

## OYSTERS (BIVALVIA: OSTREIDAE AND GRYPHAEIDAE) RECORDED FROM MALAYSIA AND SINGAPORE

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**ABSTRACT.** – Oysters recorded from Malaysia and Singapore are revised herein, based on six collected species with description of shell characters and other records from the literature. The collected oysters are *Saccostrea cucullata* (Born, 1778), *Saccostrea mordax* (Gould, 1850), *Crassostrea gigas* (Thünberg, 1793), *Planostrea pestigris* (Hanley, 1846), *Dendostrea folium* (Linnaeus, 1758) and *Hyotissa imbricata* (Lamarck, 1819). Of these, *Saccostrea mordax*, *Dendostrea folium* and *Hyotissa imbricata* are new records. Including other species recorded in the literature, i.e., *Alectryonella plicatula*, *Ostrea denselamellosa*, *Hyotissa hyotis* and *Parahyotissa numisma*, there are now 10 species of oysters recorded from Malaysia and Singapore. An identification key based on shell characters is included.

**KEY WORDS.** – Oyster, Ostreidae, Gryphaeidae.

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### INTRODUCTION

Oysters appear to have a low species diversity in Malaysia and Singapore. Morris & Purchon (1981), for example, recorded only five species of Ostreidae and two species of Gryphaeidae from the area. Species identified were *Alectryonella plicatula* (Gmelin, 1791), *?Ostrea denselamellosa* Lischke, 1869, *Ostrea palmipes* Sowerby, 1871, *Saccostrea cucullata* (Born, 1778), *Saccostrea echinata* (Quoy & Gaimard, 1835), *Hyotissa hyotis* (Linnaeus, 1758) and *Hyotissa numisma* (Lamarck, 1819) (now *Parahyotissa (Numismoida) numisma* [Lamprell & Healy, 1998, fig. 324]). A recent expedition to the Anambas and Natuna Islands, located between the West Malaysian Peninsula and Borneo, identified no oysters (Tan & Kastoro, 2004). *Saccostrea cucullata* has been identified from Malaysian rocky shores and West Malaysian mangroves by Berry (1964, 1972) and Sasekumar (1974) as either *Crassostrea cucullata* or *Ostrea cucullata*. *Crassostrea cucullata* and an unidentified *Ostrea* sp. occur on rocky intertidal surfaces in Singapore (Purchon & Enoch, 1954). All the rock oysters from Singapore were, however, later genetically identified as *S. cucullata* (Lam & Morton, 2006). Since *S. cucullata* and *S. echinata* have also been genetically identified as synonymous (Lam & Morton, 2006), the list of native oysters hitherto recorded

from Malaysia and Singapore, comprises but six species. The literature (e.g., Mathias & Charles, 1978; Zulfigar & Tan, 1998), also identifies '*Crassostrea gigas*' as being introduced into Malaysia for mariculture purposes. Tan & Chou (2000) also identify *C. gigas* from Singapore.

A recent collection of oysters from Pulau Langkawi on the west coast of Malaysian Peninsula, identifies five species of native oysters that include three new records for the area. A mariculture species, *Crassostrea gigas*, was collected from Johor Strait, Malaysia. The specimen was grown from spat flown in from hatcheries in Australia. In this paper, a checklist of Malaysian and Singaporean oysters is given and descriptions provided for native species including the new records.

### MATERIAL AND METHODS

**Sample collection.** – Oysters were collected from intertidal habitats, such as mangroves, rocky shores and sandy beaches in Pulau Langkawi, West Malaysia. Those from subtidal waters were obtained by trawling. The samples were identified using the following shell characters: (1), general size; (2), shape and surface sculpture; (3), hinge structure and ligament position and extent; (4), attachment

area of the left valve; (5), presence and pattern of chomata; (6), position, colour and relative size of the adductor muscle scar and (7), external and internal shell colour. Details of habitat and biogeography were based mainly on the authors' observations, complemented by published information.

**Abbreviations used in the text.** – NHM, The Natural History Museum, London, United Kingdom; MNHN, Musèum National d'Histoire Naturelle, Paris, France; USNM, National Museum of Natural History [formerly United States National Museum], Smithsonian Institution, Washington D. C., United States. RV, right valve; LV, left valve.

## RESULTS

### Systematic list of Pulau Langkawi oysters collected in this study

All the figured specimens have been deposited in the NHM under accession numbers 20090286–20090293.

Suborder Ostreina Férussac, 1822

Superfamily Ostreioidea Rafinesque, 1815

Family Ostreidae Rafinesque, 1815

Subfamily Crassostreinae Torigoe, 1981

Genus *Saccostrea* Dollfus and Dautzenberg, 1920

*Saccostrea cucullata* (Born, 1778)

*Saccostrea mordax* (Gould, 1850)

Genus *Crassostrea* Sacco, 1897

*Crassostrea gigas* (Thünberg, 1793)

Genus *Planostrea* Harry, 1985

*Planostrea pestigris* (Hanley, 1846)

Genus *Dendostrea* Swainson, 1835

*Dendostrea folium* (Linnaeus, 1758)

Family Gryphaeidae Vyalov, 1936

Subfamily Pycnodonteinae Stenzel, 1959

Genus *Hyothissa* Stenzel, 1971

*Hyothissa imbricata* (Lamarck, 1819)

## TAXONOMY

A comparison of shell characters of the six species of Malaysian oysters treated herein is given in Table 1.

### Ostreidae Rafinesque, 1815

#### Crassostreinae Torigoe, 1981

#### *Saccostrea* Dollfus & Dautzenberg, 1920

##### *Saccostrea cucullata* (Born, 1778)

Common name: Rock oyster (Spiny oyster for the 'echinata' morphotype) (Fig. 1)

*Ostrea cucullata* Born, 1778: 100.

*Ostrea cucullata* – Born, 1780: 114, Pl. 6, Figs. 11, 12; Awati & Rai, 1931: 1–107.

*Ostrea echinata* Quoy & Gaimard, 1835: 455, Pl. 76, Figs. 13, 14.

*Ostrea commercialis* Iredale & Roughley, 1933: 278.

*Saccostrea cucullata* – Stenzel, 1971: N1134–N1135, Fig. J106.

*Saccostrea cucullata* – Morris, 1985: 125–128, Pl. 3, Fig. E, F, G; Lam, 2003: 110–112, Pls. 11–12.

**Material examined.** – Born's type is in Naturhistorisches Museum, Vienna (Morris, 1985): data unknown.

Specimens in this collection (all preserved in alcohol) - [NHM] 20090286, "On big mangrove trees, Tanjong Rhu mangrove, Pulau Langkawi, Malaysia" (9) and "On mangrove rocks" (two clusters) coll. B. Morton, 3 & 5 Feb.2004. [NHM] 20090287, Pelangi Beach rocks, low intertidal, Pulau Langkawi, Malaysia, coll. B. Morton, 3 & 5 Feb.2004 (33). [NHM] 20090288, intertidal, Pelangi Beach groyne, Pulau Langkawi, Malaysia, coll. B. Morton, 3 & 5 Feb.2004. [NHM] 20030507, Tanah Merah, Singapore, coll. B. Morton, 9 Jul.2001 (2). [NHM] 20030508, Kallang River, Singapore, coll. B. Morton, 9 Jul.2001 (2).

**Description.** – Shell size small to medium, up to ~ 70 mm in length and ~ 75 mm in height, ~5–20 mm in width, with an oval to subtriangular outline, depending upon substratum and available space. Hinge line straight, short, with the ligament occupying its total length. Ligamental area short. External surfaces of both left and right valves white, lilac to purple with dark purple coloration at the shell margin.

Three main growth forms or ecotypes in terms of external shell characters were recorded.

