

## CORAL-BORING BIVALVE MOLLUSCS OF SOUTHEASTERN THAILAND, WITH THE DESCRIPTION OF A NEW SPECIES

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**ABSTRACT.** – Twenty-one species of intertidal and subtidal coral-boring bivalves from southeastern Thailand are described and illustrated. The species represent five families: Mytilidae, Petricolidae, Trapezidae, Pholadidae and Gastrochaenidae. Each species account includes a description of the shell and, whenever possible, a description of the living animal. Siphonal characters are presented for the first time for many of the treated taxa. The coral-boring fauna of the study region represents the highest diversity yet recorded in the Indo-Pacific Ocean. *Botula kleemanni* Valentich-Scott, new species, is herein described and illustrated.

**KEY WORDS.** – Endolithic, *Lithophaga*, *Leiosolenus*, *Botula*, *Gastrochaena*, *Spengleria*, morphology.

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### INTRODUCTION

In conjunction with a wider survey of the bivalve molluscs of the Kungkrabaen Bay region (Bieler & Mikkelsen, 2008), we here document and describe the bivalves that bore into intertidal and subtidal corals. Our goal was to not only describe the shells of these bivalves, but whenever possible, to document the living animals and their structures. The nature of this survey was brief, but we feel it provides a good foundation on which to build our understanding of the coral borers in the region.

Studies on the endolithic bivalve molluscs in Gulf of Thailand date back into the late eighteenth century (Knudsen & Jensen, 2001) with the description of *Pholas siamensis* Spengler, 1788. Fischer (1891) listed gastrochaenids and pholads from the Gulf, but surprisingly did not mention boring mytilids from the region. Lynge's (1909) report on the bivalve molluscs from the Danish Expedition to Siam (1899–1900) presented the first thorough accounting of the coral-boring Bivalvia from the eastern Gulf.

Modern treatments of Thailand coral-boring bivalves are led by the comprehensive monograph by Nielsen (1986), which detailed the fauna from Phuket Island in the Andaman Sea. Swennen et al. (2001) documented and illustrated several boring species from the southwestern Gulf of Thailand. Morton (1983b) provided an excellent overview of the ecology and biology of Indo-Pacific coral-boring bivalves.

### MATERIALS AND METHODS

Intertidal and subtidal corals were observed and sampled for boring bivalve molluscs (Fig. 1). Collecting and observation sites were in the Kungkrabaen Bay region of southeastern Thailand (Bieler & Mikkelsen, 2008: Fig. 1) from 23 Aug. through 2 Sept.2005. Samples were collected by hand, with the aid of snorkeling equipment and heavy “oyster gloves”.



Fig. 1. Typical intertidal/subtidal collecting site for coral-boring bivalves (southern entrance to Kungkrabaen Bay, KKB-07).

Corals were dissected by means of rock hammers, sledges, and chisels. Boreholes were carefully examined and photographed. Whenever possible, in situ images of the bivalves were taken. Most bivalve species sampled were boring forms, however some incidentally settled in previous boreholes or coral cavities. Although we were unable to definitively identify the coral species sampled, we feel they primarily were either *Favia* sp. or *Porites* sp.

In the laboratory, living animals were observed and photographed under a standard dissecting stereomicroscope. In many cases, living animals were relaxed using an isotonic solution of magnesium chloride (MgCl<sub>2</sub>) in seawater. If the bivalves did not respond to the MgCl<sub>2</sub> within 12 hours, then small amounts of 70% ethyl alcohol was added to their holding container. Whenever possible, living observations were made of the foot, mantle edge and siphons.

The following stations were sampled by the authors. The latitudes and longitudes were taken by a Garmin GPS (model 76C) and are slightly different than the primary workshop stations. We have, however, used the standard workshop station numbers, so that the general region will correspond with other workshop collections. Coral samples from other stations were given to us by workshop participants and their locations are given in the species accounts below.

KKB-05: northern side of Kungkrabaen Bay entrance; intertidal and subtidal; living and dead coral collected; 12°35.236'N 101°53.042'E.

KKB-07: southern side of Kungkrabaen Bay entrance; intertidal and subtidal; living and dead corals; 12°34.932'N 101°53.147'E.

KKB-21: eastern side of Koh Nom Saow (Teenage Breast Island); subtidal; living corals; 12°27.925'N 102°01.455'E.

## SYSTEMATIC ACCOUNT

We here present characters to differentiate the coral-boring species found in the southeastern Gulf of Thailand. Each species treatment contains a diagnosis, description of external and internal characters and habitats where the species were observed or collected. Pertinent literature is included at the end of each account, several of which (e.g., Oliver, 1992) give detailed synonymies of the species covered. The new species described here is attributed only to the first author (Paul Valentich-Scott).

### Mytilidae Rafinesque, 1815

#### *Botula cinnamomea* (Gmelin, 1791)

(Fig. 2A–E)

**Diagnosis.** – Shell ellipsoid-ovate; beaks inflated, terminal; periostracum chestnut brown, without fibrous mat (Fig. 2A).

**Description.** – External lateral view: Shell ellipsoid-ovate, anterior truncate, posterior narrowly rounded, not tapering; beaks very inflated, high, terminal; sculpture of commarginal striae only; periostracum shiny, adherent, medium to dark brown, without fibrous mat on posterodorsal slope (Fig. 2A).

External dorsal view: Beaks prosogyrate, not touching one another, with small gap between them (Fig. 2C); lunule absent; escutcheon not well defined, but with depression behind inflated beaks; ligament moderately long, black, sunken; siphons fused, light yellow, with maculated light brown tips (Fig. 2D), inhalant siphon broadly open posteriorly, then fused to large pedal gape and fused again anterior of foot; exhalant siphon narrow, with light brown maculations; siphonal tentacles absent.

External ventral view: Only very slightly gaping in life; mantle light orange; foot white, with dark brown tip, ellipsoid, inflated. With a pair of large, white, branched tentacles several millimeters inside the inhalant siphon.

Internal view: Ctenidia white, moderately short, moderately wide, without folding, finely scalloped on ventral edge, outer and inner demibranchs of approximately the same width; ctenidial filaments numerous (> 300), but fewer than in other mytilids. Labial palps cream-coloured, ellipsoid, moderately narrow, pointed posteriorly, recurved dorsally, with ca. 38 plicae on the surface of each palp. Digestive gland green, large; gonad small, white, occupying only a very small portion of the mantle cavity in the specimen examined; cardiac region not visible in specimen examined.

Shell interior of white nacre, without periostracum extending past the posterior margin (Fig. 2B); hinge edentate; pallial sinus moderate in depth, not extending to midline of shell; anterior adductor muscle dorsal, very small, ovate; posterior adductor muscle moderate in size, ovate, near ventral margin.

**Measurements.** – Dimensions of specimen described (SBMNH 80191): Shell length 13.36 mm, height at widest part 5.90 mm.

**Habitat.** – Found boring in dead coral at the northern (KKB-05) entrance of Kungkrabaen Bay and in living coral at the southern entrance to the bay (KKB-07), also at offshore island Koh Nom Saow (KKB-21). This species is often found boring deeply into corals (Fig. 2E).

**Literature.** – Lyngé (1909: 138–139), Morton (1983b), Wilson & Tait (1984), Nielsen (1986), Kleeman (1990a, b), Oliver (1992: 53–54), Ramesh et al. (1996), Valentich-Scott & Dinesen (2004).

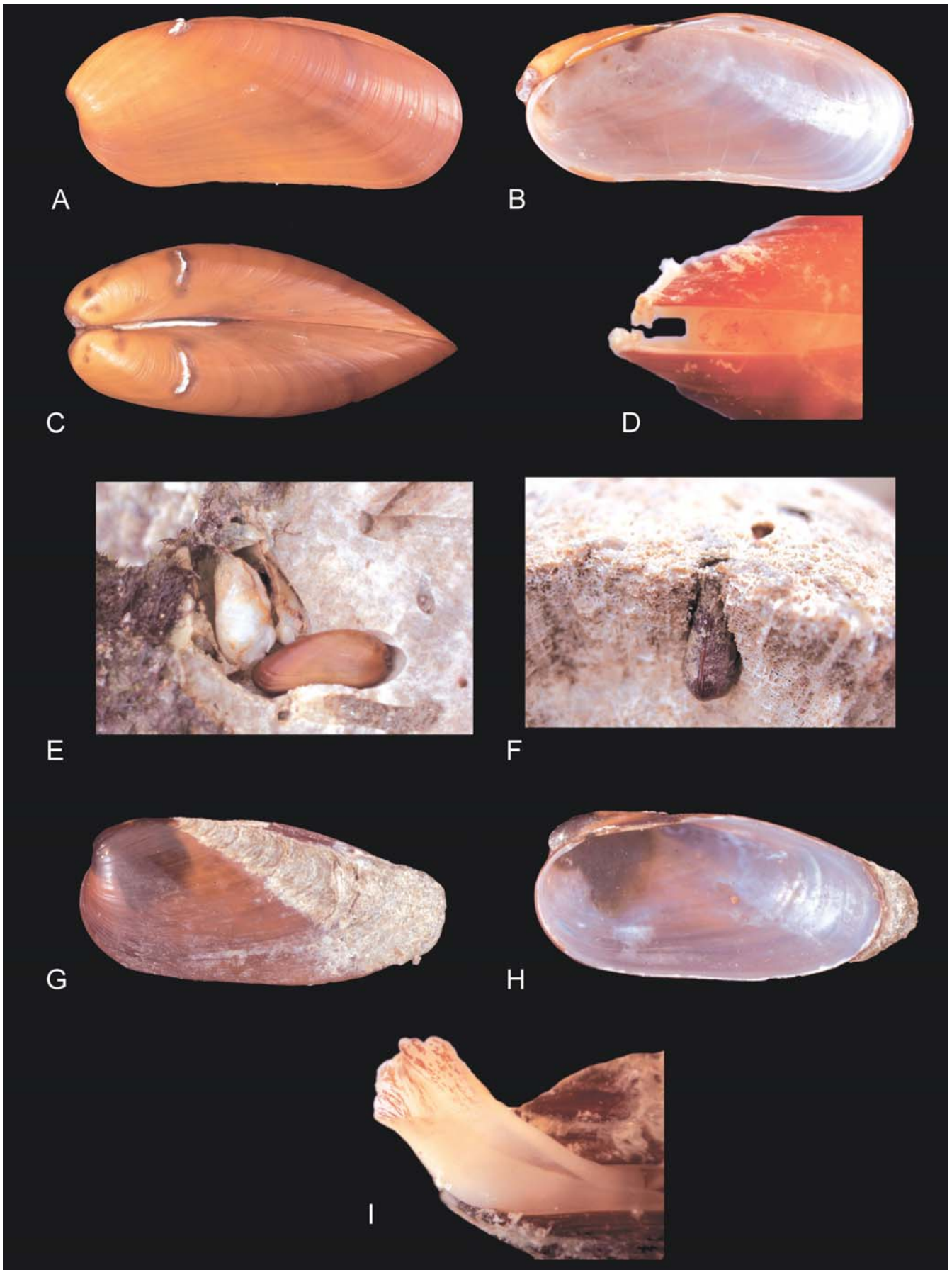


Fig. 2. *Botula cinnamomea*, A–E: A–C, SBMNH 83122, length 19.5 mm: A, external left valve; B, internal right valve; C, dorsal view; D, post-ventral view of living animal, showing mantle and siphons; E, in situ in coral, with *Aspidopholas* on posterior end. *Botula kleemanni* new species, F–I: F, in situ in living coral; G–H, holotype, SBMNH 83123, length 12.35 mm: G, external left valve; H, internal right valve; I, facultative siphon of living animal.



***Botula kleemanni* Valentich-Scott, new species**

(Fig. 2F–I)

**Material examined.** – Holotype (specimen described above) (shell SBMNH 83123; preserved anatomy SBMNH 80177): Shell length 12.21 mm, plus 1.22 mm of periostracum extending past shell, height at widest part 5.87 mm. Thailand, Chantaburi, Kungkrabaen Bay, southern side of bay entrance, 12°34.932'N 101°53.147'E, subtidal, boring in living coral (*Favia* sp. and *Porites* sp.); coll. P. Valentich-Scott and P. Tongkerd, 24 Aug.2005. Paratypes (SBMNH 80178), same as holotype, 10 specimens preserved in 100% ethanol (EtOH).

**Diagnosis.** – Shell ellipsoid-elongate; beaks subterminal; periostracum usually dark brown, with heavy fibrous mat posterodorsally, extending past the posterior margin (Fig. 2G).

**Description.** – External lateral view: Shell ellipsoid-elongate, anterior truncate, posterior produced, tapering; beaks very inflated, broad, subterminal; sculpture of commarginal striae only; periostracum shiny, adherent, light to dark brown, usually very dark brown, with fibrous mat (not calcareous) covering the posterodorsal slope and extending past shell margin in most specimens (Fig. 2G).

