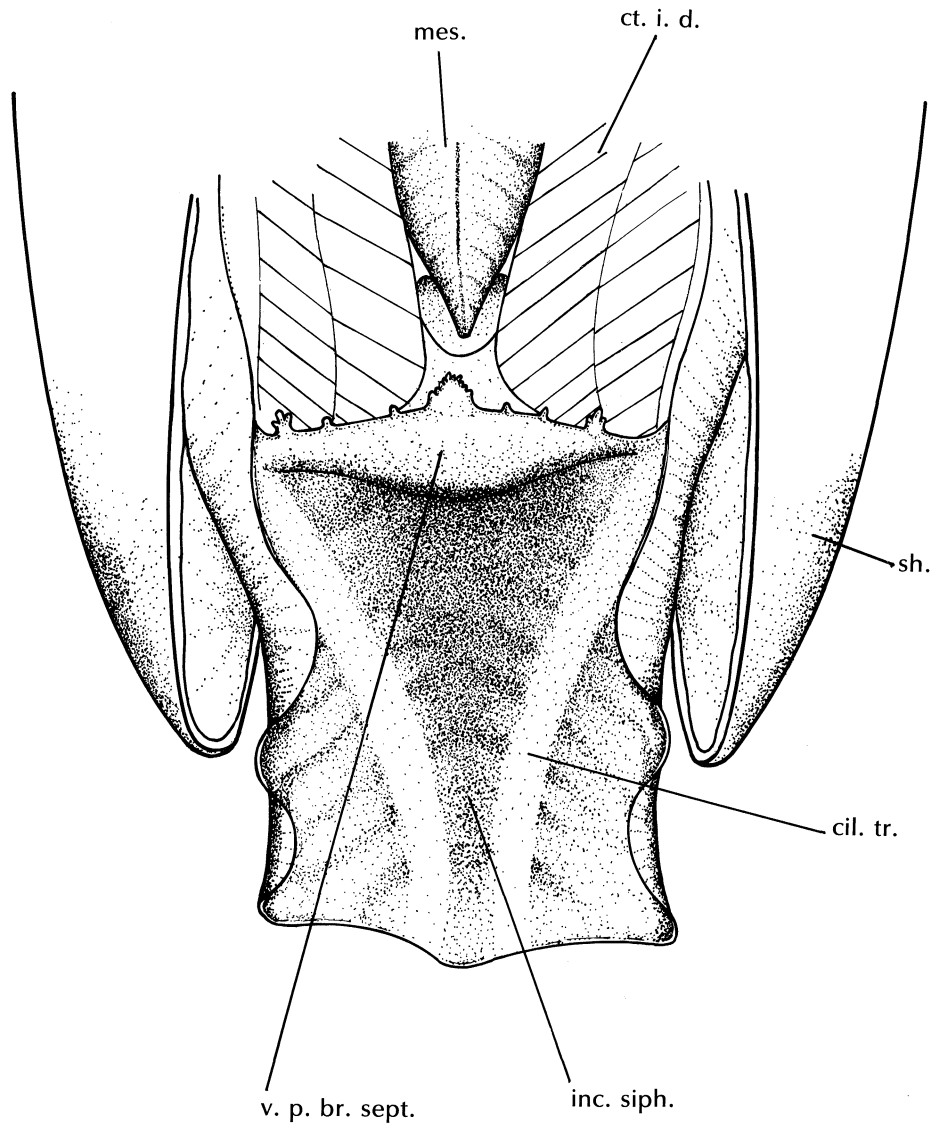


Fig. 9 *Lithophaga nasuta* (WAM 86-77). Incurrent siphon opened out and seen from below, illustrating the ventral partition of the branchial septum and its papillae and the ciliated rejection tracts in the roof of the incurrent siphon.

Gonads fill the mantle lobes and a small mesosoma, and spread superficially over the visceral mass as in *L. lessepsiana*. Testis is cream; ovary is purplish brown.

Ctenidia and kidneys as in *L. lessepsiana*.

ANATOMICAL MATERIAL EXAMINED.

Queensland:

Watson Bay, Lizard I., WAM 78-77, in dead parts of *Favia*, 3 metres.

Casuarina Beach, Lizard I., WAM 84-77, in oyster mass growing on granite, high intertidal zone.

Low Is., WAM 85-77, 86-77, in beach-rock.

Low Is., WAM 459-76, in dead *Porites*, intertidal.

Heron I., WAM 88-77, in beach-rock.

Western Australia:

Kendrew I., Dampier Archipelago, WAM 81-77, in beach-rock, and WAM 207-77, in dead coral boulders, boulder zone of reef flat.

Cape Poivre, Barrow I., WAM 3378-68, in beach-rock.

Malaysia:

Palau Langkawi, WAM 80-77, in intertidal basalt.

Solomon Is:

Morau Sound, WAM 93-77, in dead *Porites*, intertidal.

Malaupaina I., WAM 92-77, in dead *Acropora*, 7m.

REMARKS: *L. nasuta* most closely resembles *L. lima*. In fact it seems fairly clear that the mussels from Low Isles which Otter (1937) referred to as *L. cumingiana* included both species, which accounts for the range of habitats to which he attributed his material. Iredale (1939) also failed to observe that there are two "bicoloured" species at Low Isles, and introduced the name *dichroa* to account for Otter's series.

L. nasuta and *L. lima* both have a dark radial ray from the umbos to the postero-ventral margin of the valves and they are of comparable size and shape. However, close inspection will reveal several consistent differences in the shell. The radial purple ray in *L. lima* is due to pigmentation of the shell while in *L. nasuta* the wider, brown radial ray is due to pigmentation of the periostracum and the shell beneath it is plain pale brown.

Generally there are thin, sculptured superficial incrustations posteriorly in *L. lima* but the antero-ventral deposits are usually thin and discontinuous. In *L. nasuta* the posterior incrustations are smooth and there is usually a thick, continuous antero-ventral layer. Finally the postero-dorsal angle in *L. nasuta* is usually more pronounced than in the other species and the umbo is forward-leaning. (See also Lamy (1937) for a comparison of these two species).

Anatomically the two species also have many features in common but invariably they can be easily distinguished by the colour of the siphons. In *L. lima* they are uniformly brown. In *L. nasuta* there is a wide pale band along the posterior edges of the siphons and the two prominent, pale, ciliated pathways in the roof of the incurrent siphon. Also, the ventral partition of the branchial septum is strongly papillose in *L. nasuta* but possesses only low marginal thickenings in *L. lima*.

L. lima and *L. nasuta* are rarely co-inhabitants of the same substrate. The former is common only in living massive corals and rarely burrows in dead coral. *L. nasuta* on the other hand is most common in intertidal beach-rock, reasonably common boring in dead corals in the shallow sublittoral, but never bores in living corals. Only once have I found

the two boring together and this was in the dead centre of a *Porites* bomby in 3 metres in Watson Bay, Lizard I. where I obtained one *L. lima* and a series of *L. nasuta*.

I am unable to agree with the view expressed by Iredale (1939: 421) that the name *L. nasuta* Philippi should be rejected as a *nomen dubium*. It is true that several authors have incorrectly applied the name but the original figure by Philippi does adequately represent the species here considered.

Lithophaga lima (Lamy, 1919)

(Fig. 17 (5-9); text figs. 10-12)

Lithophaga nasuta. — Dunker non Philippi, nec Reeve, 1882: 5, pl. 1, figs. 5, 6, pl. 2, figs. 7, 8.

Dactylus lima 'Jousseau' Lamy, 1919: 256-257. Type locality: Djibouti, Aden. Types: 11 syntypes (Table 6) MNHN (Paris).

DISTRIBUTION: Lamy (1937) reports this species from "Mozambique, Zanzibar, Manille, Japan etc." as well as the Red Sea type locality. Kira (1962) reports it from southern Japan. I have personally collected it at localities in the Philippines, Malaysia, Indonesia, Solomon Islands and northern Western Australia, and in Queensland at Lizard I., Low Isles and Michaelmas Cay. There is also an Australian Museum specimen from Cape Gloucester. Thus it is apparent that *L. lima* is a common species widely distributed in the Indo-West Pacific Region.

HABITAT: *L. lima* normally bores among living polyps of massive corals but it may be found occasionally with its burrow mouth in the dead parts of the corallum. I have collected it boring in living *Porites*, *Favites*, *Favia*, *Pleisiostraea* and *Leptoria*. Gohar and Soliman (1963a) describe its burrows in *Montipora* and occasionally in *Cyphastrea* in the Red Sea. I have collected it from low tide level to a depth of 33 metres.

DESCRIPTION: SHELL: Smooth, thin, and fragile. Internal surface shiny, iridescent, purplish tinted, with a darker purple ray dorsally. Shell exterior white except for a radial (umbonal) purple ray which shows through a thin olive-brown periostracum. More or less cylindrical; umbos sub-terminal; anterior end bluntly rounded, posterior end rounded; ventral margin distinctly convex; dorsal margin (hinge-line) short and straight; postero-dorsal margin straight; dorsal angle moderately sharp and steep.

There is usually an indistinct incised radial line from the umbo to the postero-ventral corner. Ventral to this there is a thin, superficial, granular, calcareous coating which may be discontinuous or cover the whole area. Dorsally in the area adjacent to the hinge and above the radial line the smooth and glossy periostracum is usually not covered by secondary calcareous deposits and the radial purple ray is evident. Postero-dorsally above the radial line there is usually but not always a thick and hard calcareous layer thrown into wrinkled ridges which may be concentric but often tend to become radial and divaricate near the posterior margin. Posteriorly these accretions project hardly at all beyond the end on the valves but they sometimes form a serrated edge there.

Dimensions are given in Table 6.