The first ecotype occurs on mangrove trees and attaches to intertidal tree trunks as solitary individuals. Sizes are large, up to ~70 mm in length, 75 mm in height and 7 mm in width. Attachment area of left valve almost complete with slightly raised shell margin. Flat left valves usually slightly larger than right valve, shallowly cupped and with slightly raised margins and dense growth squamae. Commissural shelf not obvious. Surface of the right valve in large specimens eroded probably by acidic freshwaters, revealing the alternate white calcareous and brown conchiolin layers of the shell. In smaller specimens, commarginal layers of purple, weak, flaky growth squamae cover the right valves. Ribs not raised but weak crenulations along the ventral shell margin identify the number of ribs present.

The second ecotype occurs on low intertidal beach rocks as solitary individuals. Sizes are medium, up to ~45 mm in length, 50 mm in height and 8 mm in width. Flat left valve attached completely to the substratum without raised margin. Commissural shelf not obvious. Flat left valves slightly smaller than right valve, which are slightly convex, covered with commarginal layers of dense, flaky lamellar scales radiating from the ligament. Scales usually eroded along the ligamental side, where commarginal growth squamae are revealed. These end as black or purple conchiolin scales along the ventral shell margin. White or purple radiating stripes occur on the convex right valves of some specimens. Shell margin usually not crenulate or if it

Table 1. Comparison of shell characters of the six species of oysters herein recorded from Pulau Langkawi, West Malaysia.

Taxa	Chomata	Shape	Sculpture	Maximum Size <sup>1</sup>
<i>Saccostrea cucullata</i>	Present	Oval to subtriangular	Right valve covered with growth squamae with hyote spines	70 × 75 × 7
<i>Saccostrea mordax</i>	Present	Triangular or elongate D-shape	Parallel grooves run from hinge to ventral margin	47 × 30 × 6
<i>Crassostrea gigas</i>	Absent	Spatulate to oval	Both valves have radial ribs and right valve covered with calcareous growth squamae	30 × 25 × 15
<i>Planostrea pestigris</i>	Present	Oval	Flat and smooth	50 × 40 × 4
<i>Dendostrea folium</i>	Inconspicuous	Orbicular to oval	Smooth, covered by dichotomous ribs	55 × 30 × 10
<i>Hyotissa imbricata</i>	Present	Circular	Dichotomous ribs, growth squamae and occasional hyote spines on both valves	45 × 50 × 15

<sup>1</sup> Maximum size is listed here as height (mm) × length (mm) × width (mm)

is, only weakly crenulate reflecting the number and position of the slightly raised radial ribs. Marginal plications weak, usually irregularly-spaced and shallowly-rounded.

The third ecotype occurs in clusters on intertidal rocks on beaches or small hard substrata, such as dead mollusc or barnacle shells. Sizes are small, up to ~30 mm in length, 40 mm in height and 12 mm in width. Attachment area of the left valve usually ~ half the shell length. Left valve margin raised and thus deeply cupped. Commissural shelf not obvious. Surface of the left valve with up to about 15 ribs. Commarginal layers of weak, flaky growth squamae occur on the left valve margin that is raised above the substratum. Fine crenulations along the ventral shell margin identify the number of ribs present, forming a flaky shell margin patterned black, purple and white. Flat to slightly convex right valve covered with commarginal layers of dense, flaky lamellar scales radiating from the ligament. These scales are usually eroded along the ligamental side, where alternate white calcareous and brown conchiolin layers are revealed. They end as black conchiolin scales along the ventral shell margin. Shell margin crenulate reflecting the number and position of the radial ribs. Marginal plications small, usually regularly-spaced and sharply-rounded.

Interiors of both valves of all ecotypes usually either iridescent bluish green or opalescent white with patches of bluish green, or olive to yellowish green. Adductor scar large, D-shaped, and may have purple or yellow growth bands paralleling the width of the shell. Scars on the left and right valves of the same specimen of same shape, size, and colour, positioned in the posterior ventral third of the shell interior. Chomata and gutters may be present in young individuals. These are well developed from the hinge region to the adductor muscle, but fade beyond.

**Distribution and habitat.** – Subtropical and tropical Indo-West Pacific, from southern Japan to Australia, as verified by mitochondrial DNA markers (Lam and Morton, 2006). This oyster dominates the eulittoral zone of sheltered rocky shores.

**Remarks.** – The *Saccostrea cucullata* collected from Pulau Langkawi illustrate the effect of substratum on the growth form, resulting in various ecotypes. For example, those growing on mangrove tree stems are laterally compressed, with the left valve possessing a great attachment surface and a raised left shell margin. Individuals occurring on low intertidal beach rocks have a similar growth form as the former except the right valve is convex and the whole of the left valve is attached to the substratum, without a raised margin. This prevents the animal from being dislodged by wave action. *S. cucullata* also occurs on intertidal rocky substrata. Individuals from this zone cluster together, compete for attachment area and are of small size (~10 mm to 20 mm). The shell margins are plicate and left shell valves have a raised margin and small attachment area.

#### *Saccostrea mordax* (Gould, 1850)

Common name: Crenulate rock oyster (Fig. 2)

- Ostrea cucullata* Lamarck, 1819: 200 [non Born, 1778]  
*Ostrea mordax* Gould, 1850: 346; Sowerby, 1871, Pl. 15, Fig. 31a, b.  
*Ostrea forskali* var. *mordax* Lamy, 1929: 159.  
*Ostrea amasa* Iredale, 1939: 399, Pl. 17, Fig. 8.  
*Crassostrea amasa* Thomson, 1954: 154, Pl. 7, Figs. 1, 2.  
*Crassostrea tuberculata* Thomson, 1954: 157, Pl. 8, Fig. 3.  
*Saccostrea mordax* – Torigoe, 1981: 328, Pl. 17.  
*Saccostrea mordax* – Qi & Choe, 2000: 138–139, Fig. 3C–E; Lam, 2003: 112–113, Pl. 13.  
*Saccostrea cucullata* – Morris, 1985: 125–128, Pl. 3, Fig. A, B, C, D.

**Material examined.** – Syntypes: [USNM] 5958, ‘‘Feejee Islands’’ (Fiji), coll. United States Exploring Expedition, no date, 3 dry shells.

Voucher: [NHM] 20090289, Pelangi Beach rocks, low intertidal, Pulau Langkawi, Malaysia, coll. B. Morton, 4 Feb. 2004, two individuals preserved in alcohol.

**Description.** – Shell medium, up to 47 mm in height, 30 mm in length and 6 mm in width. Outline either triangular or an elongate D-shaped depending upon the substratum.