External dorsal view: Beaks prosogyrate, touching one another, without a gap between them; lunule absent; escutcheon not defined, but with depression behind inflated beaks; ligament long, black, sunken; siphons fused; inhalant siphon facultative, unfused to anterior end, flaring open posteriorly in life, with dark brown spots internally; exhalant siphon narrow, short, slightly extending past inhalant siphon, with external dark brown maculations (Fig. 2I); siphonal tentacles absent.

External ventral view: Slightly gaping in life; mantle light orange, unfused to near anterior end; foot light orange to beige, thin, compressed. Without tentacles inside inhalant siphon.

Internal view: Ctenidia white, very long, without folding, finely scalloped on ventral edge, outer and inner demibranchs approximately the same width; ctenidial filaments very numerous (> 500).

Labial palps light yellow, narrow, pointed posteriorly, recurved dorsally, with ca. 41 filaments on the surface of each palp. Digestive gland green, large; gonad small, white, occupying only a very small portion of the mantle cavity; cardiac region small, brown, ellipsoid.

Shell interior of blue-white nacre, with periostracum extending past posterior margin (Fig. 2H); hinge edentate; pallial sinus short, broad, well short of midline of shell; anterior adductor muscle dorsal, elongate, posterior adductor muscle ovate, near ventral margin.

**Etymology.** – This species is named after Dr. Karl Kleemann, University of Vienna, to honour his lifelong contributions to our understanding of the Mytilidae.

**Habitat.** – Found boring in living coral at the southern entrance of Kungkrabaen Bay (KKB-07) and in offshore living corals (KKB-13). Only found near the coral surface (Fig. 2F).

**Comparisons.** – Easily separated from *Botula cinnamomea* and other members of genus, by the heavy periostracal mat found along the posterodorsal margin of the shell.

***Lithophaga teres* (Philippi, 1846)**

(Fig. 3A–E)

**Diagnosis.** – Shell cylindrical; beaks terminal to subterminal; periostracum dark brown, with coarse vertical lines anteroventrally (Fig. 3A); interior tip of inhalant siphon with a group of small, simple trigonal and complex branched tentacles (Fig. 3E).

**Description.** – External lateral view: Shell cylindrical, anterior end narrowly rounded, posterior end broadly rounded; beaks at anterior end, subterminal, low, broad, rounded; sculpture of commarginal striae; periostracum dark brown, shiny, with coarse vertical lines from anterior end to the posteroventral margin (Fig. 3A), periostracal sculpture absent along dorsal margin and posterior end.

External dorsal view: With gap between beaks (Fig. 3C); beaks prosogyrate; lunule absent; escutcheon shallow, narrow; ligament very long, narrow; siphons white, maculated with light brown, inhalant darker brown, only slightly extending past shell margin, inhalant siphon open dorsally, formed by adjoining mantle edges, exhalant siphon narrow, constricted; External dorsal view siphonal tentacles absent.

External ventral view: Narrowly gaping in life; mantle translucent, unfused posterior of pedal gape, fused anterior of pedal gape; foot long, slender, orange to dark purple, with brown rim in some. Approximately 1 cm inside inhalant siphon there is a group of small, simple trigonal and complex branched tentacles (Fig. 3E).

Internal view: Ctenidia white, very long, narrow, extending to siphons, with outer and inner demibranchs of approximately the same width; ctenidial filaments exceedingly numerous (> 500). Labial palps elongate, pointed posteriorly, with scalloped dorsal edge, with ca. 40 filaments on the surface of each palp. Digestive gland dark green to black, elongate; gonad of mature specimens orange, long, occupying approximately 50% of mantle cavity; cardiac region posterior of shell center, dark brown, long.

Shell cylindrical; hinge edentate; pallial sinus deep, broad; anterior adductor muscle small, at extreme end; posterior adductor muscle large, ovate (Fig. 3B).

**Measurements.** – Dimensions of specimen described (SBMNH 80192): Shell length 38.3 mm, height at widest part 12.9 mm; siphonal length in relaxed condition approximately 3 mm.

**Habitat.** – Found boring, usually in dead coral, occasionally in living coral, at the northern (KKB-05) and southern (KKB-07) entrances of Kungkraen Bay, and offshore in living corals (KKB-12) and along offshore islands (KKB-21); frequently found in very high densities in dead coral.

**Literature.** – Yonge (1955), Scott (1980), Kleemann (1983), Nielsen (1986), Oliver (1992: 54), Ramesh et al. (1996), Lamprell & Healy (1998: 92), Okutani (2000: 876-877), Swennen et al. (2001: 64), Valentich-Scott (2003), Qi (2004: 232).

***Lithophaga zitteliana* Dunker, 1882**  
(Fig. 4A–D)

**Diagnosis.** – Shell cylindrical; beaks subterminal; periostracum light to medium brown, with fine vertical lines from anterior end to the posteroventral margin (Fig. 4A); inside inhalant siphon with very small, simple, translucent-brown papillae, but without tentacles (Fig. 4D).

**Description.** – External lateral view: Shell cylindrical, slightly flaring mediodorsally, anterior and posterior ends narrowly rounded; beaks at anterior end, subterminal, low, broad, rounded (Fig. 4A); sculpture of commarginal

striae; periostracum light to medium brown, shiny, with fine vertical lines from anterior end to the posteroventral margin; periostracal sculpture absent along dorsal margin and at posterior end.

External dorsal view: Beaks prosogyrate, with narrow gap between beaks (Fig. 4C); lunule and escutcheon absent; ligament very long, narrow, slightly sunken; siphons white to yellow, maculated with dark brown at tips (Fig. 4D), only slightly extending past shell margin, inhalant open dorsally, formed by adjoining mantle edges, exhalant wide, slightly flaring, constricted; external siphonal tentacles absent.

External ventral view: Narrowly gaping in life; mantle white to light yellow, unfused posterior of pedal gape, fused anterior of pedal gape; foot long, slender, orange, with brown rim and tip in some. Approximately 1 cm inside inhalant siphon there is a group of very small, simple, translucent brown papillae (Fig. 4D).

Internal view: Ctenidia translucent gray, very long, narrow, extending to siphons, outer and inner demibranchs of approximately same width; ctenidial filaments exceedingly numerous (> 500). Labial palps ellipsoid, narrow, pointed posteriorly, with scalloped dorsal edge, with ca. 51 plicae on surface of each palp. Digestive gland dark green to black;

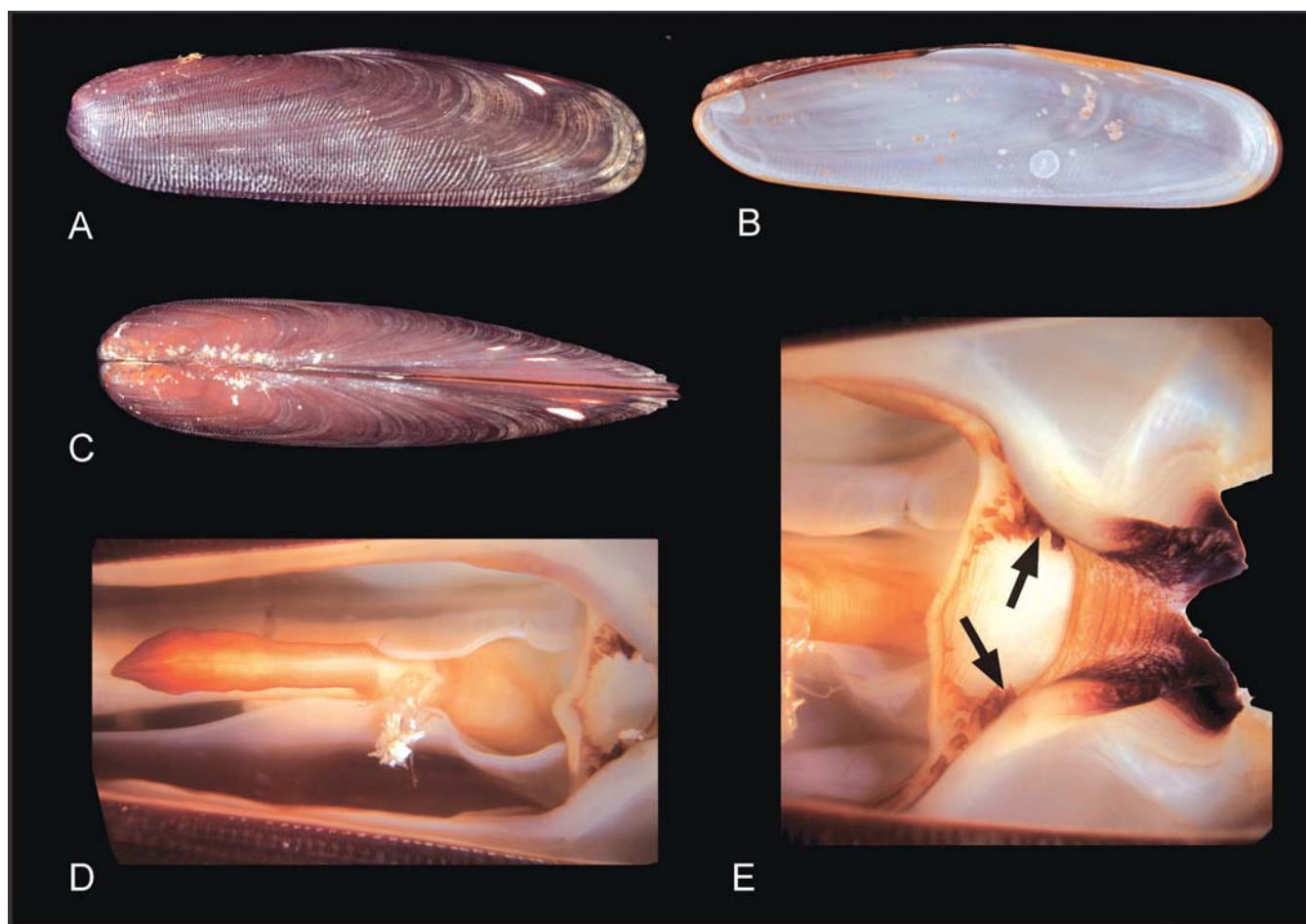


Fig. 3. *Lithophaga teres*, A–E: A–C, SBMNH 83124, length 44.55 mm: A, external left valve; B, internal right valve; C, dorsal view; D, medioventral view of living animal showing elongate narrow foot and byssus at base of foot; E, posteroventral view of living animal, arrows point to regions of dark, internal siphonal tentacles.

gonad of mature specimens white, elongate, occupying approximately 30% of the mantle cavity; cardiac region brown, posterodorsal.

Shell nacreous; hinge edentate; pallial sinus deep; anterior adductor muscle very small, at extreme end; posterior adductor muscle large, ovate (Fig. 4B).

**Measurements.** – Dimensions of specimen described (SBMNH 80193): Shell length 50.69 mm, height at widest part 15.34 mm; siphonal length in relaxed condition approximately 3 mm.

**Habitat.** – Found boring in dead coral at the southern entrance of Kungkabaen Bay (KKB-07).

**Literature.** – Kleeman (1983), Nielsen (1986), Okutani (2000: 876-877), Qi (2004: 232).

***Leiosolenus lima* (Jousseau in Lamy, 1919)**  
(Fig. 5A–E)

**Diagnosis.** – Shell cylindrical; beaks terminal; periostracum medium to dark brown; shell with calcareous concretions over entire surface (eroded in some places), concretions not extending past posterior end of shell, posterior concretions with divaricating lines (Fig. 5A); siphons solid dark purple to dark brown, external and internal siphonal tentacles absent (Fig. 5E).

**Description.** – External lateral view: Shell cylindrical, very slightly flaring mediodorsally, anterior and posterior ends broadly rounded, with calcareous concretions over entire surface (eroded in some places), concretions not extending past posterior end of shell, posterior concretions with divaricating lines (Fig. 5A); beaks at anterior end, terminal,

low, broad, rounded; sculpture of commarginal striae over entire shell; periostracum medium to dark brown, shiny, adherent.

External dorsal view: Without gap between beaks (Fig. 5C); beaks prosogyrate; lunule absent; escutcheon not well demarcated, shallow depression posterior of beaks; ligament very long, narrow; in life, widely gaping posterior of ligament; siphons solid dark purple to dark brown (Fig. 5E), only slightly extending past shell margin, inhalant open dorsally, formed by adjoining mantle edges, exhalant siphon wide, slightly constricted; external and internal siphonal tentacles absent.

External ventral view: Gaping widely in life; mantle only fused at extreme anterior end; without interlocking posteroventral concretions; foot cream-coloured, long, slender, with bulbous tip with dark brown (Fig. 5D).