ANATOMY: The ventral partition of the branchial septum has a low marginal thickening at the centre, and about 6 very small, simple, marginal papillae (Fig. 10). The incurrent and excurrent siphons including the inner and outer surfaces and branchial septum are dark purple-brown. There are scattered white spots close to the inner edge of

Table 6:

Dimensions of syntype series *L. lima* (in mm).

	length	height	width	lig length	A°	B°
1	80.5	25.2	19.7	36.5	22°	11°
2	70.6	22.3	18.9	32.5	23°	13°
3	44.8	16.9	19.4	14.0	28°	18°
4	41.6	15.2	17.0	12.5	32°	16°
5	31.0	11.0	09.7	12.5	27°	13°
6	48.6	19.1	16.4	20.6	29°	16°
7	57.7	18.6	15.0	27.0	20°	12°
8	57.1	18.2	15.3	25.3	22°	15°
9	40.1	14.8	06.3	18.2	27°	12°
10	38.1	13.9	07.1	16.7	22°	14°
11	31.8	11.6	06.1	14.8	28°	15°

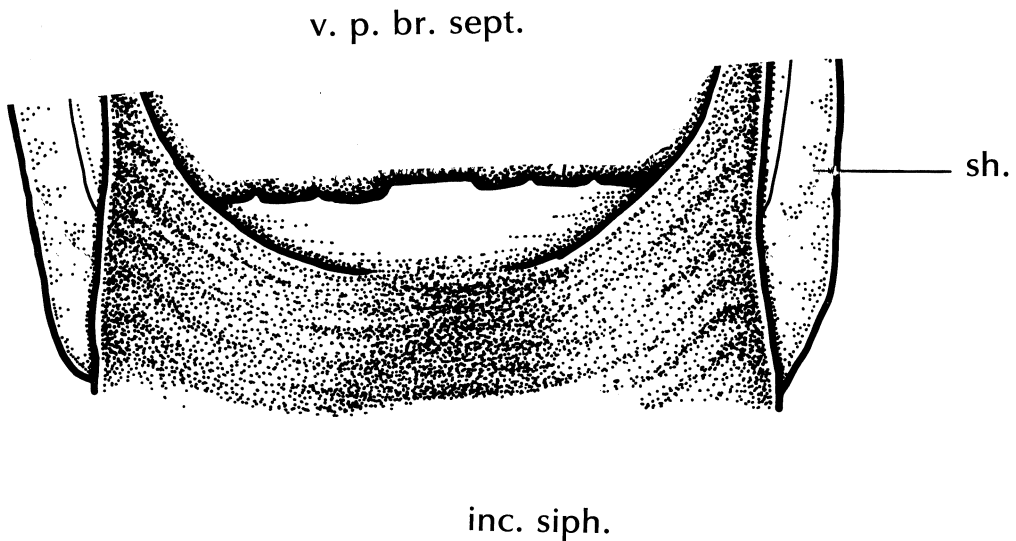


Fig. 10 *Lithophaga lima* (WAM 96-77). Incurrent siphon opened out and seen from below, illustrating ventral partition of the branchial septum.

the incurrent siphon and two oblique white bands internally. These bands arise from the inner edge of the mantle fold at the branchial septum partition, cross obliquely up the wall of the siphon and converge posteriorly at the outer edge in the mid-line immediately below the excurrent siphon. Application of carmine particles to living animals demonstrated that these white bands mark the position of strongly ciliated rejection tracts which carry particulate matter in mucous strings from the mantle cavity to a rejection point at the mantle edge where periodic expulsion of water from the excurrent siphon carries it well clear of the animal.

The recurrent loop of the rectum reaches the dorsal surface of the posterior adductors as in *L. lessepsiana*. No style was observed in the first arm of the rectum in either preserved or living specimens.

Auricles are pale brown but translucent and not heavily pigmented. Pericardial glands are not apparent on the auricles or the pericardial floor. In other respects the heart is like that of *L. teres*.

Plicate canals in the supra-branchial chamber are lacking. Instead there is an axial series of deep supra-branchial pockets between the gill axis and the visceral mass along each side. Like *L. lessepsiana*, the largest of these pockets are the ones in which the renal and genital apertures are situated, directly below the antero-lateral corners of the pericardium. They also have compressed anterior extensions into the visceral mass. *L. lima* differs from *L. lessepsiana* however, in that the series of smaller supra-branchial pockets continues posteriorly as far as the posterior retractors (Fig. 11). There are 6-8 supra-branchial pockets in front of the large central one, becoming progressively smaller anteriorly, and 8-10 small posterior pockets.

Genital and renal apertures are located as in *L. lessepsiana* (Fig. 11).

Gonad tubules, when in ripe condition, spread superficially over the digestive gland anterior to the pericardium, fill much of the space in the visceral mass below and behind the pericardium, and fill the mantle lobes. The mesosoma is small and contained no gonad in the ripe specimens examined. Ovary is purple, testis is white.

The kidneys comprise diverticulate, massed, pale-green tubules along the length of the gill axes as in *L. lessepsiana*.

The ctenidia are like those of *L. lessepsiana* having inter-lamellar septal membranes between the ascending and descending lamellae, spaced at intervals of 4-6 filaments along the gills.

There is a narrow band of muscle on each side arising separately from the pedal muscles just anterior to the posterior retractors and attaching to the shell lateral to the posterior end of the pericardium. Radial pallial muscles are well developed posteriorly but a distinct siphonal retractor is not evident.

Labial palps are short, stout and only finely plicate on their inner faces. The outer pair are slightly longer than the inner pair.

ANATOMICAL MATERIAL EXAMINED.

Queensland:

Watson Bay Lizard I., WAM 111-77, in *Porites*.

North Point, Lizard I., WAM 95-77, in *Leptoria*.

Rocky Point, Lizard I., WAM 96-77, in *Porites*.

Rocky Point, Lizard I., WAM 100-77, 97-77, in dead coral rock.

Rocky Point, Lizard I., WAM 99-77, in *Favia*.

Low Isles, WAM 98-77, in *Leptoria*.

Michaelmas Cay, WAM 107-77, in *Porites*.

Western Australia:

Kendrew I., Dampier Archipelago, WAM 109-77, in *Pleisiastrea* (?).

Solomon Is.:

Malaupaina I., WAM 110-77, in *Favites* at 33 metres.

Malaysia:

Palau Langkawi, WAM 37-73.

REMARKS: The identity of this species has been badly confused in the literature because of the similarity of the shell with that of *L. nasuta*. Lamy (1937) discusses the differences

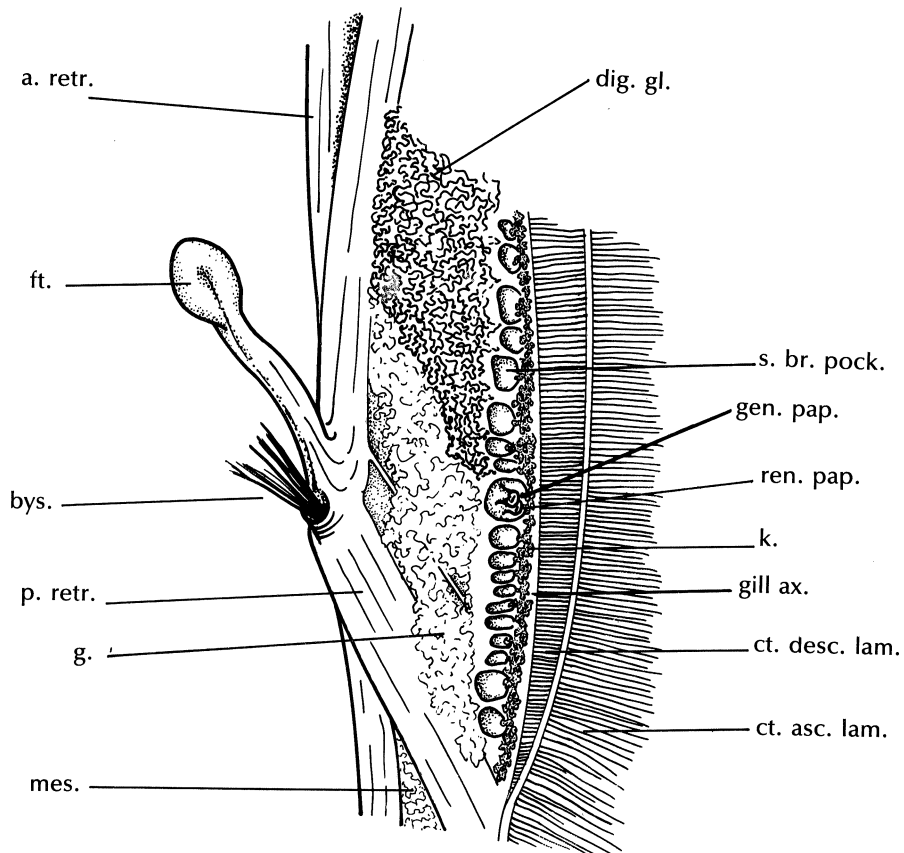


Fig. 11 *Lithophaga lima* (WAM 96-77). Roof of mantle cavity of right side illustrating the series of supra-branchial pockets and the location of renal and genital apertures.