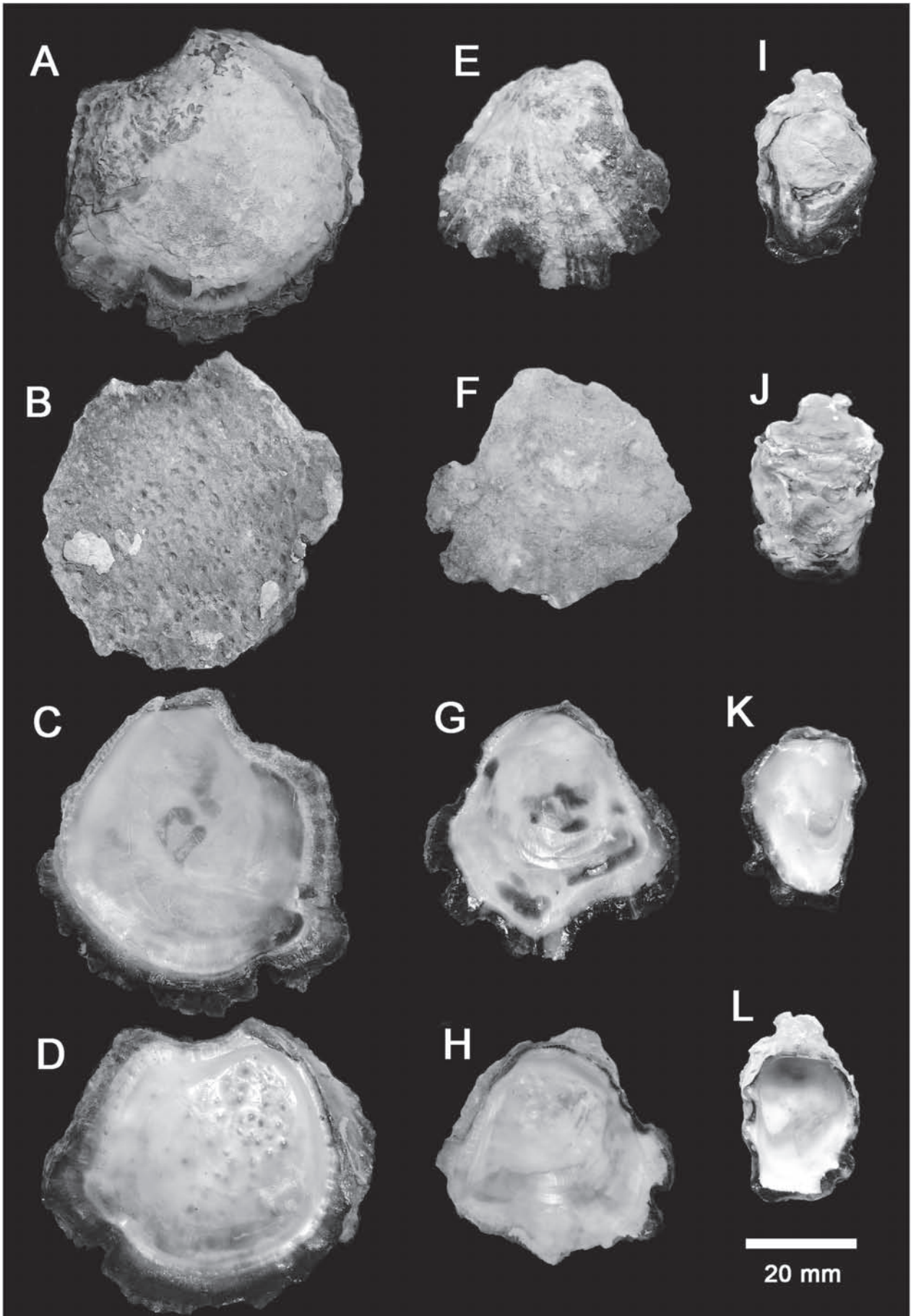


Fig. 1. *Saccostrea cucullata* (Born, 1778) from Pulau Langkawi, Malaysia, showing external and internal views of the right and left shell valves. A–D, ecotype occurring on mangrove trees (NHM20090286), E–H, ecotype occurring on low intertidal beach rocks (NHM20090287), I–L, ecotype occurring on intertidal rocks (NHM20090288).

Left valve flat and attached completely. The dorsal margin very thin and easily broken when collected. Margin of left valve built up steeply along the anterior and posterior sides. Margins thick, with packed layers of growth squamae running along the margin. Closely and evenly spaced ribs perpendicular to these end as marginal crenulations. In most cases, where the oyster grows on unlimited flat rock surfaces, the anterior margin is reduced so that the right valve is in touch with the substratum. When viewed along the mouth-anus axis, the shape of the oyster is almost a right-angled triangle with height given by the height of the posterior margin and base given by the left valve. Hinge line straight and short. Ligament area elongated to form an obvious left beak.

Right valve convex, thicker than the left valve and white with purple patches on the less eroded ventral area. Shell usually eroded with exposed conchiolin scales near the dorsal end. Parallel grooves extend from half way along the dorso-ventral axis to the ventral shell margin. These grooves reveal uneroded growth lines on the right valve. Evenly-spaced crenulations around the shell margin are more obvious anteriorly and posteriorly.

Interior of the shell white with a shiny, pearly appearance. A band of dark green conchiolin usually occur near the ventral margin of the right valve. This band may be absent in some specimens. It appears that the conchiolin and prismatic calcite layers are deposited alternately at the right, inner, ventral shell surface. Adductor muscle scar relatively large and positioned in the posterior ventral half of the pallial area, circular to elongate-oval according to the growth form of the shell and mostly white, slightly stained with growth bands or purple. Chomata white, short, rod-shaped and arranged in a single line around the inner margin. They are more prominent dorsally and fade as they extend towards the ventral shell margin.

**Distribution and habitat.** – *Saccostrea mordax* occurs only on oceanic, exposed rocky shores as individuals among the *Septifer* and *Tetraclita* zone on slopes or in pools frequently refreshed by strong waves (Lam & Morton, 2004). This species is widely distributed in the Indo-West Pacific, for example, Japan, Korea, Taiwan, Hong Kong, South China Sea, peninsular Malaysia, Singapore, Indonesia, New Hebrides [now Vanuatu] and Australia (Lam & Morton, 2006).

**Remarks.** – *Saccostrea mordax* has been identified previously as *S. amasa* and *S. tuberculata* (Thompson, 1954). This species is often confused with *S. cucullata* because of similar shell characters. Lam & Morton (2006) suggest that *S. mordax* occurs only on exposed, wholly marine rocky shores whereas the other *Saccostrea* lineages occupy a wide range of habitats from brackish mangroves to somewhat less exposed marine shores. Un-eroded *Saccostrea mordax* individuals are distinct from other species of *Saccostrea* in terms of the regularly-spaced grooves radiating from the umbone to the ventral margin of the right valve, its triangular shell shape and finely, regularly, m-shaped plicated valve margin.

#### *Crassostrea* Sacco, 1897

##### *Crassostrea gigas* (Thünberg 1793)

Common name: Giant Pacific oyster (Fig. 3)

*Ostrea gigas* Thünberg 1793: 140–142, Pl. 6, Figs. 1–3.

*Ostrea gigas* – Lischke 1869: 174.

*Ostrea laperousii* Schrenck 1861: 92–93, Fig. 6.

*Ostrea laperousii* – Schrenck 1867: 475–482, Pl. 19, Figs. 1–6.

*Ostrea (Crassostrea) gigas* – Hirase 1930: 45–49, Figs. 61–63.

*Ostrea (Crassostrea) laperousei* – Hirase 1930: 49–55.

*Crassostrea gigas* – Torigoe 1981: 304–305, 325, Pl. 2, Fig. 1, Pl. 14.