Internal view: Ctenidia dark gray to light brown, very long, narrow, extending to siphons; outer and inner demibranchs of approximately same width; ctenidial filaments exceedingly numerous (> 1,000). Labial palps large, cream-coloured, ellipsoid, narrow, ca. posteriorly, with slightly scalloped dorsal edge, with about 34 plicae on surface of each palp. Digestive gland large, long, dark green; gonads of mature specimens very large, long, pinkish-brown, occupying approximately 40% of mantle cavity; cardiac region not visible in specimen examined.

Shell nacreous within; hinge edentate; pallial sinus shallow, broad; anterior adductor muscle small, at extreme end below beaks, posterior adductor muscle large, ovate (Fig. 5B).

**Measurements.** – Dimensions of specimen described (SBMNH 80195): Shell length 53.27 mm, height at widest part 17.28 mm.

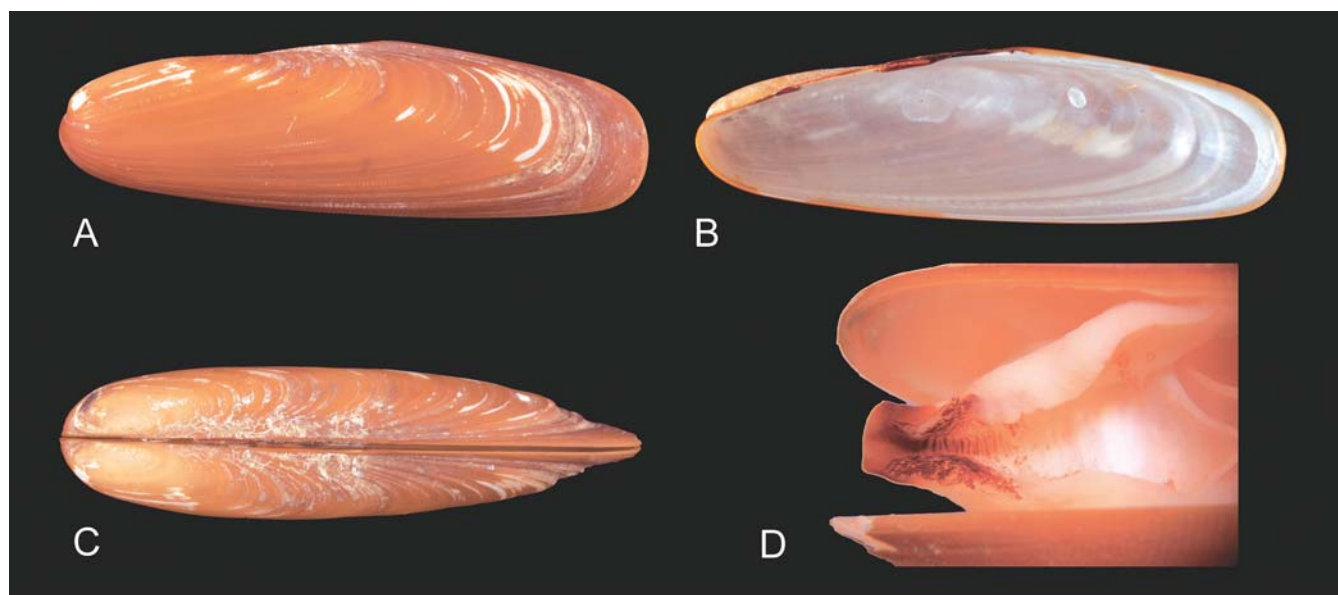


Fig. 4. *Lithophaga zitteliana*, A–D: A–C, SBMNH 83126, length 44.95 mm: A, external left valve; B, internal right valve; C, dorsal view; D, posteroventral view of living animal, note that no internal siphonal tentacles are present.



**Habitat.** – Found boring in dead coral at the southern (KKB-07) entrance of Kungkraabaen Bay;

**Literature.** – Kleemann (1980, 1983, 1990b), Morton & Scott (1980), Scott (1980), Morton (1983b), Lee & Morton (1985), Nielsen (1986), Oliver (1992: 54–55), Lamprell & Healy (1998: 92), Okutani (2000: 876–877), Valentich-Scott (2003), Qi (2004: 233).

***Leiosolenus malaccanus* (Reeve, 1858)**  
(Fig. 6A–D)

**Diagnosis.** – Shell cylindrical; beaks near anterior, subterminal; periostracum light brown; shell covered by concretions, more dense and feathery posteriorly, concretions extending past posterior end of shell (Fig. 6A–B); siphons white, maculated with light brown and white spots at posterior end (Fig. 6C).

**Description.** – External lateral view: Shell cylindrical, anterior end blunt, posterior end narrow, produced, with calcareous extensions (Fig. 6A); beaks at anterior end, subterminal, low, broad, rounded; sculpture of commarginal striae on anterior end, remainder of shell covered by concretions, more dense and feathery posteriorly, concretions extending past end of shell; periostracum light brown, shiny.

External dorsal view: With narrow gap between beaks; beaks prosogyrate; lunule absent; escutcheon not well demarcated, shallow depression posterior of beaks; ligament very long, narrow; siphons white, maculated with light brown and white spots at posterior end (Fig. 6C), without internal tentacles in inhalant siphon, but with distinct radial muscle striations; siphonal tentacles absent; foot white, long, slender, trigonal tip light brown.

External ventral view: Not gaping in life; mantle not visible; posteroventral concretions interlocking in some places.

Internal view: Ctenidia white, very long, narrow, extending to siphons; outer and inner demibranchs of approximately same width; ctenidial filaments exceedingly numerous (> 500). Labial palps small, white, ovate-elongate, pointed posteriorly, with smooth dorsal edge, with ca. 13 filaments on surface of each palp. Digestive gland large, dark green; gonad of mature specimens very large, extending into mantle and covering outer ctenidia, maculated white and pink, occupying approximately 30% of mantle cavity; cardiac region light brown, ovate.

Shell nacreous within; hinge edentate; pallial sinus absent; anterior adductor muscle small, at extreme end below beaks, posterior adductor muscle small, ovate (Fig. 6B).

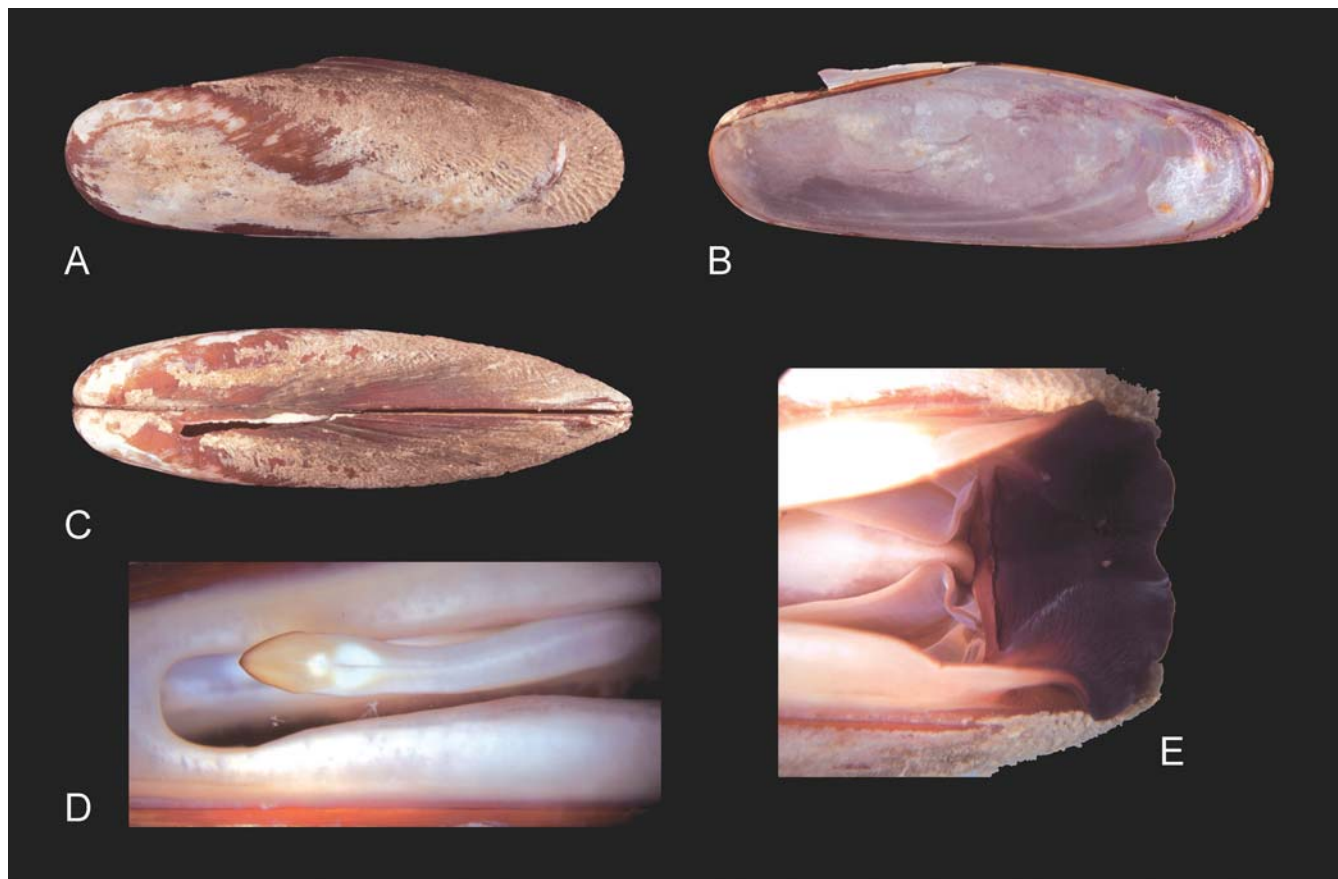


Fig. 5. *Leiosolenus lima*, A–E: A–C, SBMNH 83128, length 53.15 mm; A, external left valve; B, internal right valve; C, dorsal view; D, medioventral view of living animal with elongate foot; E, posteroventral view of living animal, with deep brown-violet colour.

**Measurements.** – Dimensions of specimen described (SBMNH 80194): Shell length 22.71 mm, with concretions extending 5.12 mm past shell, height at widest part 7.80 mm.

**Habitat.** – Found boring in living coral offshore (KKB-12) and at southern (KKB-07) entrance of Kungkrabaen Bay.

**Literature.** – Scott (1980), Kleeman (1983, 1984, 1990a, b), Lee & Morton (1985), Nielsen (1986), Lamprell & Healy (1998: 92–94), Okutani (2000: 876–877), Valentich-Scott (2003), Qi (2004: 233).

***Leiosolenus obesus* (Philippi, 1847)**  
(Fig. 6E–F)

**Diagnosis.** – Shell cylindrical, mediodorsal margin strongly flaring (Fig. 6E); beaks terminal; periostracum dark brown; shell covered by concretions, more dense and divaricate posteriorly, concretions only slightly extending past posterior end of shell (Fig. 6E).

**Description.** – External lateral view: Shell cylindrical, strongly flaring mediodorsally, anterior end narrowly rounded, posterior end broadly round, with calcareous concretions over entire surface (eroded in some places), concretions slightly extending past posterior end of shell, posterior concretions with commarginal ribs overlain by divaricate ribs (Fig. 6E); beaks anterior, terminal, low, broad, rounded; sculpture of commarginal striae over entire shell; periostracum light to medium brown, shiny, adherent.

External dorsal view: With gap between beaks; beaks prosogyrate; lunule absent; escutcheon not well demarcated, shallow depression posterior of beaks; ligament very long, narrow; siphons white with solid dark purple to dark brown tips, only slightly extending past shell margin, inhalant facultative, open dorsally, formed by adjoining mantle edges, exhalant siphon very narrow; external and internal siphonal tentacles absent.

External ventral view: Mantle unfused except for extreme anterior end; without interlocking posteroventral concretions; foot cream-coloured with ca. brown edge on tip.