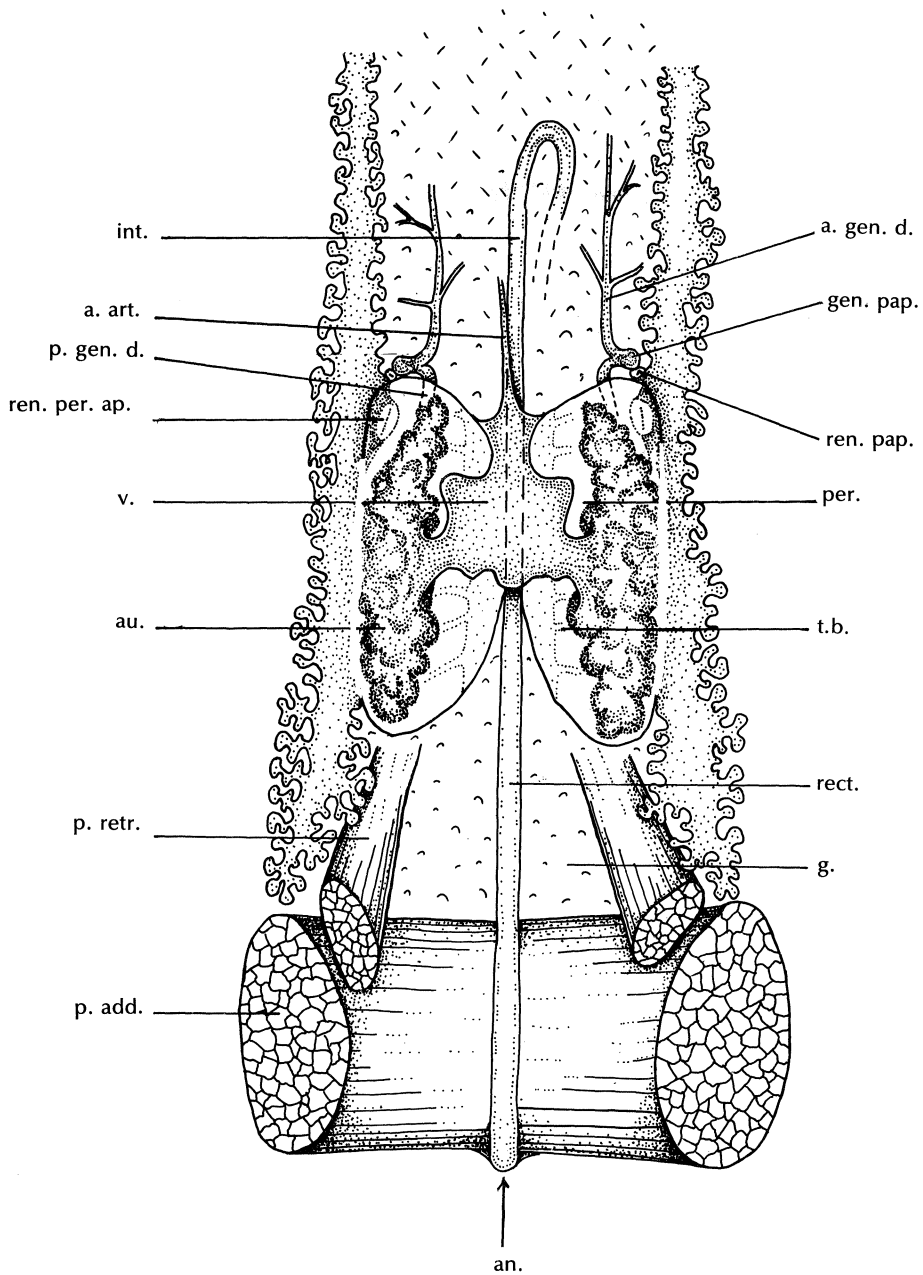


Fig.12 *Lithophaga lima* (WAM 96-77). Diagram illustrating relationships of heart, gut and posterior muscles as seen in dorsal view.

between the two species. Further discussion may be found in the remarks made here under *L. nasuta*.

The radial purple ray on the exterior of the shell is a unique character among the Indo-West Pacific lithophagids.

Lithophaga malaccana (Reeve, 1858)

(Fig. 18 (4-5); text fig. 13)

Lithodomus malaccanus Reeve, 1858: pl. 4, fig. 10. Type locality: Malacca. Syntypes: BM (NH) Regn. no. 1975104.

Lithophaga cavernosa Dunker, 1882: 7, pl. 5, figs. 15,16. Type locality: Philippines. Type: not located.

Lithophaga reticulata Dunker, 1882: 19, pl. 5, figs. 9-10. Type locality: Java, ? Type: not located.

Lithophaga calcifer Iredale, 1939: 420-421, pl. 6, fig. 28. Type locality: Low Isles, Qld. Holotype: AM regn. no. C60402.

DISTRIBUTION: Common throughout the Indo-West Pacific. In the Australian Museum and Western Australian Museum collections it is represented from the following Queensland localities: Lizard I., Low Isles, Michaelmas Cay, Lindeman I., Bowen, Humpy I., N. Keppel I., Heron I., Masthead I., Fairfax I., Swain Reefs, Port Curtis, and Moreton Bay. I have also personally collected it at a number of localities in the Philippines, Malaysia, Indonesia, Solomon Islands and northern Western Australia. Gohar & Soliman (1963b) report it from the Red Sea.

HABITAT: Iredale (1939) asserts that this species (i.e. *calcifer*) "was found in living *Favia*, *Goniastrea* and *Pocillopora*, as well as in dead coral boulders" but in my own experience it only occurs in dead corals or in the dead parts of living colonies. Gohar & Soliman (1963b) report it only from dead corals. In many localities it occurs in enormous abundance and its boring activity must play a major role in the breakdown of hard coral to calcareous silts. *L. malaccana* is common from low water spring tide level to at least 35m. Gohar & Soliman (1963b) describe the burrows.

DESCRIPTION: SHELL: Smooth, thin and fragile. Internal surface shiny and fawn or light brown with a paler umbonal ray marking the position of the external sulci; exterior with a thin yellow-brown periostracum. Cylindrical; umbos sub-terminal; anterior end broadly rounded, posterior end broadly rounded or truncate; ventral margin straight to slightly convex; dorsal margin (hinge-line) long and straight; postero-dorsal margin straight; dorsal angle rather sharp but relatively low, (about 31-35°), dorsal and ventral margins almost parallel. Ratio of height to length very variable, sometimes even within a sample from the same coral head, ranging from 0.33 to 0.28.

Tightly adhering crusty calcareous accretions superficially cover the exterior except at the umbos and along the hinge-line. There is a distinct radial umbonal sulcus from the umbo to the postero-ventral margin, and a second, less distinct sulcus a little higher from the umbo to the postero-dorsal margin. Between the sulci is a wedge-shaped area in which the accretions are thick and cast into divaricating and inter-twining wrinkles or ridges giving the surface a deeply pitted appearance. Toward the posterior extremity these ridges are raised high, thin and foliose or vertically lamellose. In this area the accretions are

especially thick and project far beyond the ends of the valves. The projections are convex and sculptured on their outer sides, and more-or-less flat but dentate on their inner sides. Antero-ventrally, i.e. below the deeper umbonal sulcus, the calcareous accretion is relatively thin, uniform and smooth though granular. On the narrow dorsal slope above the lesser sulcus the accretion is thin and smooth.

Dimensions are given in Table 7.

ANATOMY: The cup-shaped ventral partition of the branchial septum is papillose along its margin. The central lappet is the largest, sometimes bifid (Fig. 13), and bears 3 to 5 finger-like papillae on each side. There are branched lateral lappets in the corners and 2 or 3 small, simple, intermediate papillae on each side flanking the central lappet.

Internally the incurrent siphon, including the branchial septum and its ventral partition, is translucent-white, abundantly flecked with prominent opaque white spots and rectangular and linear marks. The margins of both the incurrent and excurrent siphons are light brown internally and externally.

The first loop of the rectum turns just anterior of the posterior adductor muscle. No style was observed in the first arm of the rectum of either preserved or living specimens.

Auricles are thin, transparent and not pigmented. Pericardial glands are not evident on the floor of the pericardium.

Plicate canals are lacking in the supra-branchial chamber but there is a single axial series of deep pockets between the gill axis and the visceral mass along each side. The largest pocket lies directly below the antero-lateral corners of the pericardium. There are about 13 pockets in the series anterior to the large one but more behind. In these respects *L. malaccana* is most like *L. lessepsiana*, but in this species there appears to be no anterior extension of the large supra-branchial pockets into the visceral mass.

The genital apertures are located on papillae in the roof of the large pair of supra-branchial pockets. Renal apertures were not observed but are assumed to be located immediately lateral to the genital papillae as in the other species.

Table 7

Dimensions of *L. malaccana* (in mm)

	length	height	width	lig length	A°	B°
Syntype <i>L. malaccana</i>	25.1	10.3	—	—	—	—
Holotype <i>L. calcifer</i>	36.7	12.9	10.6	19.2	16°	7°
Topotypic series	33.2	11.1	08.2	17.8	23°	9°
<i>L. calcifer</i> ex Low Is. (WAM 460-76)	29.4	10.4	08.0	13.1	25°	10°
	28.9	10.3	09.4	14.2	25°	9°
	28.8	09.1	07.8	12.5	21°	8°
	25.2	08.5	06.9	10.8	24°	11°
	22.5	06.3	02.5	09.8	25°	11°

Gonad tubules, when in ripe condition, spread superficially over the digestive gland just anterior to the pericardium, fill much of the space below and behind the pericardium, and fill the mantle lobes. There is no gonad in the small mesosoma. Ovary is chocolate-brown. Testis is white.

On the surface of mantle lobes when the shell valves are removed, two major dendritic genital duct systems, one anterior and one posterior, may be seen converging in the area above the genital aperture. They join other major anterior and posterior ducts from the visceral mass.

The kidneys are pale-green, lying along the length of the gill axes as in *L. lessepsiana*.

Ctenidia were not examined.

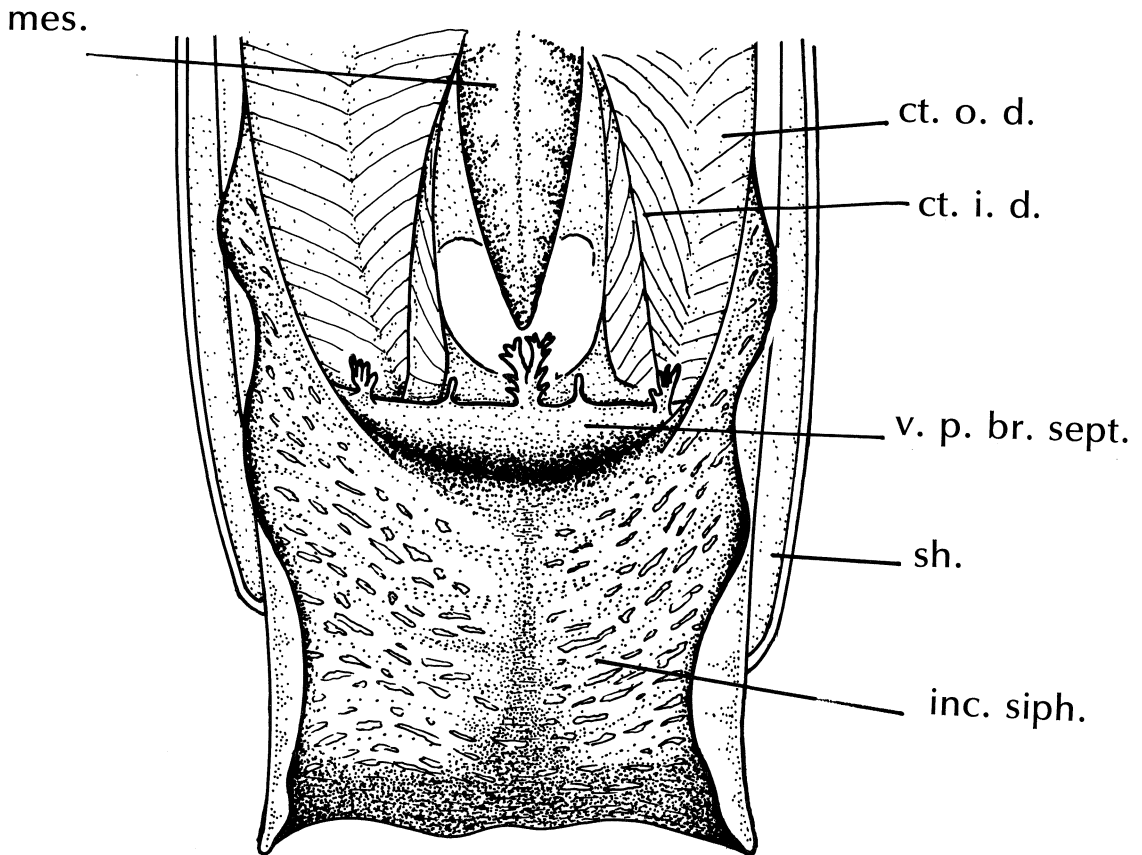


Fig. 13 *Lithophaga malaccana* (WAM 125-77). Incurrent siphon opened out and seen from below, illustrating the ventral partition of the branchial septum.