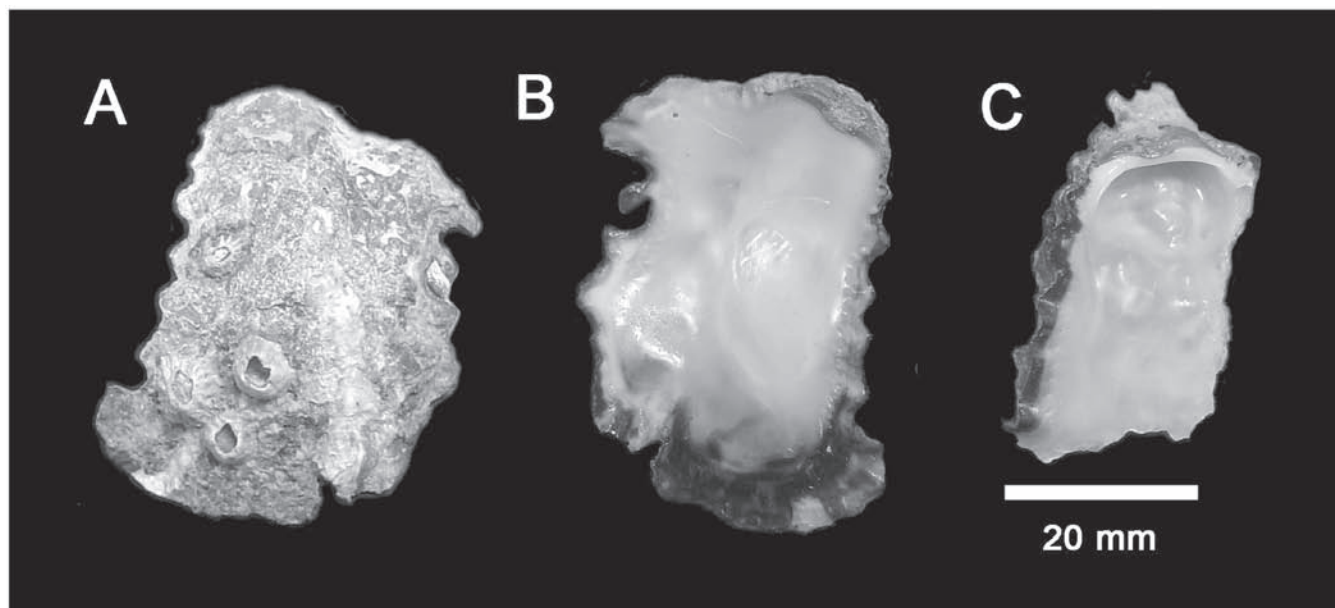


Fig. 2. *Saccostrea mordax* (Gould, 1850) from Pulau Langkawi, Malaysia (NHM20090289). A, external view of the right shell valve, B, internal view of the right shell valve and C, internal view of the left shell valve.

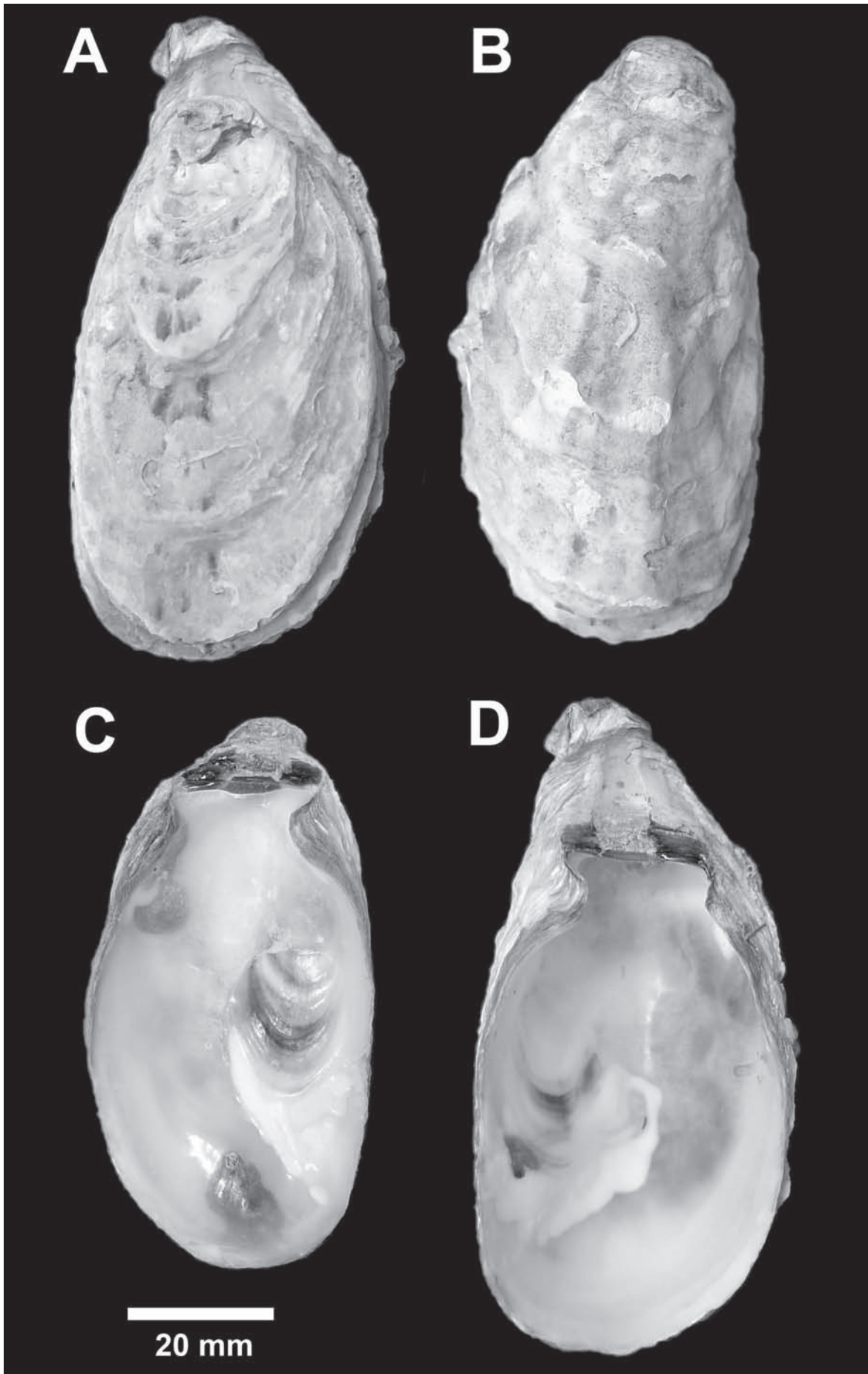


Fig. 3. *Crassostrea gigas* (Thünberg, 1793) from Johor Strait, Malaysia (NHM20090290). A, external view of the right shell valve, B, external view of the left shell valve. C, internal view of the right shell valve D, internal view of the left shell valve.

**Material examined.** – Type not studied. The type material is probably in the University Museum, Uppsala, Sweden.

Voucher: [NHM]20090290, Johor Strait, Malaysia, coll. K. S. Tan, Nov.2004, dry shells of three individuals.

**Description.** – Shell height up to ~60 mm, outline variable with usually spatulate to oval individuals. Attachment area of left valve depending on substratum type. Both valves concave with left valve more deeply cupped and hence with a deep umbonal cavity. Both valves with dichotomous radial ribs from the umbo; the tops of the ribs well-rounded, and radial ribs with growth squamae recognisable on both valves. Older part of the right valve, i.e., the dorsal surface, usually eroded. Wavy plications along the shell margins reflect the positions and height of the ribs. No chomata. Adductor muscle scar reniform, antero-dorsal border concave and close to the postero-ventral shell margin from the valve centre. External coloration of both valves is variable from white and light purple with deep purple lines radiating from the umbo. Internally, shell white with patches of chalky deposits and hollow chambers. Muscle scar colourless with occasional purple growth lines.

**Distribution and habitat.** – Distribution of native *Crassostrea gigas* includes Japan, Korea, maritime districts of Russia and the Yellow Sea of China. Mariculture stocks occur in British Columbia to California, Hawaii, Guandong Province in China, Tasmania, New Zealand and Brazil (Inaba & Torigoe, 2004).

**Remarks.** – Morphological variations in shell form occur among individuals occupying different substrata. Growth form of the shell can be cup-shaped with a deep umbonal cavity, transversely flattened with a large attachment area on the left valve or dorso-ventrally elongated in mud grown individuals (Lam, 2003).