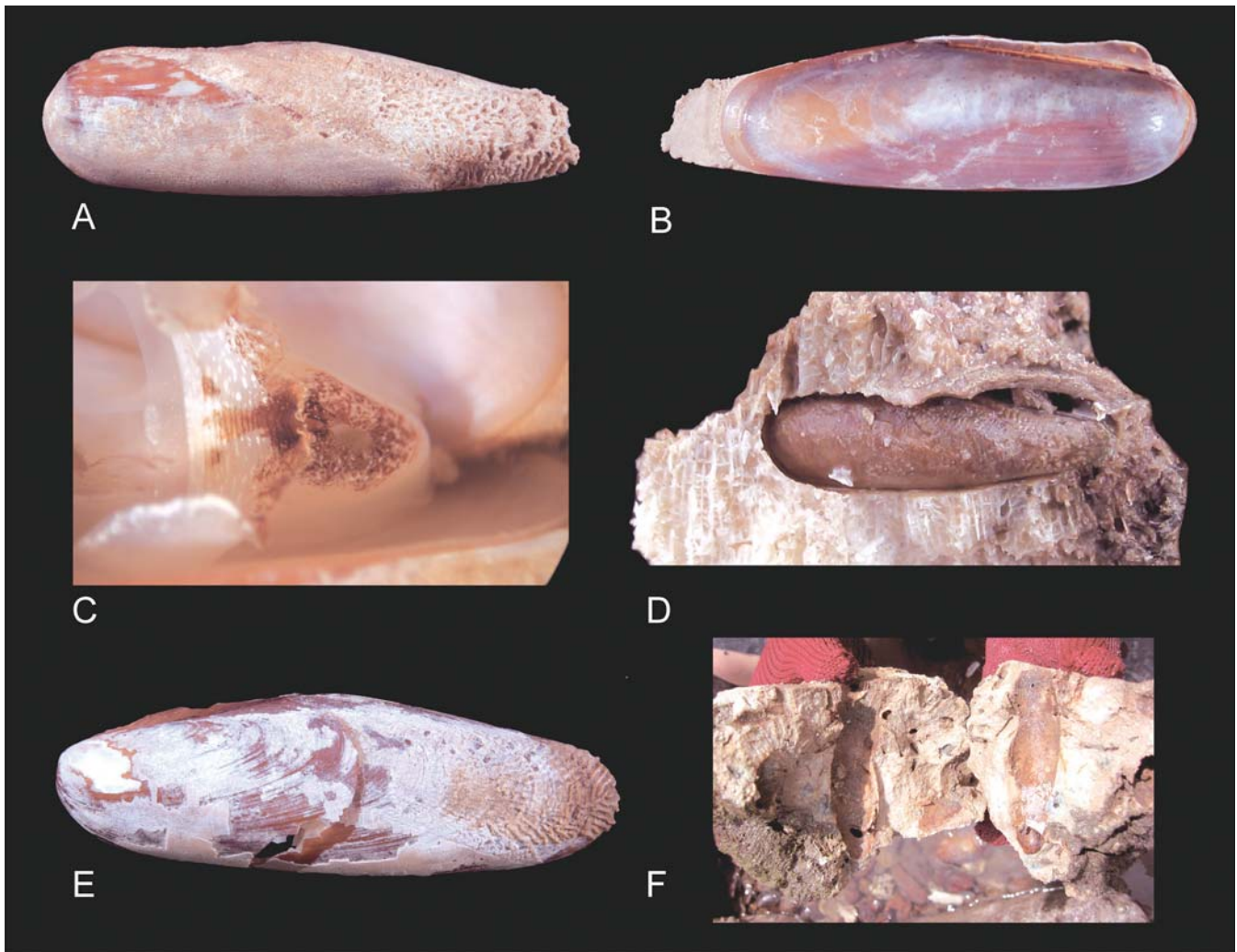


Fig. 6. *Leiosolenus malaccanus*, A–D: A–B, SBMNH 83124, length 29.80 mm: A, external left valve; B, internal left valve; C, posteroventral view of living animal, with white colour striations in the inner siphons; D, living animal in coral burrow. *Leiosolenus obesus*, E, SBMNH 80196, length 63.15 mm: external left valve (specimen cracked medially); F, coral burrow of specimen in Fig. 6E.



Internal view: Ctenidia long, white, straight, extending to siphons; outer and inner demibranchs of approximately same width; ctenidial filaments exceedingly numerous (> 1,000). Labial palps large, white, ellipsoid, long, moderately narrow, pointed posteriorly, with about 39 plicae on surface of each palp, dorsal edge wide, without plicae. Digestive gland large, long, light green; gonad of mature specimens moderate in size, long, white, occupying approximately 25% of mantle cavity; cardiac region not visible in specimen examined.

Shell purple nacreous within; hinge edentate; pallial sinus broad; anterior adductor muscle very small, at extreme end below beaks, ovate-elongate; posterior adductor muscle moderate to small in size, circular.

**Measurements.** – Dimensions of specimen described (SBMNH 80196): Shell length 64.5 mm, height at widest part 22.45 mm. Only a single specimen was collected during this study.

**Habitat.** – Found boring in offshore corals (Fig. 6F) south of Kungkrabaen Bay (KKB-13), uncommon.

**Literature.** – Yonge (1955), Kleeman (1983, 1984, 1990a, b), Morton (1983b), Nielsen (1986), Lamprell & Healy (1998: 94), Okutani (2000: 876-877), Qi (2004: 233).

**Petricolidae d'Orbigny, 1840**

***Petricola lapicida* (Gmelin, 1791)**

(Fig. 7A–B)

**Diagnosis.** – Shell subquadrate, white to cream-coloured; sculpture of commarginal and divaricate ribs, with strong radial lamellae posteriorly (Fig. 7A).

**Description.** – External lateral view: Shell subquadrate, anterior end wide, broadly rounded, posterior end broadly rounded, slightly extended posterodorsally; beaks high, broad, prosogyrate, with narrow gap between beaks; sculpture of commarginal and divaricate ribs, with strong radial lamellae posteriorly (Fig. 7A); shell white to cream-coloured; periostracum light yellow, dehiscent, dull.

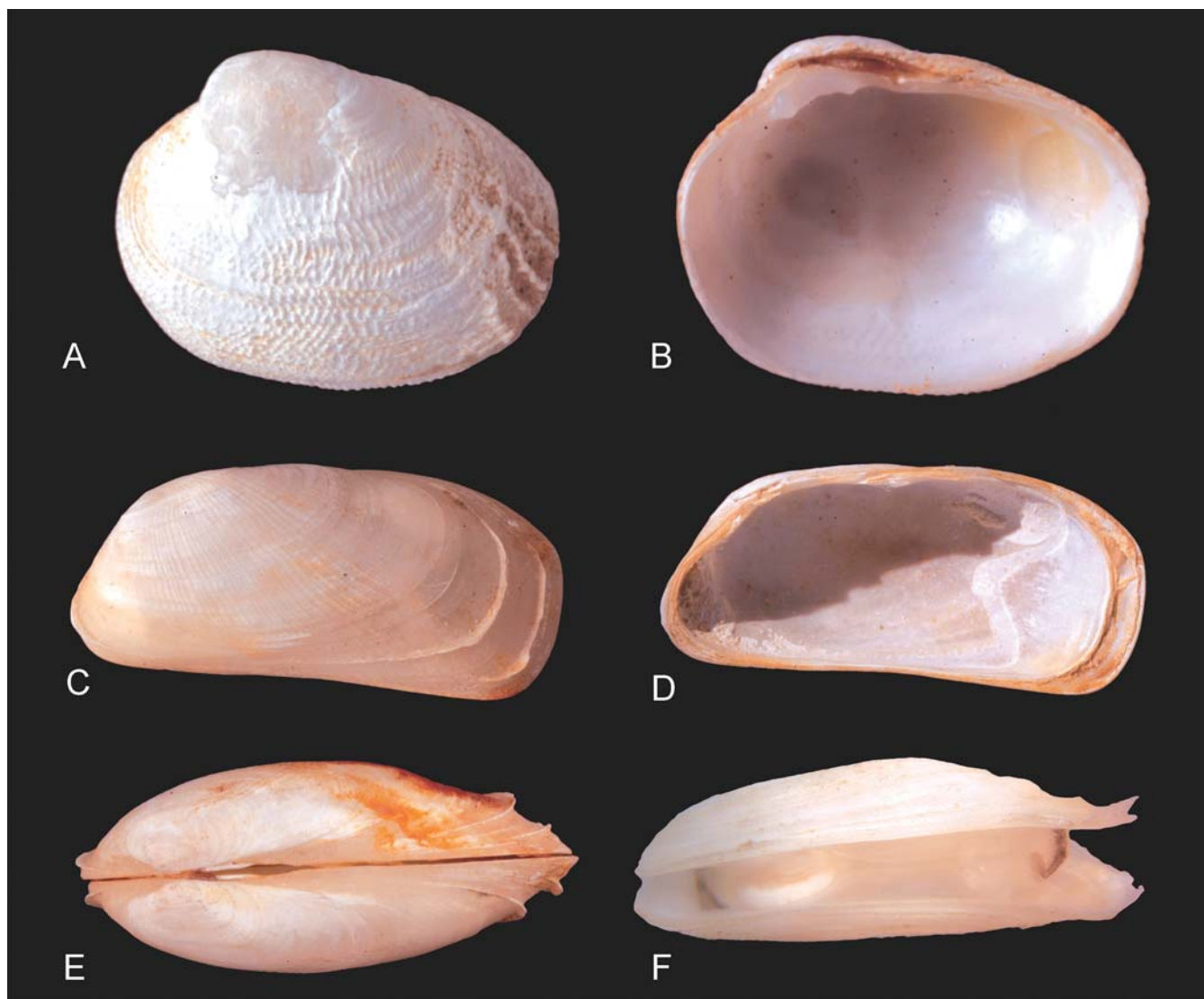


Fig. 7. *Petricola lapicida*, A–B: SBMNH 83130, length 8.19 mm; A, external left valve; B, internal right valve. *Coralliophaga coralliophaga*, C–F, SBMNH 83129, length 20.41 mm; C, external left valve; D, internal left valve; E, dorsal view; F, ventral view of living animal.

External dorsal view: Lunule absent, escutcheon long, moderately shallow, narrow; ligament moderate in length, sunken; siphons not observed in life, preserved specimen with purplish-pink tips with black spots.

Internal view: Ctenidia short, rounded, wide; outer and inner demibranchs approximately equal in width; lamellae wide, distinct, with about 11 filaments on each lamella. Labial palps small, short, subtriangular, yellow, with about 10 plicae on surface of each palp. Digestive gland small, light brown; gonad of mature specimen not observed; cardiac region not observed.

Shell white, porcellaneous; hinge with distinct cardinal teeth, left valve with thin posterior cardinal and thick bifid anterior cardinal, right valve with two stout cardinals (Fig. 7B); pallial sinus moderately deep, wide; anterior adductor muscle narrow, long; posterior adductor muscle large, ovate.

**Measurements.** – Dimensions of specimen described (SBMNH 80197): Shell length 8.22 mm, height at widest part 5.99 mm.

**Habitat.** – Found boring in dead coral at northern entrance of Kungkrabaen Bay (KKB-05). Uncommon; only one living specimen found and collected during survey. One dead specimen collected by P. Graham Oliver near KKB-05.

**Literature.** – Lamy (1923), Morton (1983b), Nielsen (1986), Morton & Scott (1988), Kleeman (1990a), Oliver (1992: 193), Valentich-Scott & Dinesen (2004).

#### Trapeziidae Pholadidae Lamy, 1920

##### *Coralliophaga coralliophaga* (Gmelin, 1791)

(Fig. 7C–F)

**Diagnosis.** – Shell subquadrate-elongate; sculpture of radial striae and commarginal striae, the latter becoming lamellose posteriorly (Fig. 7C).

**Description.** – External lateral view: Shell subquadrate-elongate, anterior broadly rounded, posterior subtruncate; beaks pointed, prosogyrate, with gap between beaks, dark brown lines inclined towards beak; sculpture of radial striae, and commarginal striae which become lamellose posteriorly (Fig. 7C); periostracum dehiscent, dull.

External dorsal view: Lunule absent, escutcheon absent; ligament moderate in length, sunken; siphons fused, translucent, short, wide; siphonal tentacles on inhalant siphon only, simple, few in number; siphonal tips with dark brown maculations (Fig. 7F).

External ventral view: Slightly gaping in life; mantle translucent, with white striae, fused for slightly more than half shell length, pedal gape large; foot white.

Internal view: Anatomy not observed.

Shell cream-coloured to light brown; hinge with two cardinal teeth and elongate posterior lateral tooth; dentition in left valve more reduced than in right; pallial sinus shallow, wide.

**Measurements.** – Dimensions of specimen described (SBMNH 80207): Shell length 16.1 mm, height at widest part 6.4 mm.

**Habitat.** – Found in living coral at southern (KKB-07) entrance of Kungkrabaen Bay, and in offshore living corals (KKB-12 and KKB-13).

**Remarks.** – This species nestles in burrows previously made by other boring species, rather than being a true coral borer (Oliver, 1992: 172).

**Literature.** – Lyngé (1909: 70–71), Scott (1980), Morton (1983b), Nielsen (1986), Lamprell & Whitehead (1992: 122), Oliver (1992: 172), Okutani (2000: 993), Valentich-Scott (2003), Qi (2004: 297).

#### Pholadidae Lamarck, 1809

##### *Aspidopholas ovata* (G. B. Sowerby II, 1849)

(Fig. 8A–G)

**Diagnosis.** – Shell half-ellipsoid, very inflated (Fig. 8C); external sculpture of two zones divided by narrow sulcus; callum weak or absent; siphonal flare tentacles simple, moderately long, thick, few in number (< five); inside inhalant siphon with large, white, complex, branched tentacles, oriented towards center of siphon, approximately 10 in number (Fig. 8F).