ANATOMICAL MATERIAL EXAMINED:

Queensland:

Low Isles, WAM 460-76, 130-77, in dead head of *Porites*, intertidal.

Lizard I., Rocky Point, WAM 125-77, in dead coral rock.

Heron I., south side, WAM 133-77, 134-77, 137-77, 140-77, dead coral slab, outer reef rim.

Heron I., south east side, WAM 136-77, dead coral boulders, reef crest.

Western Australia:

Kendrew I., Dampier Arch., WAM 169-77, in dead parts of coral heads, 2m.

Fiji:

Suva Bay, Viti Levu, WAM 116-77, in barnacle-covered lithothamnion rock, high intertidal zone.

Solomon Islands:

W. side Malaupaina I., WAM 113-77, dead parts of *Favites* ca 33m depth, outer reef slope.

Malaupaina I., WAM 132-77, 112-77, dead *Acropora* on sandy slope, 7m, lagoon entrance channel.

Malaysia:

P. Gasing, off Tg Rhu, Palau Langkawi, WAM 38-73.

REMARKS: I have compared the types of *malaccana* and *calcifer* and am satisfied that they are conspecific. In each case thick, wrinkled and pitted calcareous accretions are present in a wedge-shaped area between two narrow radial umbonal sulci, and the accretions project far beyond the ends of the valves. Dunker's types of *reticulata* and *cavernosa* appear to be lost but his figures seem best referred to this species.

Though shells of this species are unusually variable both in shape and the extent and nature of the posterior accretions, colouration of the siphons is consistent in all the living material I have examined. Shells could perhaps be confused with those of *L. lessepsiana* from *Porites* in which dentate, projecting posterior incrustations may be present. However, in *L. lessepsiana* the siphons are cream or fawn externally except for a broad brown band a short distance forward of the margin; internally the incumbent siphon is brown except for pale margins and pale converging lines marking the position of ciliated rejection tracts. The siphons of *L. malaccana* are conspicuously different; in this species they are pale internally and externally except for the posterior margins which are brown. In many other respects the anatomy of *L. malaccana* and *L. lessepsiana* are similar and there can be little doubt that they are closely related species.

Lithodomus laevigatus Quoy & Gaimard, 1835 (type locality: Port Dorey, New Guinea) could be this species as the 2 syntypes (deposited in the MNHN (Paris)) possess similar posterior encrustations (Fig. 18(3)). But the syntypes are badly damaged and could equally be *L. lessepsiana* from a *Porites* host. Because of the poor condition of the types and lack of any anatomical data I suggest that *L. laevigatus* should be regarded a *nomen dubium*.

The calcareous accretions and the radial umbonal sulci of *L. malaccana* closely resemble those of the American species *L. (Diberus) bisulcata* (d'Orbigny, 1842) and *L. (Diberus) plumula* (Hanley, 1843) and there is little doubt that future anatomical data will confirm a close affinity between them.

Lithophaga hanleyana (Reeve, 1857)

(Fig. 17 (3-4); text fig. 14)

Lithodomus hanleyanus Reeve, 1857: pl. 4, fig. 19. Type locality: Suez. Types: BM (NH), 3 syntypes, 2 broken including specimen marked "X" which is probably the one figured by Reeve.

Lithophaga laevigata instigans Iredale, 1939: 422, pl. 6, fig. 27. Type locality: Low Is., Qld. Type: AM regn. no. C60405.

DISTRIBUTION: Apparently widely distributed in the Indo-West Pacific though locality records are few. In Queensland I have collected *L. hanleyana* only at Low Isles and Heron I., and there are no other specimens in the AM or WAM collections from Australian localities. However, I found it common at Malaupaina I. in the Solomons and have also collected it at Polillo I., east coast of Quezon, Philippines. There are AM specimens from Funafuti and Tupuselei, Papua New Guinea. Gohar & Soliman (1963a) record the species from the Red Sea but I am doubtful that their specimens were correctly identified.

HABITAT: *L. hanleyana* burrows in dead coral and coral rock, perhaps preferring sheltered back-reef and lagoon situations. At Malaupaina I., Solomon Is, I found it in abundance boring in a dead colony of a thick-stemmed *Acropora* species in sheltered conditions at a depth of 6 metres in the lagoon entrance, and again fairly riddling a slab of coral rock laying among sea-grass in the intertidal zone of the lagoon itself. In the latter case the burrows were vertical with the openings on the underside of the slab.

DESCRIPTION: I did not collect this species at Lizard I. and the following description is based on material from Heron I.

SHELL: Smooth, thin and moderately fragile. Interior surface shiny and iridescent, sometimes with greenish and purple tints; exterior white with a thin light olive-green to brown periostracum. Cylindrical; umbos sub-terminal; anterior end bluntly rounded, posterior end truncate but with rounded corners; ventral margin slightly convex, almost straight; dorsal margin (hinge-line) short, straight; postero-dorsal margin straight; dorsal angle well developed but low.

There is a shallow umbonal sulcus from the umbo to the postero-ventral corner and a wide deeper one dorsally which may sometimes delineate a postero-dorsal "wing". Antero-ventrally the shell is covered by a thick, solid and smooth calcareous layer. On the dorsal wing the calcareous layer is thin and usually discontinuous so that the periostracum is visible there. Along the hinge-line dorsally solid calcareous covering is lacking but there is a loose calcareous pasty layer.

Posteriorly in the triangular area between the two sulci the accretions are solid and thick, usually smooth but sometimes weakly pitted, and protrude far beyond the ends of the valves. The projections are sharp and chisel-like at their posterior edges and may be truncate or pointed medially; sometimes they are curved upwards. Their outer side is convex but the inner side is flat (i.e. in the sagittal plane).

ANATOMY: The ventral partition of the branchial septum is colourless or very light brown and translucent. Its edge is usually entire (lacking digitations) except for a single broad triangular medial flap (Fig. 14a) but may be serrate (Fig. 14b) or filamented (Fig. 14c). Inner and outer surfaces of the two siphons are brown, conspicuously blotched with thick white spots, sometimes almost colourless becoming brown toward the posterior margins.

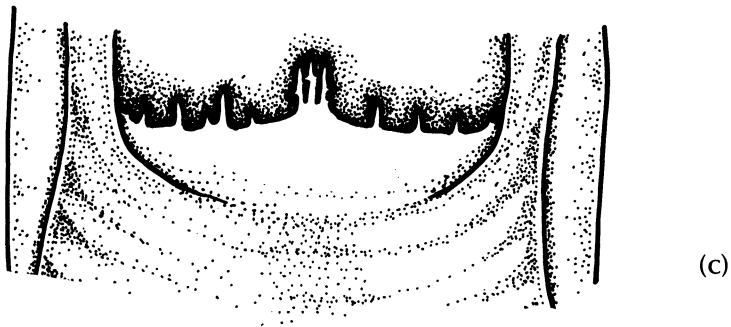
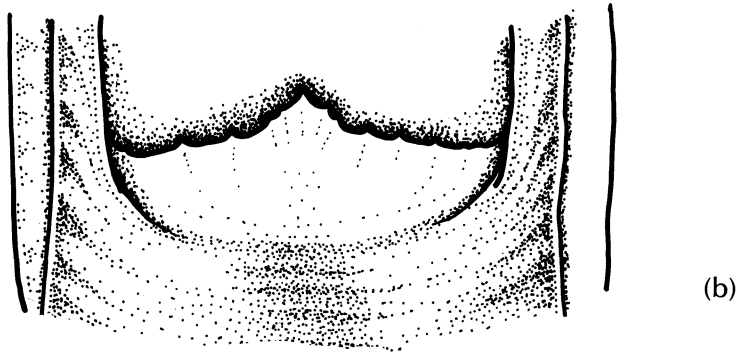
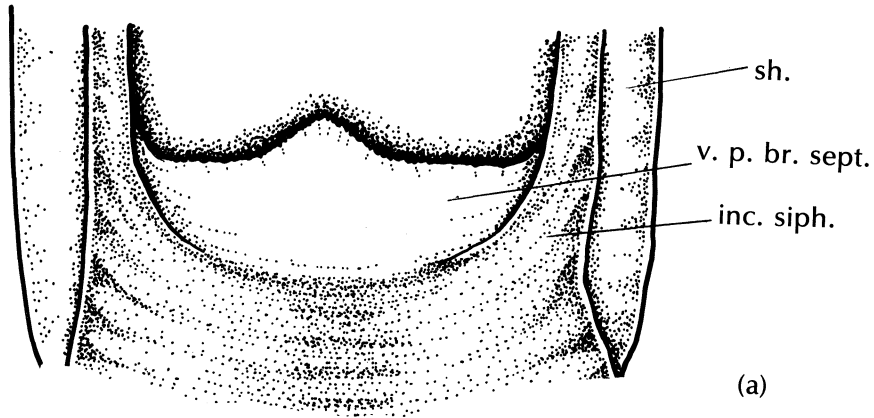


Fig. 14a, b, c *Lithophaga hanleyana* (WAM 221-77). Incurrent siphon opened out and seen from below, illustrating the ventral partition of the branchial septum.

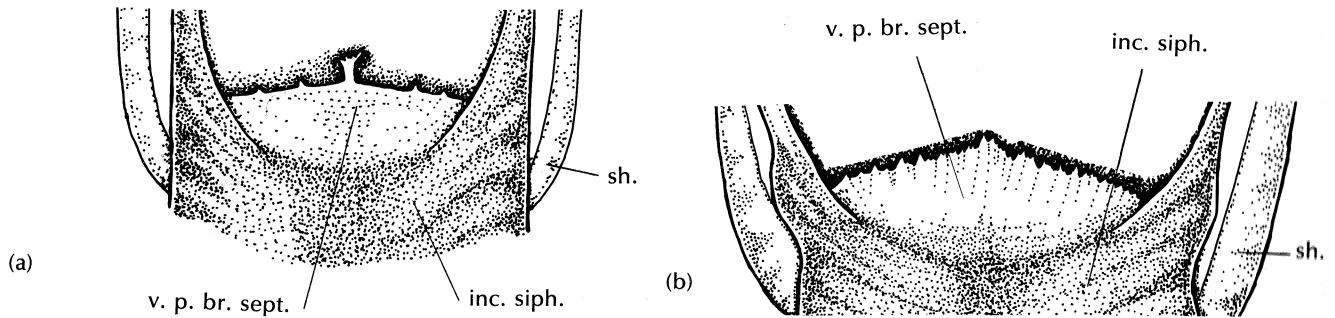


Fig. 15 *Lithophaga obesa*. Incurrent siphon opened out and seen from below, illustrating the ventral partition of the branchial septum.