### *Planostrea* Harry, 1985

#### *Planostrea pestigris* (Hanley, 1846)

Common name: Flat oyster (Fig. 4)

*Ostrea pestigris* Hanley, 1846: 106–107.

*Ostrea paulucciae* Crosse, 1869: 188.

*Ostrea palmipes* Sowerby, 1871, sp. 56, Fig. a–c.

*Planostrea pestigris* – Harry, 1985: 143, Fig. 22.

*Ostrea pestigris* – Morris, 1985: 129, Pl. 4A–D; Scott, 1994: 69, Pl. 5B.

**Material examined.** – Holotype: [USNM] 666809, ‘‘Isle of Luzon; on rocks’’, coll. H. Cumming, no date, dry shell, height, 75 mm.

Syntype of *Ostrea palmipes*: [NHM] 1907.10.28.77 & 1907.12.30.10–11, one dry shell no other data.

Voucher – [NHM] 20090291, Pelangi Beach, intertidal sand, Pulau Langkawi, Malaysia, coll. B. Morton, 4 Feb.2004, one individual preserved in alcohol.

**Description.** – Shell of moderate size, up to 50 mm in height, 40 mm in length and 4 mm in width. Outline subquadrate, attenuated dorsally. Shell laterally compressed, generally in one plane. Right valve smaller and closely fitting within the margin of the left valve. Right valve smooth, with the outer shell layer continuous and having few growth increments. Little shell erosion and few encrustations. Exterior cream to yellowish, usually with dark lavender irregular rays. Left valve usually either light or white, with between 6–10 low, widely-spaced ribs which may have obsolete hyote spines at some growth increments. Attachment area small and restricted to near the left umbo. Most specimens are attached to shells of other bivalves and gastropods. Some are unattached. Chomata small, uniform, closely-spaced and in straight lines along the anterior and posterior margins near the hinge. Hinge line straight and short. Marginal commissural shelf on the left valve wide and flat with a well-defined inner edge. Interior of the shell white with a pearly nacre. Chalky deposits prominent on the commissural shelf of the left valve only. Adductor muscle scar white, large and elongate, positioned approximately at the middle of the shell, slightly towards the posterior.

**Distribution and habitat.** – Indo-West Pacific, the Philippines, Taiwan, Thailand, North Borneo, South and East China Seas, Yellow Sea, Shandong Province, China to Honshu, Japan, Townsville, Queensland, Australia, Mauritius, Intertidal zone to -10 m on rocks and corals.

**Remarks.** – Harry (1985) proposed a new genus, *Planostrea*, exclusively for *Ostrea pestigris*. This genus is described as of moderate size (to 75 mm), very compressed in one plane, being non-lamellose and with a continuous outer shell layer. Well-developed chomata line up along the dorsal margins near the hinge, with a wide and flat marginal commissural shelf and a lavender outer surface with radial stripes. This species can be distinguished easily from other oysters because of the consistent shape of a smooth, flattened, circular disc. Unlike other oysters, it is usually free from encrustations and the influence of the substratum to which it is attached. This species can be distinguished from *Ostrea densellamellosa* and *Alectryonella plicatula* by having a smooth and straight shell margin. The latter two have crenulated shell margins. It is also different from *Hyotissa numisma* in having a white interior instead of a violet one and in lacking the vesicular microstructure of gryphaeids. This species has been synonymised with *Ostrea paulucciae* Crosse, 1869, and *Ostrea palmipes* Sowerby, 1871, on the basis of similar shell characters (Tchang & Lou, 1956). Therefore, the *O. palmipes* from Malaysia as identified by Morris & Purchon (1981) is actually *Planostrea pestigris*.

***Dendostrea* Swainson, 1835**

***Dendostrea folium* (Linnaeus, 1758)**

Common name: Foliate oyster (Fig. 5)

*Ostrea folium* Linnaeus, 1758: 699.

*Ostrea folium* – Born, 1780: 112; Dodge, 1952: 190–191.

*Dendostrea glaucina* Lamarck, 1819: 212.

*Dendostrea folium* – Swainson 1835: 39.

*Dendostrea folium* – Sowerby 1839: 137: Fig. 181, Iredale, 1939: 402, Pl. 7, Fig. 11; Torigoe 1981: 315–316, 336–337, Pl. 5, Fig. 2, Pl. 26; Harry, 1985: 137–138, Fig. 18; Carriker & Gaffney, 1996: 8; Lam, 2003: 113–114, Pl. 14.

*Ostrea (Pretostrea) bresia* Iredale, 1939: 396–397.

*Lopha folium* – Stenzel, 1971: N1157, Fig. J47.

**Material examined.** – Type not studied. The type material is in the University Museum, Uppsala, Sweden. This species is not represented in the Linnaean collection of the Linnean Society of London.

Voucher: [NHM] 20090292, “Dredged from off Pelangi Beach, ~2–3 m, Pulau Langkawi, Malaysia”, coll. B. Morton, 7 Feb.2004, six individuals preserved in alcohol.

**Description.** – Shell of medium size, up to 55 mm in height, 30 in length and 10 in width. Outline oval, subequivalve.