**Description.** – External lateral view: Shell half-ellipsoid; anterior end pointed, broadly open ventrally; posterior end broadly rounded, incurved medioventrally; beaks low, broad, covered by mesoplax; sculpture in two zones, divided by shallow radial sulcus, imbricated commarginal ribs on anterior end, fine commarginal striae on posterior end (Fig. 8A); mesoplax recurved, strongly adhering to anterior portion of shell (Fig. 8A–B); callum not present in material examined; periostracum translucent, dull.

External dorsal view: Shell very inflated, anterior end covered by fleshy, thick mantle (Fig. 8D); beaks small, low, broad, covered by mesoplax (Fig. 8C); lunule absent; ligament short, narrow, slightly protruding; siphons fused, wide, long, white, flaring at end, internally maculated gray at tip, with numerous, sporadic white spots; siphonal flare with simple, short, trigonal papillae at edge of flare; siphonal tentacles simple, moderately long, thick, few in number (< 5), maculated dorsoventrally, with attachment inside siphonal flare (Fig. 8G); low papillae surrounding siphonal apertures, but not on apertural edge (Fig. 8G); inside inhalant siphon with large, white, complex, branched tentacles, oriented towards center of siphon, ca. 10 in number (Fig. 8F).

External ventral view: Shell widely gaping, but meeting medially (Fig. 8E); mantle white; foot white, large, wide, dorsal-ventrally flattened, oval; byssal gland observable as yellow-green region on posterior portion of foot.

Internal view: Ctenidia long, narrow, extending into base of siphons, very thick, outer demibranch irregularly folded,

inner demibranch with strong radial bands, outer and inner demibranchs of approximately same width; lamellae very fine, inner demibranch with about 17 filaments between radial bands. Labial palps trigonal-elongate, pointed at posterior end, with about 36 plicae on surface of each palp, ventral edge scalloped. Digestive gland large, extending into foot, dark green; gonad primarily in posterodorsal portion of foot,

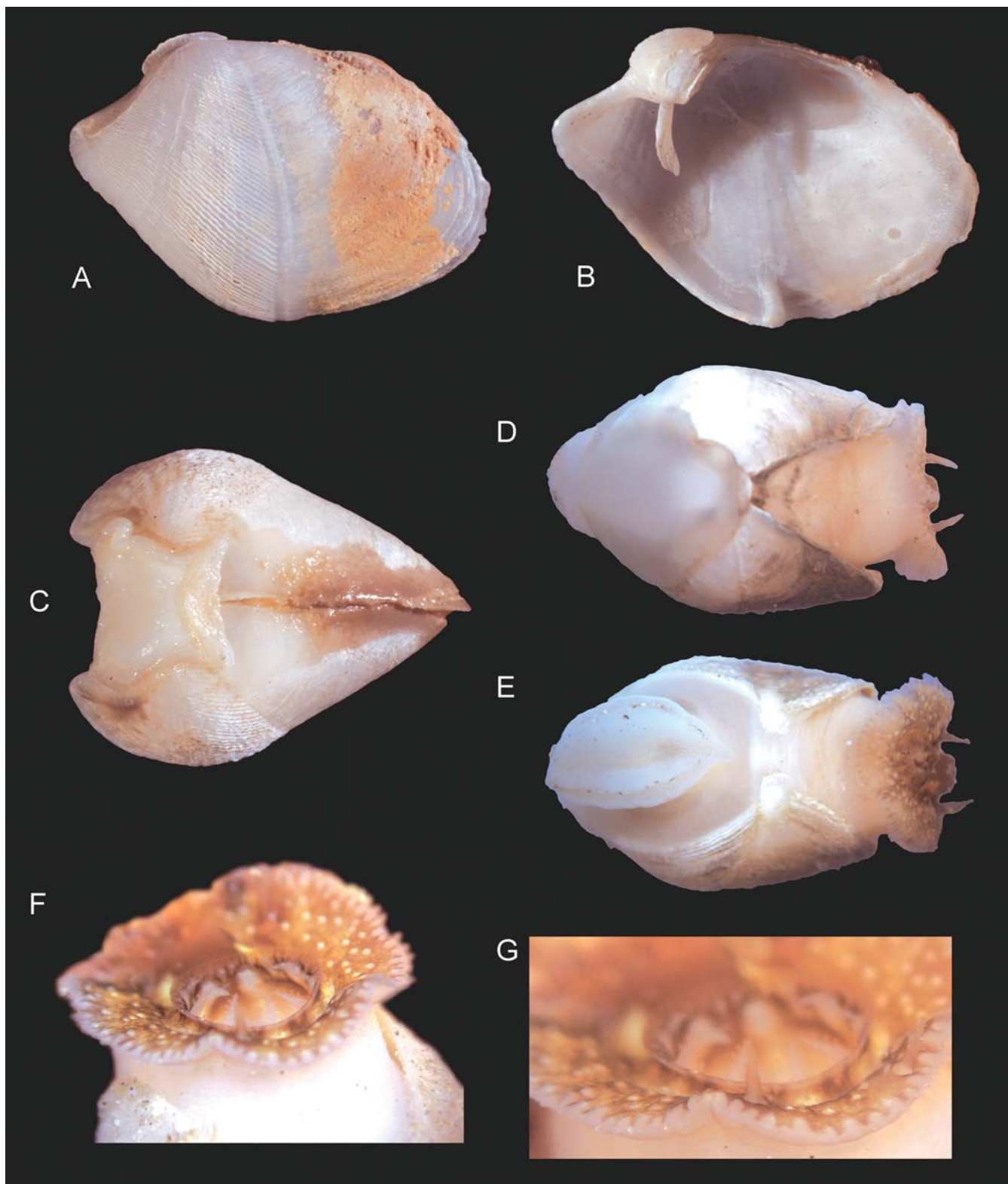


Fig. 8. *Aspidopholas ovata*, A–G: A–B, SBMNH 83131, length 18.90 mm: A, external left valve, B, internal right valve; C–G, SBMNH 83131, length 14.10 mm: C, dorsal view of shell; D, dorsal view of living animal; E, ventral view of living animal; F, close-up of siphonal region; G, serrate siphonal tentacles.



white, spotted, not extending into mantle cavity; cardiac region not easily observed.

Shell bright white to cream-coloured, porcellaneous; hinge edentate; apophysis short to moderate in length, narrow, tangentially truncate (Fig. 8B); pallial sinus very deep, broad; anterior adductor muscle large near dorsal margin; posterior adductor muscle small, near ventral margin.

**Measurements.** – Dimensions of specimen described (SBMNH 80200): Shell length 14.35 mm, height at widest part 10.90 mm; siphonal length in constricted condition 10.77 mm

**Habitat.** – Found boring in living coral at southern (KKB-07) entrance of Kungkrabaen Bay and offshore (KKB-13), sometimes in very high densities in living coral. Also found boring into thick dead shells (*Spondylus* and *Hyotissa*). Siphonal opening in coral small, round.

**Remarks.** – In his original description of this species, Sowerby (1849) stated that the locality of the type specimen was unknown. Given the close resemblance between his original illustrations and our Thailand specimens, we can reasonably presume that the type locality of this species is in the tropical Indo-Pacific. To our knowledge, this species has not been reported since Sowerby (1872). We are hopeful that the illustrations provided here will allow other workers to expand the known distribution of the species.

**Literature.** – Sowerby (1849: 493; 1872: Pl. 7, sp. 29).

***Aspidopholas multistriata* (G. B. Sowerby II, 1849)**  
(Fig. 9A–G)

**Diagnosis.** – Shell ellipsoid, moderately inflated (Fig. 9D); external sculpture of four zones, divided by narrow sulcus between medial zones; callum present, even in small specimens (Fig. 9F); siphonal tentacles simple, long, thin, numerous (> 10) (Fig. 9C, E); few white tentacles longitudinally arranged inside siphonal aperture.

**Description.** – External lateral view: Shell ovate-elongate; posterior produced, narrowly rounded; beaks low, broad, covered by mesoplax; sculpture of four zones, imbricated commarginal ribs on anterodorsal zone, very fine commarginal striae on anteroventral zone (callum), moderate commarginal ribs on medial zone, followed posteriorly by radial sulcus, then by very fine commarginal striae on posterior zone (Fig. 9A); mesoplax recurved, strongly adhering to anterior portion of shell; callum present, even in small specimens (< 10 mm) (Fig. 9A); periostracum translucent, dull.

External dorsal view: Small portion of anterior end covered by fleshy, thick mantle (Fig. 9D); beaks small, low, broad, covered by mesoplax; lunule absent; ligament short, narrow, slightly protruding; siphons fused, wide, long, white, flaring at end, internally maculated brown at tip; siphonal tentacles simple, long, thin, numerous (> 10) (Fig. 9C, E), maculated

orange-brown in colour, with attachment inside siphonal flare, low papillae surrounding siphonal apertures, but not on apertural edge; inside inhalant siphon with few white tentacles longitudinally arranged.

External ventral view: Narrowly gaping anteriorly (Fig. 9F), capable of completely closing posteriorly (Fig. 9D); mantle white, with translucent radial striae, completely fused except for anterior pedal gape; foot white, moderate in size, moderately narrow, flat, ellipsoid; byssal gland not observed.

Internal view: Ctenidia white, wide, extending into base of siphons, very thick, outer demibranch irregularly folded, inner demibranch with strong radial bands, outer and inner demibranchs of approximately same width; lamellae very fine, inner demibranch with ca. 17 filaments between radial bands. Labial palps white, trigonal-elongate, pointed at posterior end, with about 32 plicae on surface of each palp, ventral edge scalloped. Digestive gland small, light brown; gonad large, partially in posterodorsal portion of foot, white, occupying approximately 25% of mantle cavity; cardiac region not observed.

Shell bright white to cream, porcellaneous; hinge edentate; apophysis short to moderate in length, very narrow, straight truncate (Fig. 9B); pallial sinus moderately deep, broad, well short of apophysis; anterior adductor muscle large, near dorsal margin; posterior adductor muscle small, near ventral margin; short, wide internal rib medioventrally, reflecting external sulcus.

**Measurements.** – Dimensions of specimen described (SBMNH 80199): Shell length 18.96 mm, height at widest part 11.78 mm; siphonal length in constricted condition 6 mm.

**Habitat.** – Found boring in living and dead coral at southern (KKB-07) entrance of Kungkrabaen Bay, frequently in very high densities (Fig. 9F) in living coral. Also found boring into thick dead shells (*Spondylus* and *Hyotissa*). Siphonal opening in coral small, round.

**Remarks.** – Placed in the wood-boring genus *Martesia* Sowerby, 1824, by Lamprell & Healy (1998), we find this coral-boring species to align much better with *Aspidopholas*, based on shell and siphonal characters (Fischer, 1887).

**Literature.** – Lamprell & Healy (1998: 200).

***Aspidopholas obtecta* (G. B. Sowerby II, 1849)**  
(Fig. 10A–F)

**Diagnosis.** – Shell ellipsoid, moderately inflated (Fig. 10D); external sculpture of four zones; medial zones divided by narrow sulcus; callum present, even in small specimens; calcareous burrow lining attached to posterior end of shell in most specimens (Fig. 10E); siphonal tentacles simple, very short, trigonal, translucent; inside flare with very few

long, slender tentacles; near exhalant siphon with very few (< 5) long, slender, brown tentacles (Fig. 10C); with short, white tentacles inside inhalant siphon.

**Description.** – External lateral view: Shell ovate-elongate (Fig. 10A); posterior produced, narrowly rounded, compressed laterally; beaks low, broad, covered by mesoplax (Fig.