15a Lizard I., Qld (WAM 148-77).

15b Dampier Arch., W.A. (WAM 151-77).

Digestive gland is light olive-green.

The first loop of the rectum reaches only as far as the posterior end of the pericardium.

Auricles are thin, transparent and lack pigmentation.

Plicate canals are lacking between the visceral mass and the gill axes. Instead there are axial series of deep supra-branchial pockets as in *L. lessepsiana*, with about 13 in each series, the largest being the posterior pair which have deep visceral diverticulae.

Genital and renal papillae are located on the walls of the most posterior supra-branchial pockets as in *L. lessepsiana*.

Gonad tubules fill the mantle lobes and some of the space between the posterior retractor muscles but, in the specimens examined, there is no mesosoma. Testis is white, ovary puce.

Kidneys as in *L. lessepsiana* but colourless.

Ctenidia as in *L. lessepsiana* but inter-lamellar septae are spaced 5 to 8 filaments apart and reach a height of only about a quarter of the gill height.

ANATOMICAL MATERIAL EXAMINED.

Queensland:

Heron I., WAM 221-77, in beach-rock, low intertidal zone.

Heron I., WAM 34-73, in dead coral boulder, outer reef rim.

Heron, I., WAM 210-77, in dead *Porites* on reef flat.

Philippines:

Polillo I., Quezon, WAM 208-77, in limestone rocks, low tide.

REMARKS: The thick, smooth and projecting posterior incrustations suggest that this species may be most closely allied to the several American species generally associated in the subgenus *Labis*.

I have compared Reeve's types of *L. hanleyana* with Iredale's types of *L. laevigata instigans* and believe them to be conspecific. The smooth posterior incrustations of the latter compare well with those still preserved on the types of *L. hanleyana* and are very different to the pitted and toothed structures so characteristic of *L. malaccana*.

Gohar & Soliman (1963a) record *L. hanleyana* from the Red Sea but I am doubtful about the identity of their material. Their photographic illustrations (Pl. 1, fig. 1 centre) are like the type and the specimens described here but their line drawings (Text-figs. 8, 9) and descriptions of the shell appear to represent another species, possibly *L. lima*. They report the species boring almost exclusively in living corals (*Cyphastrea*, *Montipora*, *Goniastrea*) which also suggests a misidentification.

•
***Lithophaga divaricalx* Iredale, 1939**

(Fig. 18 (1))

Lithophaga divaricalx Iredale, 1939: 420, pl. 6, fig. 23. Type locality: Low Isles, Qld. Holotype: AM regn. no. C60401.

DISTRIBUTION: This species appears to be uncommon. The type specimen is the only one of the species I have seen from Qld. In the WAM there are 2 additional samples which come from off Peak I., northern W.A. and Quezon, Philippines respectively, suggesting a central Indo-West Pacific distribution.

HABITAT: There is no information about the site of collection of the Low Isles type specimen. The two WAM samples were removed from dead coral rock. The W.A. sample was dredged from a depth of 20 metres; the Philippine sample was collected by a diver at a depth of 2 metres.

DESCRIPTION: SHELL: Smooth, moderately thin. Internal surface iridescent, purplish below the umbos, exterior whitish, covered by a smooth light yellow-brown periostracum. Umbos sub-terminal; anterior and posterior ends broadly rounded; ventral margin convex; dorsal margin (hinge-line) straight and rather long; postero-dorsal margin short and straight; dorsal angle steep and well defined. Ligament length greater than half the shell length. There is a broad radial sulcus from the umbo to the postero-ventral corner, and a well defined postero-dorsal wing.

The whole of the ventral area below the radial sulcus is covered with a thick, uniformly granular calcareous incrustation. On the postero-dorsal wing there is a thinner but also uniform calcareous layer arranged in concentric granulose cords which follow the growth striae of the shell. In a wide radial ray immediately dorsal to the radial sulcus is an area of very thick incrustation cast into raised chevron-shaped ridges which tend to become rough and irregular posteriorly; at the posterior end the incrustations project several mm beyond the ends of the valves.

Dimensions are given in Table 8.

ANATOMY: The two samples available (WAM 314-77, 84-63) are poorly preserved and colourless. I can determine only that the ventral partition of the branchial septum is ornamented by a digitate, rectangular, central lappet, and that there are supra-branchial pockets between the visceral mass along the whole length of the gill axes as in *L. lima*.

REMARKS. *L. divaricalx* appears to be closely related to *L. pessulatus* Reeve, 1857. The only specimen of the latter species known to me is the probable holotype in the collections of the British Museum (Nat. Hist.) (regn. no. 197593). Mrs Solene Whybrow has kindly sent illustrations (Fig. 18(2)) of the Reeve specimen and the following descriptive notes:

Table 8.

Dimensions of *L. divaricalx* shells (in mm)

	length	height	width	lig length	A°	B°
Holotype	40.6	22.5	14.9	22.6	39°	15°
Philippines (WAM 314-77)	27.7	11.4	09.9	15.4	40°	13°
Peak I, W.A. WAM 84-63)	37.5	16.1	14.0	22.1	35°	16°
Peak I, W.A. (WAM 84-63)	29.9	11.9	09.3	15.4	39°	14°

"Length 3.95cm; height at broadest point 1.16cm. Specimen articulated, ventrally separated. Anterior end of LV broken away. Shell strongly eroded at anterior end; where remaining, periostracum is chestnut brown. Calcareous outer covering is dirty white extending about 5mm (4.75mm) beyond posterior end of shell, is approximately 2 mm thick at shell margin and marked on the inside at its junction with the shell margin by small teeth like ridges.

Exteriorly the pattern of this calcareous covering is slightly abraded and appears only superficially similar to *L. divaricalx* Iredale (from your photo) in the posterior area. Ventrally it is distinguished by raised "ribs" of calcareous material approximately perpendicular to the hinge axis."

From these data I conclude that *L. pessulatus* Reeve is probably not conspecific with *L. divaricalx* Iredale but a larger series of shells, and observations on anatomy of both forms are needed.

There is little doubt that *L. divaricalx* is distinct among the Queensland lithophagids. The thick posterior incrustations are most like those of *L. malaccana* but in the small series available to me the chevron ridges are consistent and quite different to the granulose or wrinkled sculpture of the latter species.

The shape of the shell resembles that of *L. lima* but the more prominent postero-dorsal wing and steeper dorsal angle distinguish *L. divaricalx*. In *L. lima* the ligament length is less than half the total shell length while in *L. divaricalx* it is greater than half, and again the strong chevron sculpture of *L. divaricalx* is distinctive. The few data on the habitat of *L. divaricalx* indicate that it bores in dead coral whereas *L. lima* is most commonly found in living massive corals.

Lithophaga obesa (Philippi, 1847)

(Fig. 17 (1); text fig. 15).

Modiola (Lithophagus) obesa Philippi, Aug. 1847: 118. Type locality: China? Figured Philippi, Sept. 1847: pl. 2, fig. 2. Type: Not located. Neotype here nominated is the holotype of *L. obesa suspecta* Iredale, 1939.

Lithophaga obesa suspecta Iredale, 1939: 422, pl. 6, fig. 30. Type locality: Low Isles, Qld. Holotype: AM regn. no. C60407.

DISTRIBUTION: Widely distributed throughout the Indo-West Pacific. It occurs in northern W.A. (Dampier Archipelago) and down the east coast of Australia as far as Coffs Harbour, NSW. In AM and WAM collections *L. obesa* is represented from the following Qld. localities: Lizard I., Low Is., Dingo Beach, Lindeman I., Heron I.

HABITAT: *L. obesa* usually burrows in coral rock. Otter (1937) shows that it is most common in boulders on the reef front and reef slope at Low Isles but also occurs in intertidal boulders in the boulder tract zone and on the reef flat. At Heron I. and at Kendrew I., Dampier Archipelago, W.A. it has a similar ecological distribution. In these wave-beaten situations burrows of this mussel will be found on the sides and undersides of the boulders. In the first case the burrow is horizontal and in the latter case it is vertical with the opening facing downwards. At Lizard I. where there are no exposed reef flats I found *L. obesa* burrowing in the dead centre of a *Porites* bomby in the lagoon sublittoral (3 metres), and in this situation the burrow was vertical with the opening facing upwards. At Watson Bay a single specimen was extracted from among living polyps of a large massive coral head (probably *Cyphastrea*) at a depth of 3 metres.

The mouth of the burrow is very large (up to 6cm long), has the typical hour-glass shape, and a thick, hard calcareous lining.

DESCRIPTION: SHELL: Large, smooth, moderately thin. Exterior buff, with a uniform light yellow-brown periostracum; interior iridescent. Elongate-ovate, slightly attenuate anteriorly, tumid. Umbos large, sub-terminal or terminal; anterior end curved but sloping, posterior end rounded; ventral margin strongly convex; dorsal margin (hinge-line) straight; postero-dorsal margin slightly convex; dorsal angle not pronounced.

There is usually a weak radial sulcus from the umbo to the postero-ventral margin demarcating the antero-ventral and postero-dorsal areas, and sometimes another weaker one a little below the hinge-line. There is usually a thin, discontinuous, smooth chalky covering layer on the antero-ventral area; above the umbonal sulcus there is a thin, discontinuous, granulose, chalky layer which becomes thicker and more even posteriorly but does not extend beyond the ends of the valves.

Dimensions are given in Table 9.

Table 9.

	Dimensions of <i>L. obesa</i> shells (in mm)					
	length	height	width	lig length	A°	B°
Neotype	81.7	28.3	20.1	37.1	24°	17°
Heron I., Qld. (WAM 32-73)	29.6	13.2	10.0	13.9	29°	23°
Yeppon, Qld. (WAM 150-77)	69.1	26.3	22.1	33.2	28°	18°
Kendrew I., W. A. (WAM 151-77)	108.5	35.1	27.1	48.5	20°	18°
Kendrew I., W.A. (WAM 151-77)	86.9	30.9	23.1	39.2	22°	21°

ANATOMY: The siphons are very large in this species and tend to turn downward at the posterior end. They are dark brown inside and out, becoming even darker at the posterior margins.