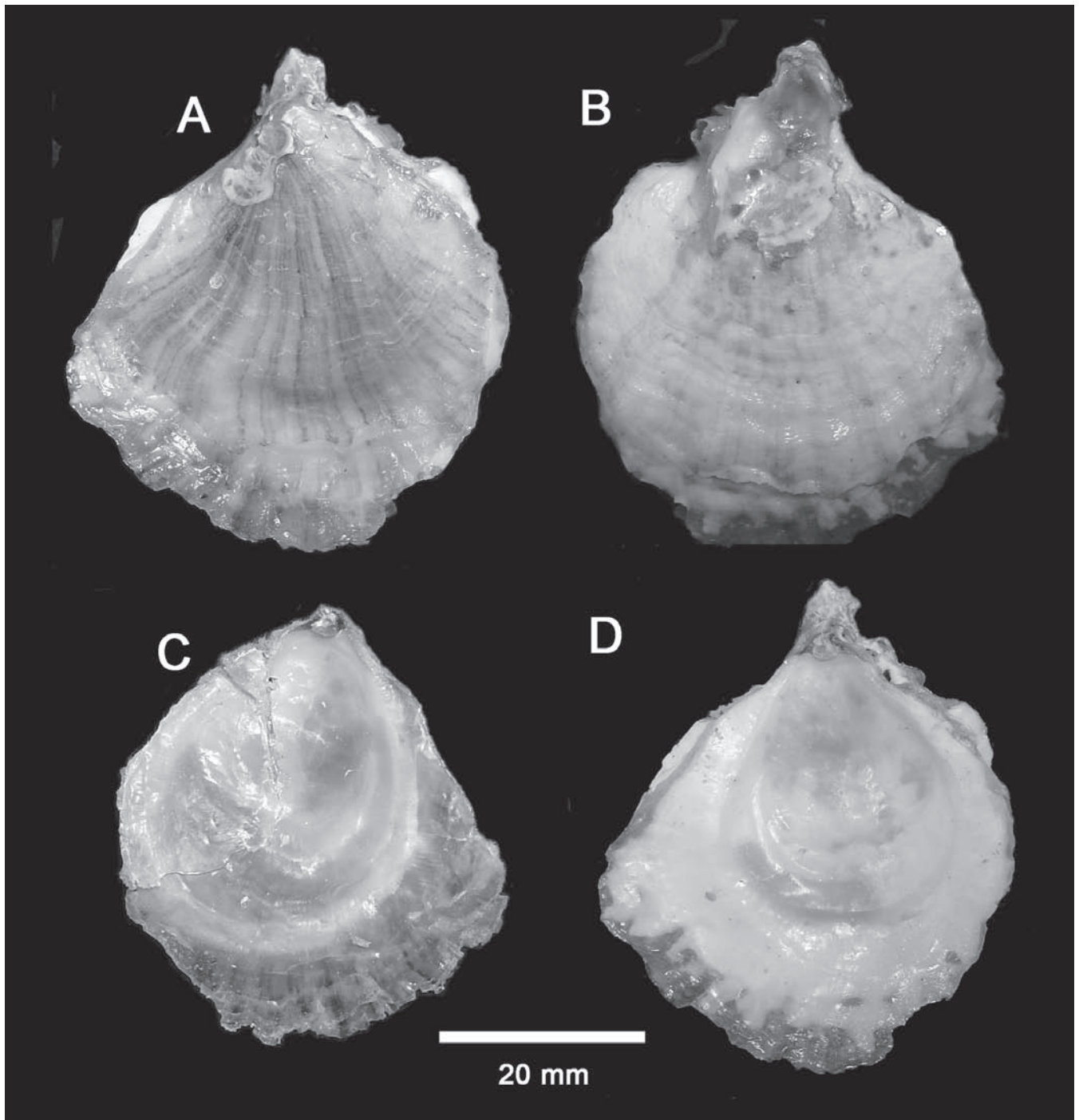


Fig. 4. *Planostrea pestigris* (Hanley, 1846) from Pulau Langkawi, Malaysia (NHM20090291). A, external view of the right shell valve, B, external view of the left shell valve, C, internal view of the right shell valve and D, internal view of the left shell valve.



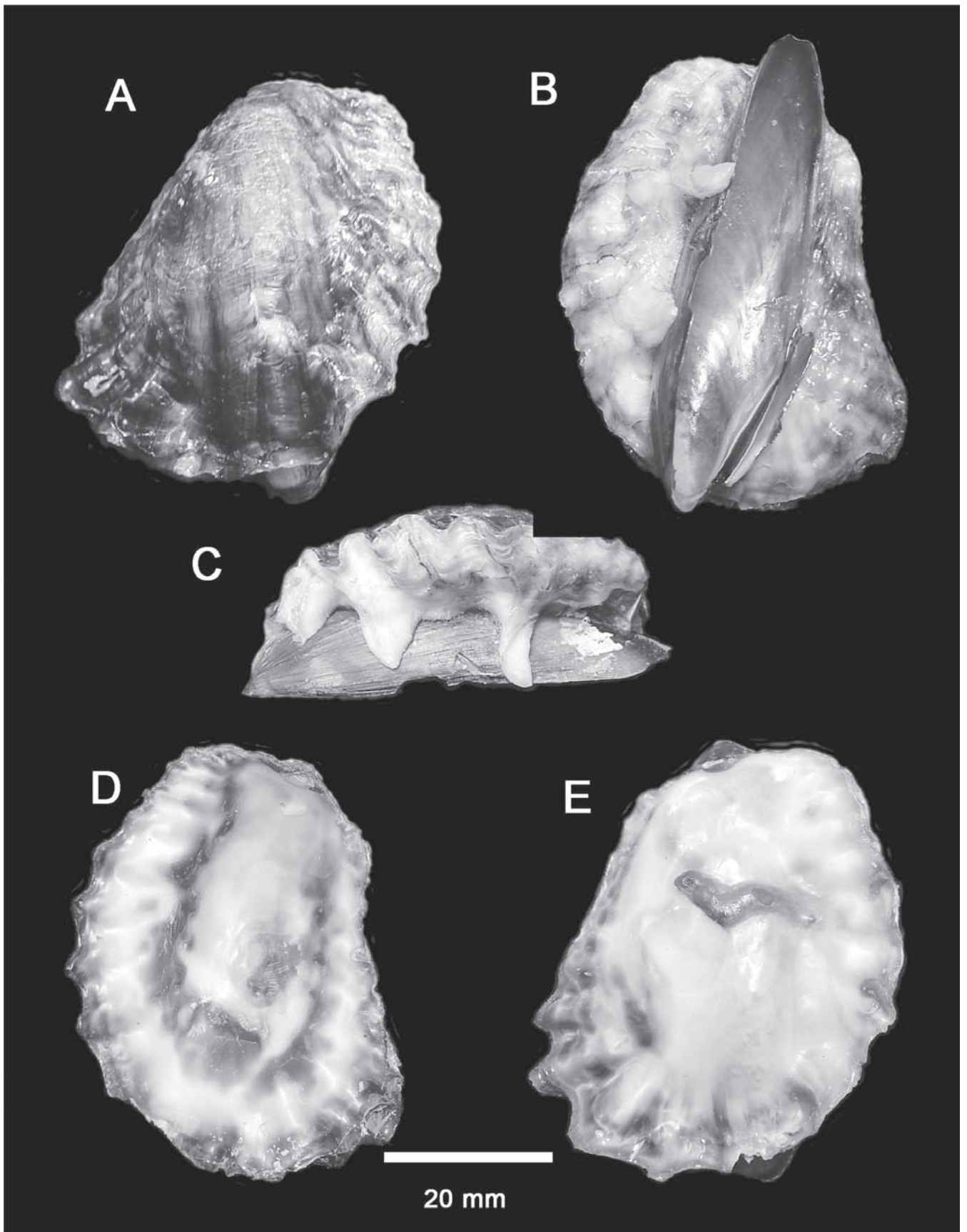


Fig. 5. *Dendostrea folium* (Linnaeus, 1758) from Pulau Langkawi, Malaysia (NHM20090292). A, external view of the right shell valve, B, external view of the left shell valve, C, anterior view of an individual, showing the "graspers" developed to hold on to a *Modiolus micropterus* shell, D, internal view of the right shell valve and E, internal view of the left shell valve.

Right valve lilac to dark purple externally, left valve white with thin purple stripes. Both valves with dichotomous ribs radiating from the umbones and ending ventrally as either a zig-zagged or rounded undulating margin. Rib tops rounded and bearing obsolete hyote spines at some growth increments. Reddish-purple streaks may radiate from the umbones. Usually, growth squamae on both valves eroded and shell thus often smooth. Attachment area of the left valve extending halfway from the umbo to the ventral margin. Right valve convex left valve attached to hard substratum with “claspers”, which are shelly processes that clasp the twig-like substratum (Stenzel, 1971).

Commissural shelf not developed. Umbonal cavity shallow, ligament short. Chomata usually either not present or restricted to both sides of the ligament and to half the shell height as small elongate tubercles and corresponding pits. Interior of the shell lustrous white with iridescent bluish green patches particularly along ridges formed by the ribs. Adductor muscle scar either reniform or crescentic and the same colour as the interior of the shell. It is positioned posterior to the centre of the pallial region.

**Distribution and Habitat.** – Indo-West Pacific, Australia, the Philippines, South and East China Seas, Hainan, Taiwan to Kii Peninsula, Japan. Usually shallow, from the sublittoral fringe to 8–10 m; it might extend to 50 m on rocks. Attached to other living sessile bivalves. The specimens collected were attached to the mussel *Modiolus micropterus* Deshayes, 1836 (Fig. 4).

**Remarks.** – Sometimes, species of *Hytissa* may be confused with *Dendostrea folium* especially in terms of external shell characters. Internal shell characters are more reliable in distinguishing these two species. For example, the shape of the adductor muscle scar is the most important feature for identification: that of *Hytissa* is large and circular while that of *Dendostrea folium* is crescentic. Species of *Hytissa* also have a well-developed commissural shelf and are whitish internally whereas *Dendostrea* does not have an obvious commissural shelf and internally the basal whiteness is always patterned with dark yellowish green patches showing the position of radial rays. The gryphaeid vesicular microstructure also readily distinguishes *Hytissa*.