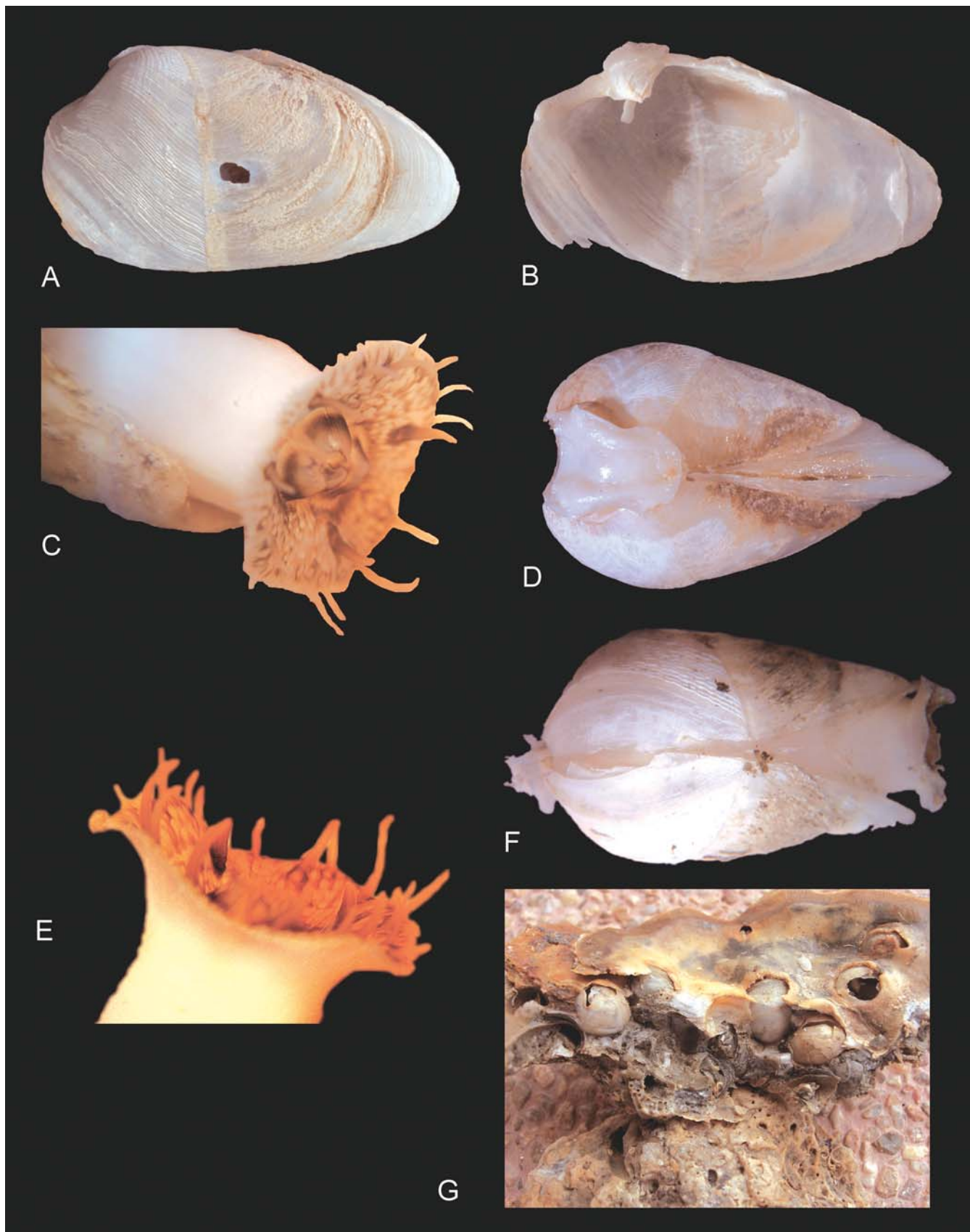


Fig. 9. *Aspidopholas multistriata*, A–G: A–B, SBMNH 83132, length 23.40 mm: A, external left valve, B, internal right valve; C–F, SBMNH 80199, length 25.10 mm: C, fused siphon of living animal with smooth tentacles; D, dorsal view of shell; E, fused siphon of living animal with smooth tentacles; F, ventral view of living animal; G, group of specimens in substratum.

10D); sculpture of four zones, imbricated commarginal ribs on anterodorsal zone, very fine commarginal striae on anteroventral zone (callum), moderate commarginal ribs on medial zone, followed posteriorly by radial sulcus, then by very fine commarginal striae on posterior zone (Fig. 10A);

mesoplax recurved, strongly adhering to anterior portion of shell; callum present, even in small specimens (< 10 mm); calcareous burrow lining attached to anterior end of shell; periostracum translucent, dull.

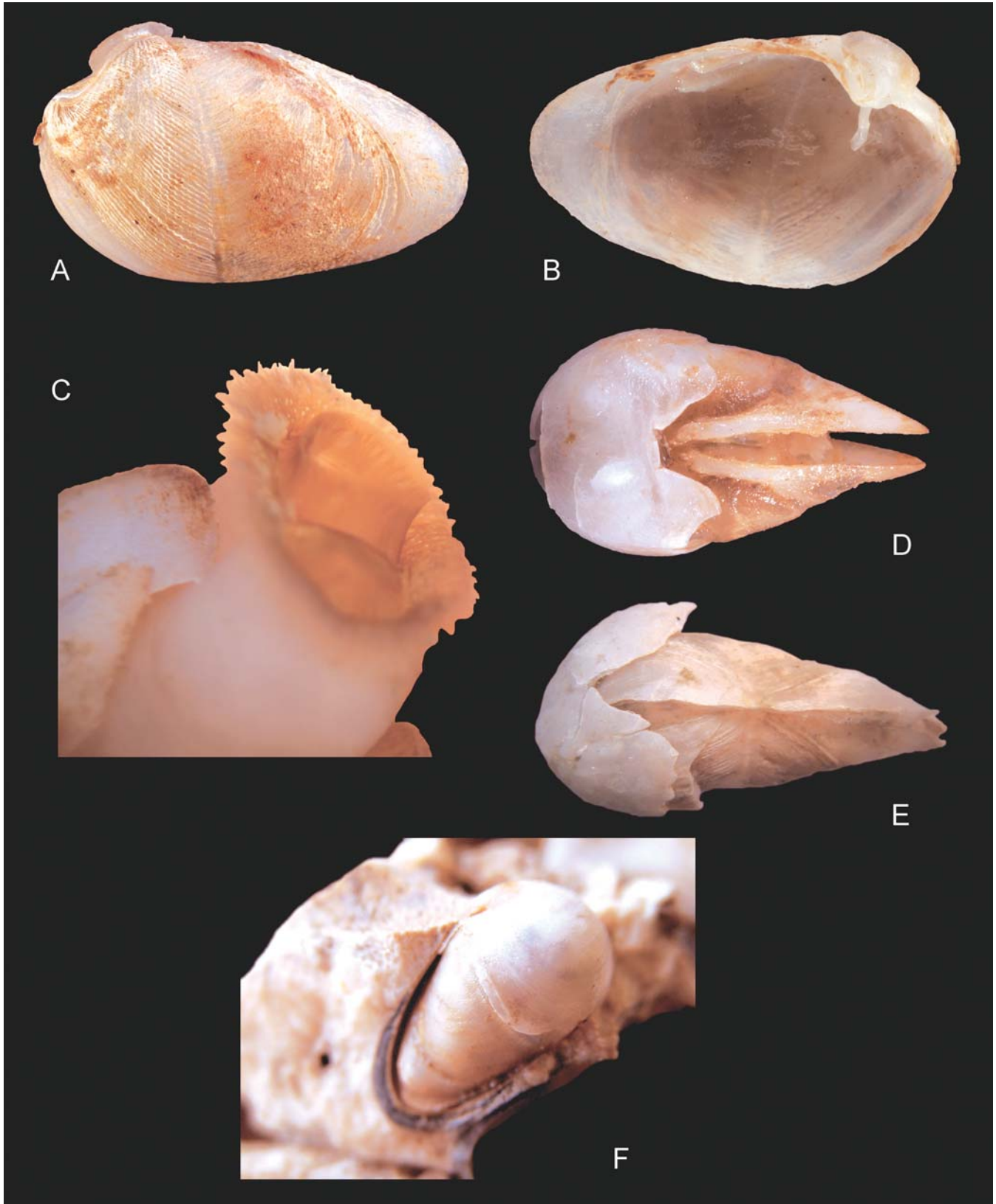


Fig. 10. *Aspidopholas obtecta*, SBMNH 83120, A–B, length 17.16 mm: A, external left valve, B, internal left valve; C, fused siphon of living animal without elongate tentacles; D–E, length 22.05 mm; D, dorsal view of shell; E, ventral view of shell; F, living animal in coral burrow.



External dorsal view: Anterior end mostly covered by fleshy, thick mantle; beaks small, low, broad, covered by mesoplax; lunule absent; ligament short, narrow, slightly protruding; siphons fused, wide, long, white outside, flaring at end, internally maculated brown at tip; siphonal flare with very small, short, white papillae; siphonal tentacles simple, along flare margin very short, trigonal, 5ucent; inside siphonal flare with very few long, slender tentacles; inhalant and exhalant siphons without external marginal tentacles; near exhalant siphon with very few (< 5) long, slender, brown tentacles; with short, white tentacles inside inhalant siphon.

External ventral view: Narrowly gaping anteriorly, capable of completely closing posteriorly (Fig. 10E); mantle white, with translucent radial striae, completely fused except for anterior pedal gape; foot white; byssal gland not observed.

Internal view: Ctenidia long, narrow, extending into base of siphons, very thick, outer demibranch irregularly folded, inner and outer demibranchs with strong radial bands, outer and inner demibranchs of approximately same width; lamellae very fine, inner demibranch with ca. 23 filaments between radial bands. Labial palps very large, trigonal-elongate, pointed at posterior end, with about 33 plicae on surface of each palp, ventral edge scalloped. Digestive gland large, dark green; gonad massive, extending into foot, white, spotted, occupying approximately 50% of mantle cavity; cardiac region white, mediodorsal, trigonal-elongate.

Shell moderately inflated, bright white to cream-coloured, porcellaneous (Fig. 10B); hinge edentate; apophysis long, thin, blunt at end; pallial sinus deep, broad, sharply pointed, extending to apophysis; anterior adductor muscle large, ovate, near dorsal margin; posterior adductor muscle large, near ventral margin; short, wide internal rib medioventrally, reflecting external sulcus.

**Measurements.** – Dimensions of specimen described (SBMNH 80201): Shell length 11.8 mm, height at widest part 5.5 mm; siphonal length in constricted condition 2 mm.

**Habitat.** – Found boring in living and dead coral (Fig. 10F) at southern entrance of Kungkrabaen Bay (KKB-07).

**Literature.** – Wong (1982), Lamprell & Healy (1998: 200), Swennen et al. (2001: 99).

### Gastrochaenidae Gray, 1840

#### *Gastrochaena carteri* Nielsen, 1986

(Fig. 11A–D)

**Diagnosis.** – Shell ovate, anterior end truncate (Fig. 11A); gaping ventrally for only anterior half of shell (Fig. 11D); siphons completely fused, white throughout, with light brown tips, inhalant siphon constricted distally (Fig. 11B); tentacles on exhalant siphon simple, long, blunt at ends; siphonal tentacles not present on inhalant siphon.

**Description.** – External lateral view: Shell ovate, anterior end truncate, posterior moderately rounded, anteroventral edge straight, dorsomedially flaring (Fig. 11A); beaks low, broad, rounded; sculpture of commarginal striae over entire surface, anteroventral slope with few tangential lamellae; periostracum translucent, dull, dehiscent.

External dorsal view: Beaks terminal, small, broad, prosogyrate; narrow gap between beaks (Fig. 11C); lunule and escutcheon absent; ligament short, moderately wide, moderately protruding; without posterodorsal gap; siphons completely fused, white throughout, with light brown tips, inhalant siphon constricted distally (Fig. 11B); tentacles on exhalant siphon simple, long, blunt at ends; siphonal tentacles not present on in view halant siphon.

External ventral: Only gaping for anterior half of shell (Fig. 11D); mantle translucent white, completely fused except for small pedal aperture; foot not observed.

Internal view: Interior not examined (see Remarks).

**Measurements.** – Dimensions of specimen described (SBMNH 80210): Shell length 6.08 mm, height at widest part 3.66 mm.

**Habitat.** – Found boring in dead coral at offshore island Koh Nom Saow (KKB-21), and boring into dead shells off Kungkrabaen Bay (SBMNH 83187).

**Remarks.** – Two specimens of this species were collected on the final day of the workshop. We were unable to examine the internal anatomy of the living animal. In order not to damage the specimens, we chose not to examine the interior of the shell. We can find no other record of this species outside of the type locality on Phuket Island in the Andaman Sea. This species is small and cryptic. We expect that the distributional range will likely expand as workers examine coral borers more carefully.

**Literature.** – Nielsen (1986).

#### *Gastrochaena* sp. 1

(Fig. 11E–H)

**Diagnosis.** – Shell ellipsoid, anterior constricted (Fig. 11E), posterior narrowly rounded; ventral shell gape for two thirds of length; siphons completely fused, white throughout, with very slight light brown maculations on the exhalant siphon, siphonal tentacles simple, short, broad at base, blunt at ends.

**Description.** – External lateral view: Shell ellipsoid, anterior constricted, posterior narrowly rounded (Fig. 11E); beaks low, broadly rounded; sculpture of very dense commarginal lamellae over entire surface, stronger ventrally, some commarginal lamellae slightly scalloped on edge; periostracum translucent, dull, dehiscent.

External dorsal view: Beaks small, broad, prosogyrate, gap between beaks not observed; lunule deep, broad, heart-shaped; ligament short, moderately narrow, not protruding; periostracum covering posterodorsal gap short, not extending

greatly posterior of ligament; siphons completely fused, white throughout (Fig. 11H), with very slight, light brown maculations on exhalant siphon, siphonal tentacles simple, short, broad at base, blunt at ends.