The ventral partition of the branchial septum is thick; muscular and dark brown. Its edge is normally irregularly serrate along its whole length with the largest, rather compressed-triangular serrations at the centre (Fig. 15). Occasionally the edge may be entire except for a small branched digit centrally.

Digestive gland is light olive-green.

The first loop of the rectum reaches far back between the posterior retractors almost to the front edge of the posterior adductor.

Auricles are thick, opaque and dull orange.

Plicate canals are lacking between the visceral mass and the gill axes but axial series of deep supra-branchial pockets are present there. The largest of these is located below the antero-lateral corner of the pericardium and possesses a deep antero-dorsal extension into the visceral mass. Pockets occur both anterior and posterior to the large central ones as in *L. lima*.

Genital and renal apertures are located on small papillae in the large central supra-branchial pocket as in *L. lessepsiana*.

Gonads fill the mantle lobes and a small mesosoma and spread superficially over the visceral mass as in *L. lessepsiana*. The specimens examined were all male and the testis is white.

Kidneys as in *L. lessepsiana*.

Ctenidia are like *L. teres* and unlike *L. lessepsiana* in that the inter-lamellar connections are simple bars not septae.

ANATOMICAL MATERIAL EXAMINED.

Queensland:

Watson Bay, Lizard I., WAM 148-77, in live *Porites* in 3 metres.

Lagoon, Lizard I., WAM 149-77, in dead *Porites*, intertidal.

S. side Heron I., WAM 32-73, in dead coral slab, reef outer edge, intertidal.

Western Australia:

Kendrew I., Dampier Archipelago, WAM 151-77, in sides of limestone boulder, reef crest, intertidal.

DISCUSSION

The nine species of *Lithophaga* listed and described here from Queensland waters are shown to be widely distributed in the tropical Indian and Western Pacific Oceans and it seems likely that they comprise the majority of the lithophagine fauna of the region as a whole. One species, *L. teres*, has a very close relative, *L. nigra*, in the tropical Western Atlantic. Another species, *L. antillarum*, itself occurs in the tropical Western Atlantic as well as in the Indo-West Pacific.

In the central Indo-West Pacific Region (including northern Australia) on any shore rich in corals and calcareous rocks at least six species of *Lithophaga* will be common, though they exhibit some degree of habitat specialization.

DEPTH DISTRIBUTION

Intertidal. All species except *L. divaricalx* are recorded from the intertidal zone. *L. nasuta* and *L. malaccana* are found highest on the shore. Where there is an intertidal notch or rocks at the inner part of a coral or limestone reef these two species are usually found together high in the intertidal zone boring in the oyster mass or the rock itself if it is calcareous. *L. teres* may also occur there but not usually abundantly. *L. obesa* sometimes occurs boring in vertical or overhanging walls of the lower notch if there is exposure to strong wave action.

Where there is a beach with sloping or near horizontal beach rock in the upper intertidal zone *L. nasuta* is usually abundant but *L. teres* and *L. malaccana* are not found in that situation.

On the inner reef flat *L. teres* and *L. malaccana* are usually the abundant species boring in coral or other calcareous boulders. *L. hanleyana* may also occur there though perhaps more often in deeper pools or other sheltered situations.

On the outer reef flat where there is a boulder tract slightly higher than the main reef flat the boulders will be heavily bored by *L. teres*, *L. malaccana* and *L. nasuta*. On the sides and undersides of larger boulders *L. obesa* may also occur in this zone. The only ecological information I have for *L. antillarum* is based on a single specimen from a boulder in the intertidal boulder tract at Heron I.

The two species which bore in living corals, *L. lima* and *L. lessepsiana* may be common in appropriate corals at the lower inter-tidal levels of the reef front slope and in reef flat pools.

Sublittoral. All 9 species extend well down into the sublittoral except *L. nasuta* which is rarely found below a depth of a few metres.

In the sublittoral zone *L. malaccana* is usually the most abundant species boring in dead corals though *L. teres* is perhaps more widely distributed. Both these species extend well down the reef-front slope. I have collected *L. malaccana* in coral rocks at 35 m on a reef-front slope in the Solomons. I have taken *L. teres* from a dead coral boulder at a depth of 50m in the Solomons and from calcareous lithothamnion nodules dredged at 66 m off the W.A. coast.

L. hanleyana and *L. obesa* are also found boring in coral boulders and rock in the sublittoral but I have insufficient data to comment on their depth range. The only available data for *L. divaricalx* suggest that it too bores in coral rock in the sublittoral.

L. lima and *L. lessepsiana* are frequently common in suitable living corals on exposed reef front slopes and in lagoons to depths of at least 10 m which is the zone where their favoured colonial host corals begin to thin out. I have collected *L. lima* in *Favia* at a depth of 33m down a reef-front slope in the Solomons. Arnaud & Thomassin (1976) record *L. lessepsiana* burrowing in the basal parts of the free-living coral *Heteropsammia michelini* on soft substrates at 95m.

The ability of *L. lessepsiana* and *L. lima* to bore among living coral polyps is remarkable. It poses many questions about the settlement and post-settlement behaviour of the larval stages. A curious point is that although *L. lima* is occasionally found with its burrow mouth in the dead parts of a corallum this is apparently never the case with *L. lessepsiana*. It seems that the latter species is not just capable of living among the living polyps of its host but is obliged to do so. Arnaud & Thomassin (1976) proposed that the mussels are killed by the growth of calcareous algae after death of the coral host, but this is not the case with other species of *Lithophaga*.

Another curiosity is that both mussels are found only in certain kinds of coral. *Lithophaga lima* bores in a number of living massive corals but apparently not in any branching forms. *L. lessepsiana* lives in colonies of *Acropora palifera* but not in other species of that genus and in colonies of *Pocillopora eydouxi* but apparently not *P. damicornis* which is usually the more abundant species of *Pocillopora* present. It lives in some species of *Favia* and *Porites* but apparently not in other massive corals. It burrows in *Heteropsammia michelini* but apparently not in other species of that genus or related free-living genera. Arnaud and Thomassin (1976) propose that "boring into the coral is favoured by the structure of the coral branches: dense at the surface, but light within". The relationships of *L. lessepsiana* and *L. lima* to their coral hosts would make fascinating studies.

The anatomical data presented here indicate that major changes are necessary in the generic classification of lithophagines. Among the Indo-West Pacific series *L. teres* and *L. antillarum* stand well apart from the others. They have sculptured shells and lack superficial calcareous incrustations. Blocking the burrow mouth is apparently achieved by apposition of the thickened, lip-like ends of the shell itself while in some other species the posterior incrustations form a plug. There are also several major anatomical differences. In *L. teres* there are plicate canals between the visceral mass and the gill axes like those described in *Mytilus*. The single specimen of *L. antillarum* has no plicate canals but it has no supra-branchial cavities pockets either the genital and renal papillae are situated on the roof of the supra-branchial chamber as they are in *L. teres*. In the other Indo-West Pacific lithophagines, plicate canals are lacking and there is instead a series of deep pockets or cavities along the roof of the supra-branchial chambers in that position. The largest of these supra-branchial pockets are located immediately below the antero-lateral corners of the pericardium and the genital and renal apertures are located on contiguous papillae on their walls. In *L. teres* and *L. antillarum* there is a block of hard amorphous tissue in the roof of the dorsal cul-de-sac of the mantle cavity, i.e. in the mantle lobes posterior to the pericardium. Such a structure was not observed in the other Qld lithophagines.

Taken together these shell and anatomical characters suggest that *teres* and *antillarum* are not congeneric with *lessepsiana*, *malaccana*, *hanleyana*, *obesa*, *nasuta*, *lima* and *divaricalx*. If this is the case the generic name *Lithophaga* should be restricted to *L. lithophaga*, *L. nigra*, *L. teres* and *L. antillarum*. The other seven Qld species, presently assigned to various subgenera, deserve generic separation from *Lithophaga*. In my own opinion there is insufficient difference between these seven species to warrant even subgeneric distinction among them.

If these views should prevail then the oldest of the current subgeneric names, i.e. *Leiosolenus* Carpenter, 1856, should be elevated to generic status and the other pertinent subgeneric names, i.e. *Diberus*, *Myoforceps*, *Labis* and *Myapalmula*, should fall into synonymy. However, the type species of most of these subgenera are American and until their anatomy has been examined in comparison with the Qld series it would be unwise to take this action.

SUMMARY

The habitats and shell and anatomical morphology of 9 Queensland species of the rock-boring mytilid genus *Lithophaga* are described, and their nomenclature and geographical distribution are reviewed.

All 9 species are shown to be widely distributed. In Queensland and Central Indo-West Pacific localities at least 6 of these species will be found living together wherever there is abundant coral and calcareous rocks although they show some degree of

habitat preference. The majority of the species will burrow only in dead coral or calcareous rocks. *Lithophaga lima* and *L. lessepsiana* burrow in living corals but each is restricted to a limited variety of coral host species.

The morphological data indicate that the generic and subgeneric classification of these mytilids needs revision.

ACKNOWLEDGEMENTS

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KEY TO FIGURE CAPTIONS

a. add.	anterior adductor
a. art.	anterior artery
ac. gl.	"acid gland"
a. gen. d.	anterior genital duct
an.	anus
a. retr.	anterior retractor
au.	auricle
br. sept.	branchial septum
bys	byssus
ct.	ctenidium
cil. tr.	ciliated rejection tract
ct. asc. lam.	ascending lamella of right ctenidium (inner demibranch)
ct. desc. lam.	descending lamella of right ctenidium (inner demibranch)
ct. i. d.	inner demibranch of ctenidium
ct. o. d.	outer demibranch of ctenidium
dig. gl.	digestive gland
ex. siph.	excurrent siphon
f. per.	floor of pericardium
ft.	foot
g.	gonad
gill ax.	gill axis (left)
inc. siph.	incurrent siphon
inn. m. lobe fused	inner mantle lobe fused
int.	intestine
k.	kidney
lab. p.	labial palp
lig.	ligament
m. c. cul de sac	dorsal cul de sac of mantle cavity
mes.	mesosoma
p. gen. d.	posterior genital duct
pl. can.	plicate canals
o.m.l.	outer lobe of mantle
pap.	papillae
per.	pericardium
p. add.	posterior adductor
p. retr.	posterior retractor
rect.	rectum
ren. gen. pap.	renal and genital papillae
s. br. pock.	supra-branchial pockets
sh.	shell
siph. retr.	siphonal retractor
t. b.	transverse bars in roof of supra-branchial chamber visible in floor of pericardium
v.	ventricle
v. cup. br. sept.	ventral cup of branchial septum
v. p. br. sept.	ventral partition of branchial septum.