### Gryphaeidae Vyalov, 1936

#### Pycnodonteinae Stenzel, 1959

##### *Hytissa* Stenzel, 1971

##### *Hytissa imbricata* (Lamarck, 1819)

Common name: Imbricated oyster (Fig. 6)

*Ostrea imbricata* Lamarck, 1819: 213.

*Ostrea imbricata* – Sowerby, 1871, sp. 36, Pl. 17, Fig. 36 a, b.

*Dendostrea imbricata* – Habe, 1951: 93.

*Pretostrea imbricata* – Habe & Kosuge, 1967: 138, Pl. 51, Fig. 14.

*Hytissa hyotis* forma *imbricata* – Stenzel, 1971: N961 & N1026, Fig. J5 & J49.

*Hytissa hyotis imbricata* – Habe & Okutani, 1975: 195.

*Parahytissa imbricata* – Harry, 1985: 130.

**Material examined.** – Type not studied. Probably in the Geneva, Switzerland Museum.

Voucher: [NHM] 20090293, “Dredged from off Pelangi Beach, ~2–3 m, Pulau Langkawi, Malaysia”, coll. B. Morton, 7 Feb. 2004, two individuals preserved in alcohol.

**Description.** – Shell semicircular or orbicular, up to 45 mm in height, 50 mm in length and 15 mm in width, equivalve. Hinge line long and straight and approximately equal to shell length in smaller individuals. Shell relatively thin and light in smaller individuals but becoming thicker and heavier in larger ones. Both valves with dichotomous ribs bearing prominent growth squamae that increase in length to become hyote spines. In eroded individuals hyote spines obsolete but growth squamae still prominent at the newly-grown ventral margin. Attachment area from small and limited at the umbones, to large and encompassing the entire left valve. Shell margins of both valves undulate, fitting into each other and, thus, reflecting the positions of the radial ribs. External coloration of both valves from white to cream in younger individuals to pink and purple with dark purple bands in older ones. Shell interior white. Commissural shelf large, dull in texture because of the vesicular shell structure. Ligament short, ligamental area usually not elongate. Umbonal cavity shallow, chomata absent. Adductor muscle scar large, white or pink, approximately circular and positioned postero-dorsally from the centre of the valve.

**Distribution and habitat.** – An Indo-West Pacific species, occurring from the Philippines, Australia and South China Sea to the Boso Peninsula, Japan. This subtidal species is usually obtained by trawling and diving (Lam & Morton, 2004).

**Remarks.** – Morris & Purchon (1981) recorded two gryphaeids, *Hytissa hyotis* (Linnaeus, 1758) and *Hytissa numisma* (Lamarck, 1819) by trawling off the West coast of Malaysia. Our collected *Hytissa* is distinguished from these two in having an irregular and rounded shell margin, crenulations and a white shell interior. *Hytissa hyotis* has regular, strong and acute shell margin crenulations and *H. numisma* has white shell exterior and slightly violet or largely white interior.

### DISCUSSION

Several checklists of oysters are available for various areas of South East Asia and Australia. Twenty-two species of Ostreidae and Gryphaeidae have been recorded from (sub)tropical Japan (Torigoe, 1981), 13 from Korea (Qi & Choe, 2000), 12 from Hong Kong (Lam & Morton, 2004), nine from Thailand (Yoosukh & Duangdee, 1999) and 11 from Australia (Thomson, 1954). Tsi et al. (1983) records a total of 17 oyster species from the South China

Sea but, conversely, Tomascik et al. (1997) identifies only *Crassostrea gigas* as present in Indonesian mangroves, and, as noted earlier, Tan & Kastoro (2004) identified no oysters from the Anambas and Natuna Islands, located between the West Malaysian Peninsula and Borneo. This study identifies nine species of oysters from peninsular Malaysia, although the two species of *Hytissa* reported upon by Morris & Purchon (1981) were actually collected from Phuket (Thailand) and from more northerly latitudes on the east coast of peninsular Malaysia (Table 2). Similarly, although *Saccostrea cucullata* and its morphotype *S. echinata* plus the similarly rocky intertidal *Alectryonella plicata* were recorded by Morris & Purchon (1981) from both coasts of peninsular Malaysia and Singapore, *Ostrea palmipes* (= *Planostrea pestigris*) was only recorded from the west coast as reported herein. Similarly, we also herein identify *Saccostrea mordax*, *Dendostrea folium* and *Hytissa imbricata* as new records from the west coast of peninsular Malaysia. Thus, a total of nine oyster species are

recorded from Malaysia and Singapore plus an introduced mariculture species typically identified as '*Crassostrea gigas*'. The name *Crassostrea gigas* was commonly given to the cultivated oyster in Hong Kong until Lam & Morton (2003) identified it genetically as a new species – *Crassostrea hongkongensis*. It is therefore possible that the species of *Crassostrea* identified from cultivation areas in Malaysia may not be *C. gigas* and this requires study.

The number of species recorded in the present study is similar to that recorded from Thailand by Yoosukh & Duangdee (1999) except there is a difference in species composition. Oysters present in Thailand but not in Peninsula Malaysia include *Crassostrea iredalei* (Faustino, 1932), *Striostrea* (*Parastrriostrea*) *mytiloides* (Lamarck, 1819), *Lopha cristagalli* (Linnaeus, 1758) and the cultured *Crassostrea belcheri* (Sowerby, 1871) (not *C. gigas*). The so-called *S. cucullata* figured as a second specimen in Yoosukh & Duangdee (1999, Fig. 6) is in fact *Saccostrea*