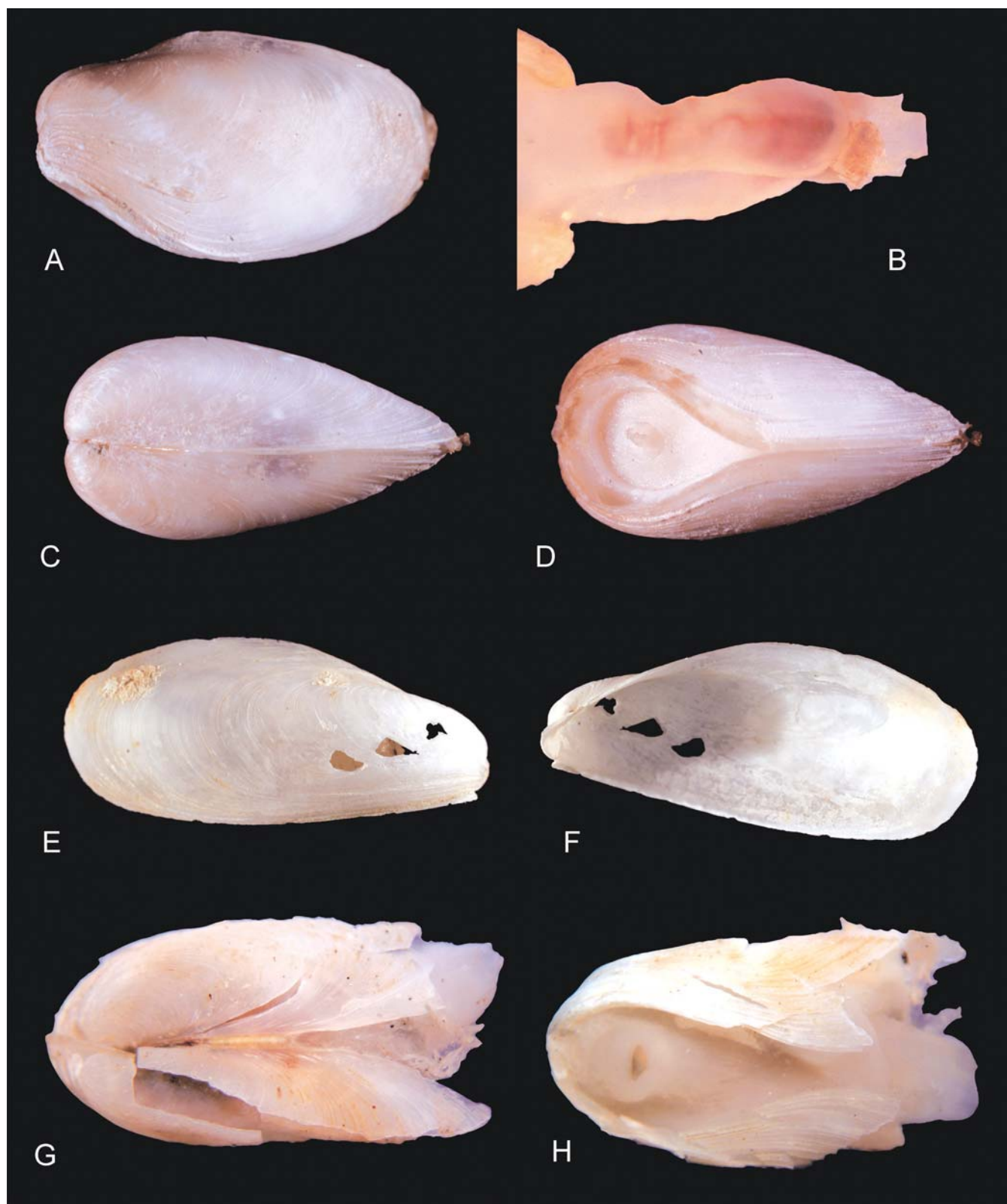


Fig. 11. *Gastrochaena carteri*, SBMNH 80210, length 6.50 mm, A–D: A, external left valve; B, fused siphons of living animal; C, dorsal view; D, ventral view. *Gastrochaena* sp. 1, SBMNH 83135, length 13.75: E, external right valve; F, internal right valve; G–H, SBMNH 80209, length approximately 11 mm (specimen crushed): G, dorsal view of living animal; H, ventral view of living animal.

External ventral view: Widely gaping for approximately two-thirds of shell length (Fig. 11H); mantle gray-white, completely fused except for small pedal aperture; foot not observed.

Internal view: Ctenidia long, moderately wide, extending into base of siphons, very thin, translucent, irregularly folded, outer and inner demibranchs approximately equal in width; lamellae fine, with ca. 13 filaments between bright white longitudinal bands. Labial palps not visible in specimens examined. Digestive gland not visible in specimens examined; gonad of mature specimens of moderate size, occupying approximately 15% of mantle cavity; cardiac region not visible in specimen dissected.

Shell white, porcellaneous; hinge edentate; pallial sinus deep, narrowly pointed anteriorly (Fig. 11F); anterior adductor muscle very small, at extreme end, posterior adductor muscle very large, ovate.

**Measurements.** – Dimensions of specimen described (SBMNH 80209): Shell length 11.15 mm, height at widest part 4.81 mm.

**Habitat.** – Found boring in dead shells offshore of Kungkrabaen Bay in coral beds (KKB-13), also at offshore island Koh Nom Saow (KKB-21).

**Remarks.** – We have been unable to fit these relatively rare specimens with a described species from the region.

***Gastrochaena cymbium* (Spengler, 1783)**

(Fig. 12A–G)

**Diagnosis.** – Shell subquadrate, anterior subtruncate, posterior end produced, narrowly rounded (Fig. 12A); siphons fused, long, narrow, slightly flaring at tip, translucent, with internal dark brown maculations, exhalant siphon slightly shorter than inhalant (Fig. 12C); ventral gape less than half shell length (Fig. 12D); usually boring into shells and forming calcareous “igloo” (Fig. 12F).

**Description.** – External lateral view: Shell subquadrate, anterior subtruncate, posterior end produced, narrowly rounded (Fig. 12A); beaks low, broadly rounded; sculpture of widely spaced commarginal striae; periostracum translucent, dull, dehiscent.

External dorsal view: Beaks large, broad, prosogyrate, without gap between beaks (Fig. 12B); lunule and escutcheon absent; ligament short, narrow, not protruding; periostracum covering dorsal gap only in medial area, not gaping posteriorly; siphons fused, long, narrow, slightly flaring at tip, translucent, with internal dark brown maculations, exhalant siphon slightly shorter than inhalant (Fig. 12C); siphonal tentacles simple, short, broad, exhalant tentacles short, inhalant longer, inhalant siphon with a few longer tentacles (ca. 5) with two or three shorter tentacles between them.

External ventral view: Widely gaping, gape less than half the length of the shell (Fig. 12D); mantle white, completely fused except for small pedal aperture; foot white, compressed mushroom-shaped in outline.

Internal view: Internal features not observed (specimen damaged).

**Measurements.** – Dimensions of specimen described (SBMNH 80216): Shell length 4.20 mm, height at widest part 1.76 mm.

**Habitat.** – Found boring into dead shells (Fig. 12F–G) and coral (Fig. 12E), offshore of Kungkrabaen Bay, collected by fisherman on trawl boats; precise locality and depth unknown.

**Remarks.** – Carter (1978) and Morton (1982) described the formation of the unusual igloo made by this species. We found specimens, with identical shells and siphons, boring into dead coral, in contrast to Carter (1978). We hypothesize that the igloo is only constructed by animals that break through the surface of their substratum. In thick corals, the igloo is not formed, but is rather a flask-like case (Fig. 12E). Further study of this species complex is necessary to define this phenomenon, and whether the specimen illustrated in Fig. 12E is conspecific with *Gastrochaena cymbium* or a distinct species.

We gratefully acknowledge the assistance of Graham Oliver for recognizing this species, and referring the material to us.

**Literature.** – Lyngø (1909: 185), Carter (1978: 63–66), Morton (1982, 1983a, b), Oliver (1992: 198, 200), Lamprell & Healy (1998: 196–98), Okutani (2000: 1026–1027), Hylleberg & Knudsen (2001), Swennen et al. (2001: 98), Valentich-Scott (2003), Qi (2004: 320).

***Gastrochaena cuneiformis* Spengler, 1783**

(Fig. 13A–E)

**Diagnosis.** – Shell ellipsoid, anterior constricted, posterior broadly rounded (Fig. 13A); ventrally gaping for almost complete length of shell (Fig. 13D); siphons completely fused, long, wide, flaring at tip, white anteriorly, dark brown at posterior end; siphonal tentacles simple, short, slender, broad at base, pointed at ends, frequently in groups of two or three, maculated dark brown at base, white at tips (Fig. 13E).

**Description.** – External lateral view: Shell ellipsoid, anterior constricted, posterior broadly rounded; beaks low, rounded; sculpture of very dense commarginal ribs anteriorly, becoming more widely spaced and lamellate posteroventrally (Fig. 13A); periostracum translucent, dull, dehiscent.

External dorsal view: Beaks small, broad, orthogyrate, with no gap between beaks (Fig. 13C); lunule deep, broad,



heart-shaped; ligament long, narrow, slightly protruding; periostracum covering posterodorsal gap very long, nearly reaching siphons, broadly U-shaped posteriorly; siphons

completely fused, long, wide, flaring at tip, white anteriorly, dark brown at posterior end; siphonal tentacles simple, short, slender, broad at base, pointed at ends, frequently

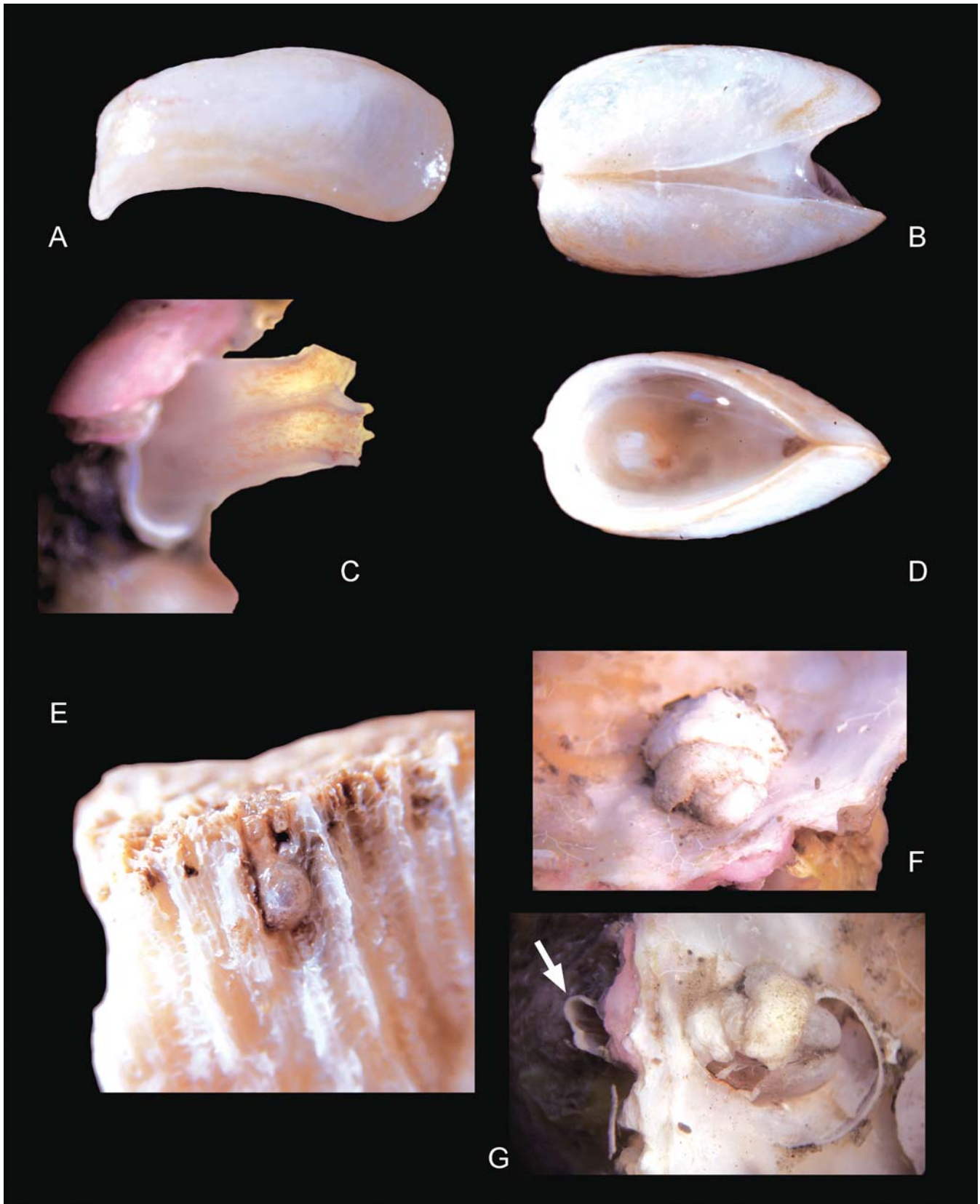


Fig. 12. *Gastrochaena cymbium*, A–G: A–D, SBMNH 80216, length 4.95 mm: A, external left valve; B, dorsal view; C, siphons of living animal (shell and igloo of this specimen are figured in Figs. 12F, G below); D, ventral view; E, encased shell in coral; F, “igloo” on surface of coral; G, broken igloo showing dorsal view of shell inside, note “figure eight” calcified siphon chamber on left (arrow).