FOOTNOTE

Since this manuscript was initially submitted a study by Dr Karl Kleeman (Oct., 1977, *Veliger*, 20 (2): 151-154, figs 1-8) has been published in which a description of a new species, *L. kuehnelti*, is given. The host coral was *Acropora palifera* and the type locality is Heron I., Queensland.

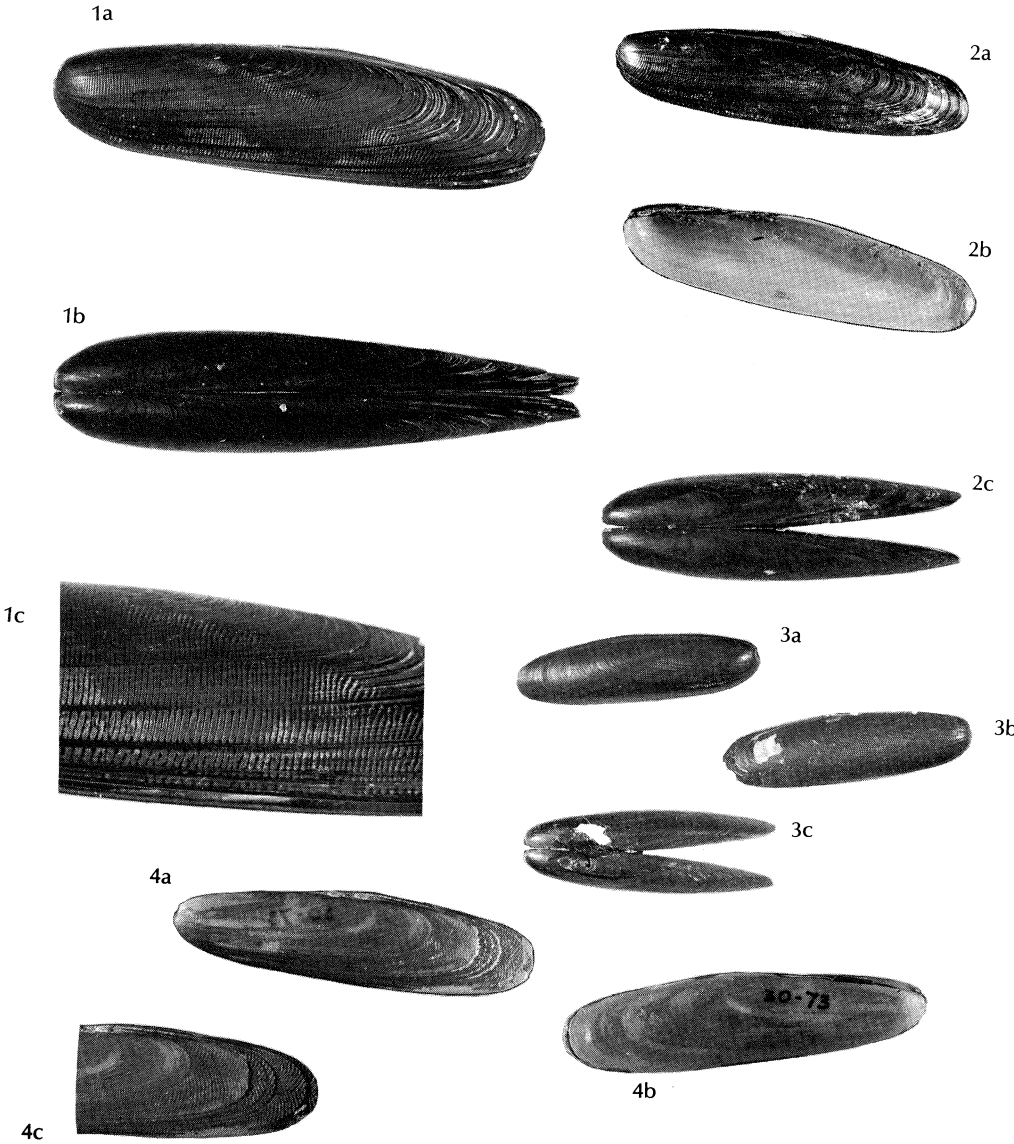
The diagnostic character of *L. kuehnelti* is said to be the presence of posterior incrustations on the shell. According to Kleeman this feature is lacking in *L. lessepsiana*, which he reports as occurring in the same host corals at Heron I. as his new species. Kleeman also regards *L. simplex* as a distinct species and gives a redescription of it claiming that *L. simplex* also lacks "real incrustation".

Since the appearance of this paper I have re-examined my own Queensland material which includes large series topotypic of both *L. simplex* and *L. kuehnelti*. I cannot confirm Kleeman's conclusions regarding the nature and significance of variation in the posterior incrustations of these mussels. In my manuscript I have noted that the nature of posterior incrustations in this group vary with the species of host coral. In my opinion this is a very poor character to use for species differentiation in *Lithophaga*. I can find no anatomical or colour differences which might support the opinion that more than one species exists.

Thus, what I have interpreted here as ecotypes, Kleeman regards as species. The question needs further study but on available evidence I propose to include *L. kuehnelti* with *L. simplex* in the synonymy of *L. lessepsiana*.

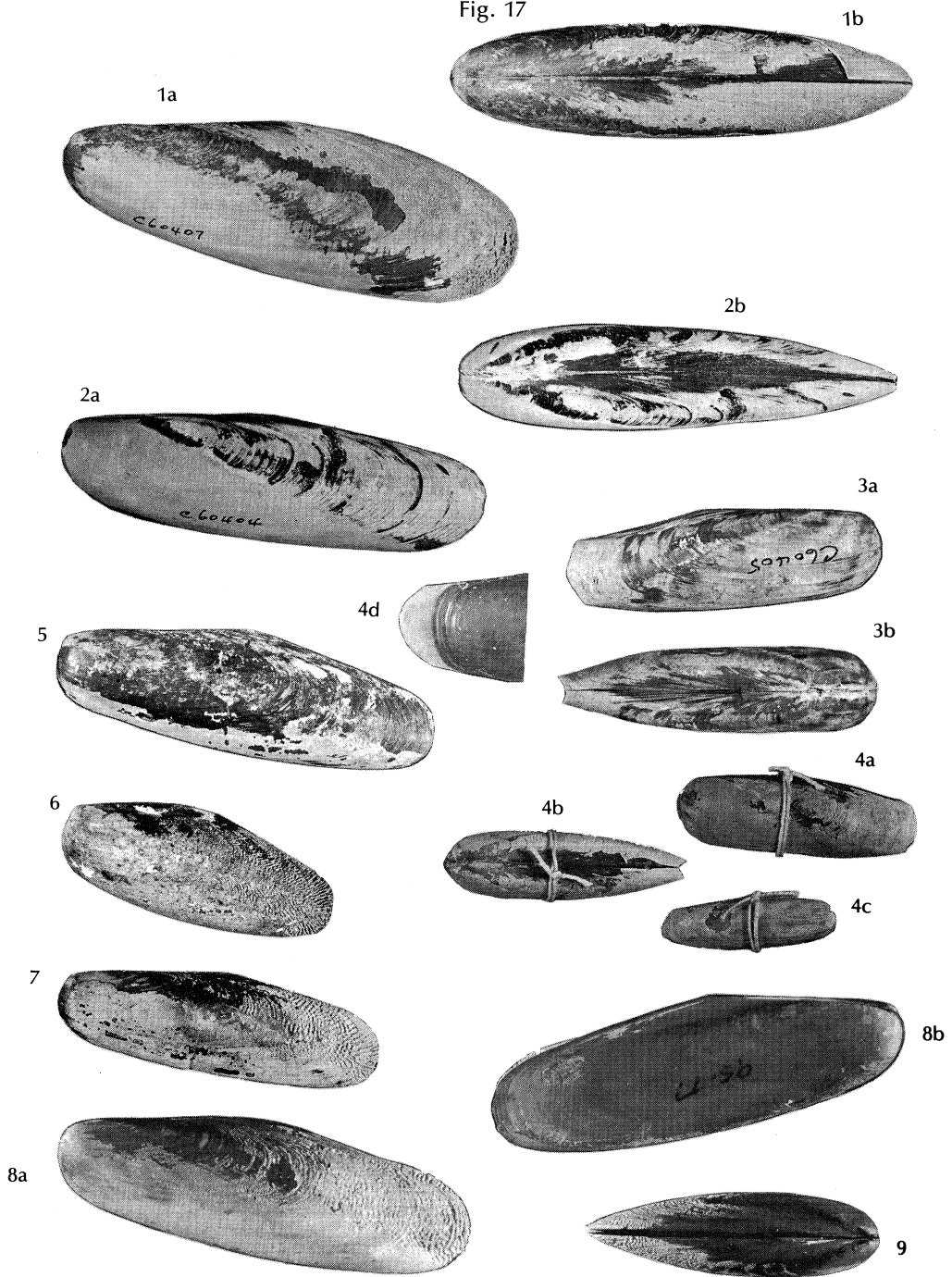
1. *Lithophaga teres* (Philippi) Low Isles, Qld. AM. regn. no. C63285.
HOLOTYPE of *L. t. annectans*, Iredale.
 - (a) Left valve (x1).
 - (b) Dorsal (x 1).
 - (c) Enlargement of a section of the ventral surface showing vertical cords aligned in growth series.
2. *Lithophaga teres* (Philippi). Aden, "Dr Jousseume, 1917". From M.N.H.N. collection, Paris. SYNTYPES of *L. erythraensis* Lamy.
 - (a) Left valve (x 0.75).
 - (b) Right valve, internal (x 0.75).
 - (c) Dorsal (x 0.75).
3. *Lithophaga teres* (Philippi). Djibouti, "Dr Jousseume, 1917". From M.N.H.N. collection, Paris. SYNTYPES of *L. erythraensis* Lamy.
 - (a) Right valve (x 0.75).
 - (b) Right valve second specimen (x 0.75).
 - (c) Dorsal (x 0.75).
4. *Lithophaga antillarum* (d'Orbigny). S.E. side Heron I., Qld. WAM regn. no. 30-73.
 - (a) Left valve (x 1).
 - (b) Left valve, internal (x 1).
 - (c) Enlargement of posterior end showing chevron-like sculpture.