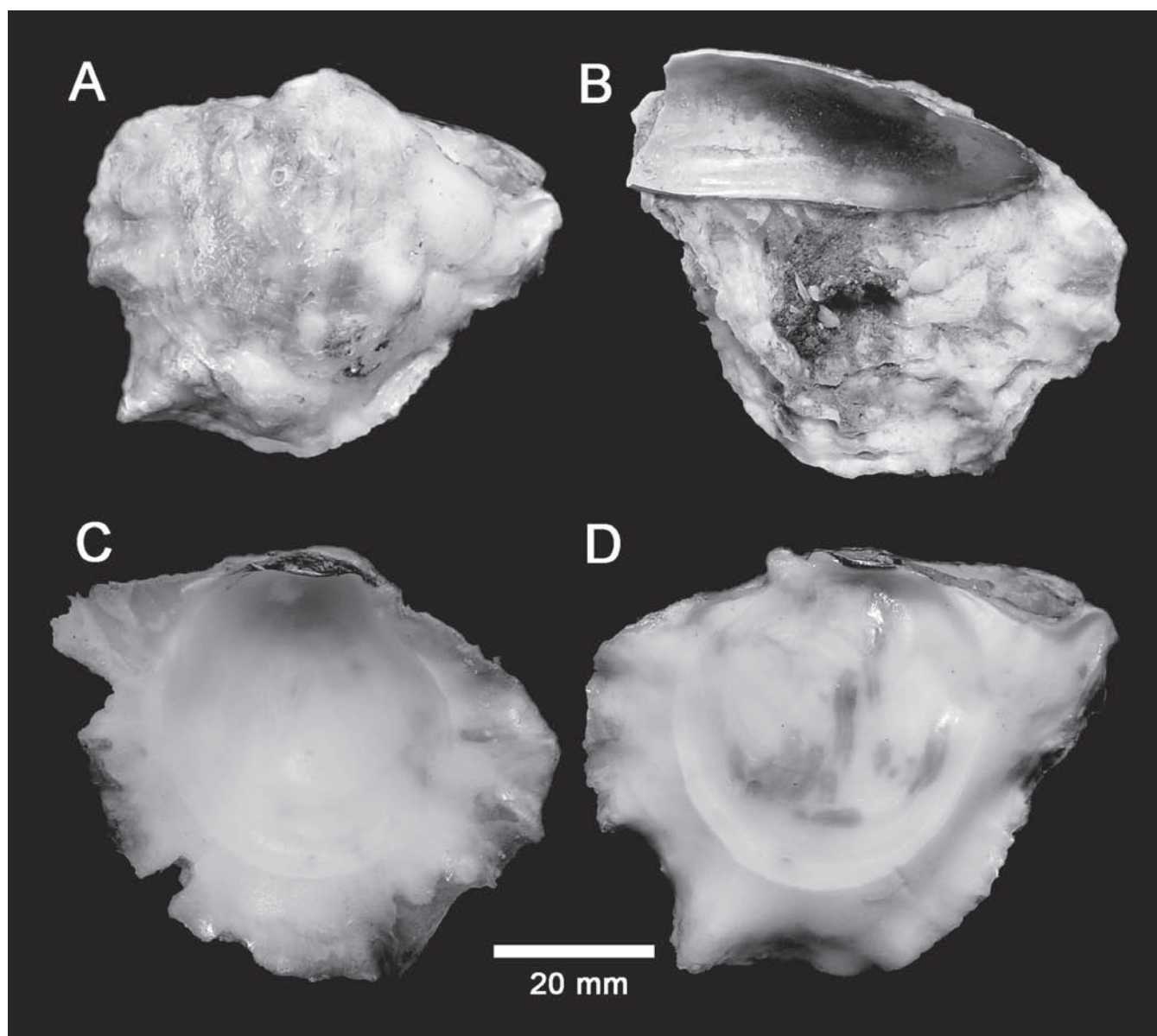


Fig. 6. *Hytissa imbricata* (Lamarck, 1819) from Pulau Langkawi, Malaysia (NHM20090293). A, external view of the right shell valve, B, external view of the left shell valve, C, internal view of the right shell valve and D, internal view of the left shell valve.

Table 2. A list of oysters recorded from Malaysia and Singapore. Taxa in bold are treated in the present study.

Taxa	Localities (detailed as possible)	Recorded / Collected by whom and when	Reference	Remarks
Family Ostreidae				
<b><i>Saccostrea cucullata</i></b> (Born, 1778)	East and West coast of Malaysia, Singapore waters  Tanah Merah and Kallang River, Singapore  Pulau Langkawi, Malaysia	C. Nielson, 1976 and R. D. Purchon  B. Morton, 9 Jul.2001  B. Morton, 3 & 5 Feb.2004	Morris & Purchon, 1981  Lam & Morton, 2006  This study	This species has been identified from Malaysian rocky shores and West Malaysian mangroves by Berry (1964, 1972) and Sasekumar (1974) as either <i>Crassostrea cucullata</i> or <i>Ostrea</i> <i>cucullata</i> . <i>Crassostrea cucullata</i> and an unidentified <i>Ostrea</i> sp. occur on rocky Enoch, 1954). Also regarded as <i>S. echinata</i> by Morris and Purchon (1981).
<b><i>Saccostrea mordax</i></b> (Gould, 1850)	Pulau Langkawi, Malaysia	B. Morton 4 Feb.2004	This study	
<b><i>Crassostrea gigas</i></b> (Thünberg, 1793)	Malaysia  Johor Strait, Malaysia Singapore	  Tan Koh Siang November 2005	Mathias & Charles, 1978 Zulgigar & Tan, 1998  This study  Tan & Chou, 2000	As introduced species to Malaysia for mariculture  Grown-out from spat flown from hatcheries in Australia
<b><i>Planostrea pestigris</i></b> (Hanley, 1846)	West coast of Malaysia  Pulau Langkawi, Malaysia	R. D. Purchon  B. Morton, 4 Feb.2004	Morris & Purchon, 1981  This study	This species was identified as <i>Ostrea</i> <i>palmipes</i> from Malaysia by Morris and Purchon (1981).
<b><i>Dendostrea folium</i></b> (Linnaeus, 1758)	Pulau Langkawi, Malaysia	B. Morton, 7 Feb.2004	This study	
<b><i>Alectryonella plicatula</i></b> (Gmelin, 1791)	East and West coasts of Malaysia, Singapore	C. Nielson, 1976 and R. D. Purchon	Morris & Purchon, 1981	
<b>?<i>Ostrea denselamellosa</i></b> Lischke, 1869	West coast of Malaysia	D. Broome	Morris & Purchon, 1981	
Family Gryphaeidae				
<b><i>Hyotissa imbricata</i></b> (Lamarck, 1819)	Pulau Langkawi, Malaysia	B. Morton 7 Feb.2004	This study	
<b><i>Hyotissa hyotis</i></b> (Linnaeus, 1758)	East and West coasts of Malaysia	C. Nielson, 1976 and R. D. Purchon	Morris & Purchon, 1981	
<b><i>Parahyotissa numisma</i></b> (Lamarck, 1819)	West coast of Malaysia	R. D. Purchon	Morris & Purchon, 1981	This species was regarded as <i>Hyotissa</i> <i>numisma</i>

*mordax*. The figured *Saccostrea forskalii* (Gmelin, 1791) in the same paper also conforms to the description of *Saccostrea cucullata*.

On the other hand, *Alectryonella plicatula*, *Planostrea pestigris*, *Ostrea denselamellosa*, *Hyotissa* are recorded from Malaysia but not Thailand. The intertidal and shallow

coastal waters of Peninsula Malaysia (but including southern Thailand) are thus now known to possess 13 species of oyster. These are: *Crassostrea belcheri*, *Crassostrea iredalei*, *Crassostrea gigas*, *Saccostrea cucullata*, *Striostrea mytiloides*, *Alectryonella plicatula*, *Planostrea pestigris*, *Ostrea denselamellosa*, *Lopha cristagalli*, *Dendostrea folium*, *Hyotissa hyotis*, *Hyotissa*

*numisma* and *Hyotissa imbricata*. However, the three species of *Crassostrea* need closer study not only to ascertain true identities and hence species numbers, but also to assist in the management genetics of maricultural stocks. Notwithstanding, species numbers recorded from the West Malaysian Peninsula approximate those recorded from elsewhere in Southeast Asia.

**KEY FOR IDENTIFICATION OF OYSTERS FROM MALAYSIA AND SINGAPORE**

- 1. Shell smooth, outline subquadrate, laterally compressed in one plane ..... *Planostrea pestigris*  
– Not so ..... 2
- 2. Fingerprint shell structure on the internal face of the valves ..... *Alectryonella plicatula*  
– Not so ..... 3
- 3. Alternative conchiolin and calcareous layers make up shell and presence of chomata ..... 4  
– Not so ..... 5
- 4. Radiating ridges on RV, evenly crenulated m-shaped ventral margin ..... *Saccostrea cucullata*  
– Not so ..... *Saccostrea mordax*
- 5. Shell exterior dark purple, interior lustrous brown or green. LV sometimes with claspers ..... *Dendostrea folium*  
– Not so ..... 6
- 6. Vesicular shell structure in shell interior ..... 7  
– Not so ..... 9
- 7. Shell margin with strong, acute plication ..... *Hyotissa hyotis*  
– Not so ..... 8
- 8. Tops of dichotomous radial ribs rounded or bear prominent growth squamae which becomes hyote spines .....  
..... *Hyotissa imbricata*  
– Not so ..... *Parahyotissa numisma*
- 9. RV covered concentrically by many dense layers of fragile growth squamae, Shell margin finely crenulated .....  
..... *Ostrea denselamellosa*  
– Not so ..... *Crassostrea gigas*

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