Fig. 16



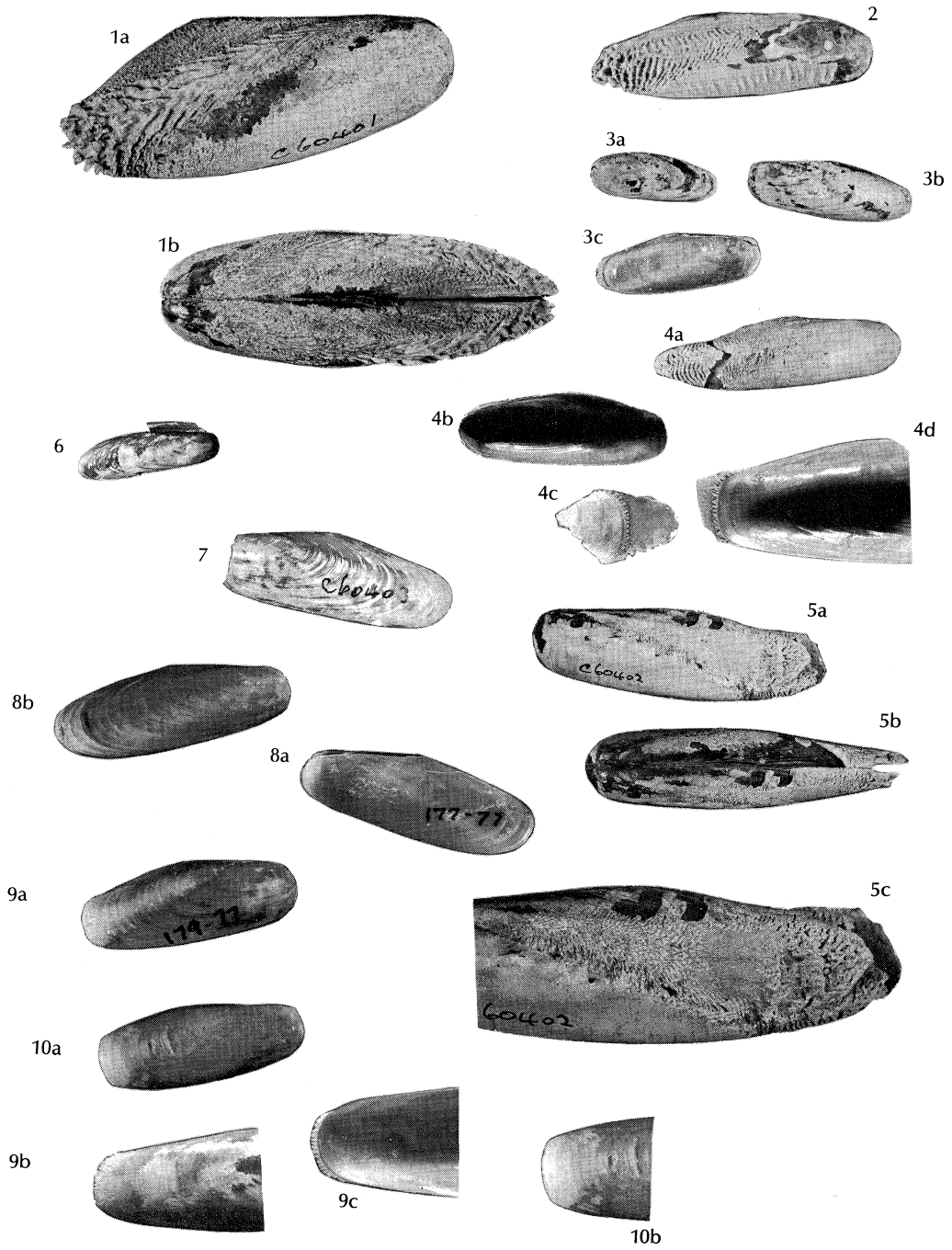
1. *Lithophaga obesa* (Philippi). Low Isles, Qld. AM. regn. no. C60407.
HOLOTYPE of *L. obesa suspecta* Iredale.
 - (a) Left valve (x 0.75).
 - (b) Dorsal (x 0.75).
2. *Lithophaga nasuta* (Philippi). Low Isles, Qld. AM. regn. no. C60404.
HOLOTYPE of *L. dichroa* Iredale.
 - (a) Right valve (x 1).
 - (b) Dorsal (x 1).
3. *Lithophaga hanleyana* (Reeve). Low Isles, Qld. AM. regn. no. C60405.
HOLOTYPE of *L. laevigata instigans* Iredale.
 - (a) Right valve (x 1).
 - (b) Dorsal (x 1).
4. *Lithophaga hanleyana* (Reeve). Suez. B.M. (N.H.). collection. SYNTYPES.
 - (a) & (b). Largest unbroken syntype (x 1).
 - (c) Smallest syntype (x 1).
 - (d) Enlargement of posterior end, third (broken) syntype, showing chisel-like extension of incrustation.
5. *Lithophaga lima* (Lamy). Djibouti. From M.N.H.N. collection, Paris. SYNTYPE.
Left valve (x 0.75).
6. *Lithophaga lima* (Lamy). Aden. "Dr Jousseume, 1917". From M.N.H.N. collection, Paris. SYNTYPE.
Left valve (x 1).
7. *Lithophaga lima* (Lamy). Aden "Dr Jousseume, 1917". From M.N.H.N. collection, Paris. SYNTYPE.
Left valve (x 1).
8. *Lithophaga Lima* (Lamy). North Point, Lizard Island, Qld. WAM. regn. no. 95-77.
 - (a) Left valve (x 1).
 - (b) Left valve interior (x 1).
9. *Lithophaga lima* (Lamy). Rocky Point, Lizard Island, Qld. WAM. regn. no. 96-77.
Dorsal (x 1).

Fig. 17



1. *Lithophaga divaricalx* Iredale. Low Isles, Qld. AM. regn. no. C60401. HOLOTYPE.
 - (a) Right valve (x 1.25).
 - (b) Dorsal (x 1.25).
2. *Lithophaga pessulatus* (Reeve). Probable HOLOTYPE. B.M.(N.H.) regn. no. 197593.
3. *Lithodomus laevigatus* Quoy & Gaimard. Port Dorey, New Guinea. From M.N.H.N. collection, Paris. 2 SYNTYPES.
 - (a) Syntype 1, left valve (x 1).
 - (b) Syntype 2, left valve (x 1).
 - (c) Syntype 2, left valve interior (x 1).
4. *Lithophaga malacanna* (Reeve). Malacca. B.M.(N.H.) regn. no. 1975104. SYNTYPE
 - (a) Syntype, right valve (x 1.25).
 - (b) Syntype, right valve, interior with posterior incrustation removed.
 - (c) Syntype, right valve, tip of posterior incrustation detached from the shell and seen from inner side (x 2).
 - (d) Syntype, left valve, interior. Enlargement of posterior end showing incrustations intact. (x 2).
5. *Lithophaga malacanna* (Reeve). Low Isles, Qld. AM. regn. no. C60402. HOLOTYPE of *L. calcifer* Iredale.
 - (a) Left valve (x 1).
 - (b) Dorsal (x 1).
 - (c) Left valve enlarged to show details of incrustations (x 2).
6. *Lithophaga lessepsiana* (Vaillant). Suez. From M.N.H.N. collection, Paris. 1 of 2 broken SYNTYPES.
Right valve (x 1).
7. *Lithophaga lessepsiana* (Vaillant). Low Isles, Qld. AM. regn. no. C60403. HOLOTYPE of *L. simplex* Iredale.
Left valve (broken) (x 1.25).
8. *Lithophaga lessepsiana* (Vaillant). Watson Bay, Lizard Island, Qld. WAM. regn. no. 177-77. From living *Favia* colony.
 - (a) Right valve (x 1.25).
 - (b) Right valve interior (x 1.25).
9. *Lithophaga lessepsiana* (Vaillant). Rocky Point, Lizard Island, Qld. WAM. regn. no. 179-77. From living *Porites* colony.
 - (a) Right valve (x 1.25).
 - (b) Right valve, posterior end exterior enlarged to show sculptured terminal incrustations.
 - (c) Right valve, posterior end interior enlarged to show dentate edge of terminal incrustations.
10. *Lithophaga lessepsiana* (Vaillant). Lagoon Heron Island, Qld. WAM. regn. no. 33-70. From living *Acropora palifera* colony.
 - (a) Right valve (x 1.25).
 - (b) Right valve, posterior end exterior enlarged to show smooth terminal incrustations.

Fig. 18



THE LIZARD ISLAND MALACOLOGICAL WORKSHOP

A Molluscan Workshop, with nine malacologists participating, was held on Lizard Island, Queensland during 1 to 12 of December, 1975.

The aim of the Workshop was to get together a small number of malacologists at the Lizard Island Research Station on the Great Barrier Reef. Each scientist undertook one or two projects, the results of which are to be published in a collected series of papers. This issue of the 'Records' contains the first of these papers.

The scientists in attendance were:

Dr J. B. Burch (then of The Australian Museum, now at the University of Michigan);

Mr R. Burn (Research Associate of the Australian Museum and Associate of the National Museum of Victoria);

Dr B. Morton (University of Hong Kong);

Dr W. F. Ponder (The Australian Museum);

Dr C. F. E. Roper (Museum of Natural History, Washington, D.C.);

Mrs S. M. Slack-Smith (Western Australian Museum);

Dr J. B. Smith (National Museum of Victoria);

Dr B. R. Wilson (Western Australian Museum);

Sir C. M. Yonge (University of Edinburgh);

The projects included a survey of the non-marine Mollusca (Burch and Smith), studies on opisthobranchs (Burn), bivalve functional morphology (Wilson, Slack-Smith, Morton and Yonge), cephalopods (Roper) and gastropod reproductive morphology (Ponder).

Lizard Island (Figure 1) is a continental island in the northern end of Australia's Great Barrier Reef (lat. 14°40'S, long. 145°28' E). It is predominantly composed of granite, is about 2 square miles in area and at its highest point is about 360 m. It lies 30 km off the coast and is 17 km from the outer barrier reefs.

The Research Station on Lizard Island is operated by the Australian Museum. The participants of the Workshop acknowledge the support given them by the then Director, Mr S. Domm.

Mr P. H. Colman, Mr I. Loch, Ms B. Duckworth, Mr E. K. Yoo and Mrs M. Burch are also gratefully acknowledged for their able assistance with running and organizing the workshop.

One paper resulting from the workshop has been published elsewhere:

Morton, B., 1978. The diurnal rhythm and the processes of feeding and digestion in *Tridacna crocea* (Bivalvia: Tridacnidae). *J. Zool., Lond.*, 185: 371-387.

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