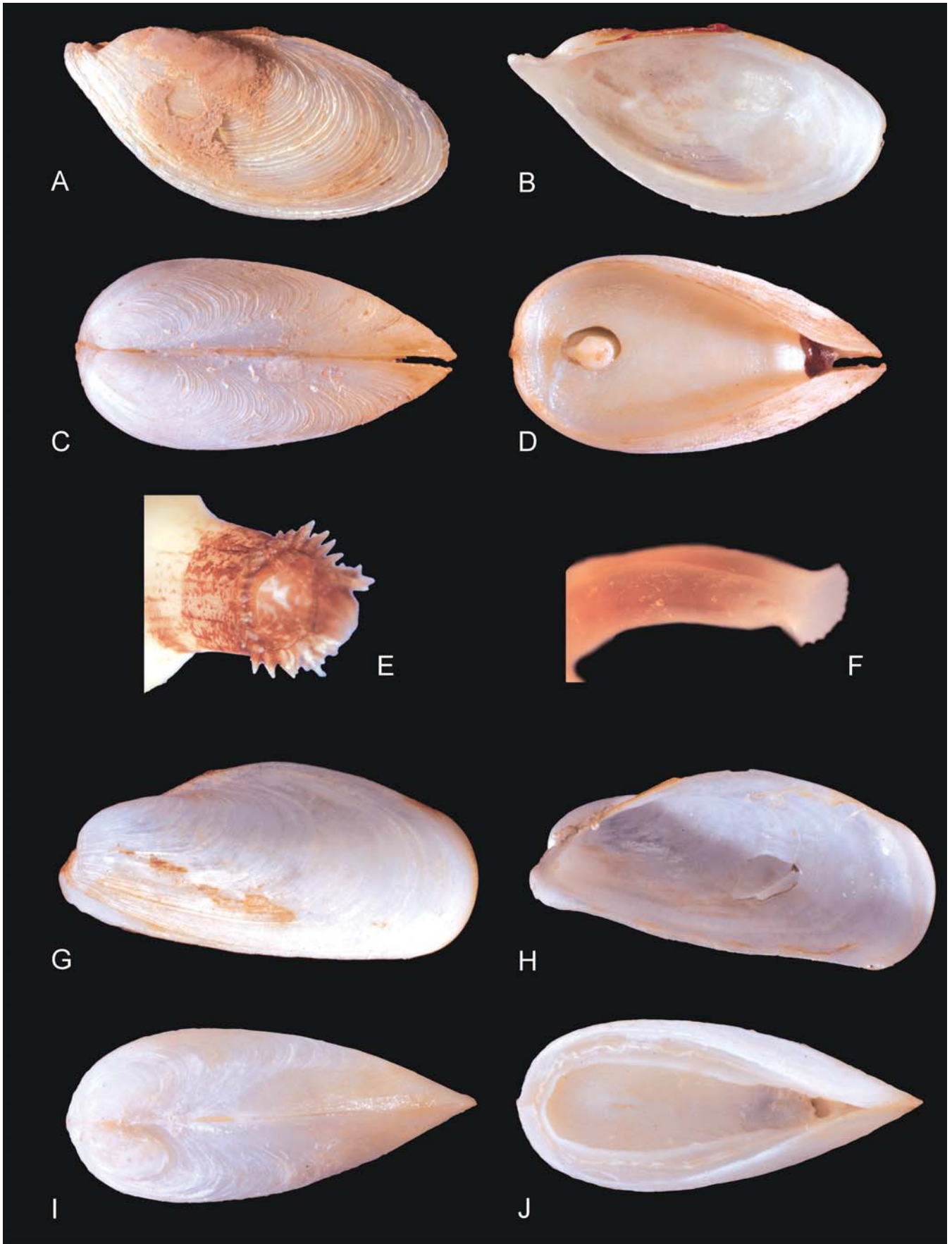


Fig. 13. A–E, *Gastrochaena cuneiformis*: A–B, SBMNH 83133, length 21.06 mm; A, external left valve, B, internal right valve; C–D, SBMNH 83118, length 18.30 mm; C, dorsal view; D, ventral view; E, fused siphons of living animal. F–J, *Gastrochaena cf. inaequistriata*; F, fused siphons of living animal; G–J, SBMNH 83134, length 15.05 mm; G, external left valve; H, internal right valve; G–I, SBMNH 80206, length 15.05 mm; I, dorsal view; J, ventral view.

in groups of two or three, maculated dark brown at base, white at tips (Fig. 13E), exhalant tentacles short, those of inhalant longer.

External ventral view: Widely gaping for almost complete length of shell (Fig. 13D); mantle white, completely fused except for small pedal aperture; foot white, broad at base, slender and blunt at tip.

Internal view: Ctenidia long, narrow, extending into base of siphons, very thick, irregularly folded, outer demibranch half width of inner demibranch; lamellae very fine, with 11–17 filaments between bright white longitudinal bands. Labial palps large for family, thin, subquadrate, scalloped on dorsal edge, with about 19 filaments on surface of each palp. Digestive gland small, limited to anterodorsal region, dark green; gonad of mature specimens massive, occupying ca. 25% of mantle cavity; cardiac region immediately posterior of digestive gland, reddish-brown, trigonal-elongate.

Shell white, porcellaneous (Fig. 13B); hinge edentate; pallial sinus deep, broad posteriorly, pointed anteriorly; anterior adductor muscle very small, at extreme end, posterior adductor muscle large.

**Measurements.** – Dimensions of specimen described (SBMNH 80203): Shell length 22.08 mm, height at widest part 10.35 mm; siphonal length in relaxed condition 16.13 mm.

**Habitat.** – Found boring in living and dead coral at northern (KKB-05) and southern (KKB-07) entrances of Kungkrabaen Bay and offshore in living corals (KKB-12), frequently in very high densities in living coral; also in offshore living corals at KKB-08, and offshore of the island Koh Nom Saow (KKB-21). Calcified siphonal opening easily visible in coral, as figure-eight shape.

**Remarks.** – This was the most numerous of the *Gastrochaena* species in the region, and was found in almost every habitat sampled. Carter (2008) has synonymized *G. gigantea* (Deshayes, 1830) with this species.

**Literature.** – Scott (1980), Morton (1983a, b), Kleeman (1990a), Lamprell & Healy (1998: 196), Okutani (2000: 1026–1027), Hylleberg & Krudsen (2001), Valentich-Scott (2003), Qi (2004: 320), Carter (2008). Carter (2008) has synonymized *G. gigantea* (Deshayes, 1830) with this species.

***Gastrochaena cf. inaequistriata* Jousseume in Lamy, 1923**

(Fig. 13F–J)

**Diagnosis.** – Shell ellipsoid, anterior constricted; external shell sculpture including strong anteroventral tangential ribs (Fig. 13G); ventrally gaping for almost complete length of shell (Fig. 13J); siphons fused most of length, but with medial depression between them, long, narrow, slightly flaring at

ends, inhalant slightly longer than exhalant, externally white, translucent at tip, internally dark brown (Fig. 13F).

**Description.** – External lateral view: Shell ellipsoid, anterior very constricted, posterior end broadly round; beaks low, rounded; sculpture of closely spaced commarginal striae, strong tangential ribs anteroventrally; periostracum translucent, dull, dehiscent.

External dorsal view: Beaks moderately large, broad, orthogyrate, with no gap between beaks; lunule deep, broad, heart-shaped; ligament long, narrow, not protruding; periostracum covering posterodorsal gap almost reaching siphons, broad, straight posteriorly; siphons fused most of length, but with medial depression between them, long, narrow, slightly flaring at ends, inhalant slightly longer than exhalant, externally white, translucent at tip, internally dark brown (Fig. 13F); siphonal tentacles simple, very short (even shorter on exhalant siphon), narrow, translucent, few in number.

External ventral view: Widely gaping for almost complete length of shell (Fig. 13J); mantle light yellow, with white spots in larger specimens, completely fused except for small pedal aperture; foot white, byssal gland apparent with dark colouration.

Internal view: Ctenidia relatively short, broad, not extending into base of siphons, very thin, slightly folded, outer demibranch one half width of inner demibranch; lamellae very fine, without bright white longitudinal bands or easily visible, strong interlamellar junctions between filaments, filaments very numerous (> 500). Labial palps white, small, short, moderately narrow, ellipsoid, broadly pointed posteriorly, with ca. 13 filaments on surface of each palp. Digestive gland small, limited to anterodorsal region of mantle cavity, dark green; gonad of mature specimens massive, occupying approximately 50% of mantle cavity, ovate, white throughout; cardiac region immediately posterior of digestive gland, brown.

Shell white, porcellaneous (Fig. 13H); hinge edentate; pallial sinus deep, trigonal, broad posteriorly, narrow and pointed anteriorly; anterior adductor muscle very small, at extreme end, posterior adductor muscle large.

**Measurements.** – Dimensions of specimen described (SBMNH 80206): Shell length 8.11 mm, height at widest part 4.52 mm; siphonal length in relaxed condition 12.79 mm.

**Habitat.** – Found boring in living and dead coral at the northern (KKB-05) and southern (KKB-07) entrances of Kungkrabaen Bay, and offshore in living corals (KKB-12), and also at the offshore island Koh Nom Saow (KKB-21). Siphonal openings easily visible in coral as figure-eight shape.

**Remarks.** – Moderately uncommon in the study area, especially when compared to the high densities of *Gastrochaena cuneiformis*.



*Literature.* – Nielsen (1986), Oliver (1992: 199).

***Gastrochaena cf. pexiphora* Sturany, 1899**

(Fig. 14A–D)

*Diagnosis.* – Shell ellipsoid, anterior end constricted, posterior end subtruncate (Fig. 14A); ventrally gaping for over three fourths of shell length, gape rounded posteriorly (Fig. 14D); siphons completely fused, translucent white over entire length, inhalant siphon broad, exhalant constricted; siphonal tentacles simple, very short, very narrow, blunt at ends (Fig. 14B).

*Description.* – External lateral view: Shell ellipsoid, anterior end constricted, posterior end subtruncate (Fig. 14A); beaks low, broad, rounded; sculpture of commarginal striae over entire surface, ventral slope with strong commarginal ribs; periostracum translucent, dull, dehiscent.

External dorsal view: Beaks small, broad, prosogyrate, without gap between beaks (Fig. 14C); lunule and escutcheon absent; ligament short, moderately wide, moderately protruding; with short posterodorsal gap; siphons completely fused, translucent white over entire length, inhalant siphon broad, exhalant constricted; siphonal tentacles simple, very short, very narrow view, blunt at ends (Fig. 14B).

External ventral: Ventrally gaping for over three fourths of shell length, gape rounded posteriorly (Fig. 14D); mantle translucent white, completely fused except for large pedal aperture; posterior end blunt, slightly projecting medially; foot not observed.

Internal view: Internal characters not examined (see Remarks below).

*Measurements.* – Dimensions of specimen described (SBMNH 80211): Shell length 11.83 mm, height at widest part 5.16 mm.

*Habitat.* – Found boring in dead coral at the offshore island Koh Nom Saow (KKB-21).

*Remarks.* – Only a single individual of this species was collected during the survey. As such, we were unable to observe or document the anatomy or inner characters of the shell.

*Literature.* – Nielsen (1986), Oliver (1992: 199).

***Gastrochaena dentifera* Dufo, 1840**

(Fig. 14E–H)

*Diagnosis.* – Shell subquadrate-elongate, anterior not constricted, slightly incurved ventromedially (Fig. 14E); widely gaping ventrally, extending almost entire length of shell (Fig. 14H); siphons fused for most of length, long, narrow, slightly flaring at ends, inhalant slightly longer

than exhalant, externally white, tips sparsely maculated dark brown, internally white to light brown; siphonal tentacles simple, very short, narrow, translucent.

*Description.* – External lateral view: Shell subquadrate-elongate, anterior not constricted, slightly incurved ventromedially (Fig. 14E); posterior end broadly truncate; beaks low, rounded; sculpture of closely spaced commarginal striae; periostracum translucent, dull, dehiscent.

External dorsal view: Beaks at anterior end moderately large, broad, prosogyrate, with narrow gap between beaks (Fig. 14G); lunule not visible from dorsal side, shallow, broad; ligament very short, narrow, slightly protruding; periostracum covering posterodorsal gap approximately three quarters of distance to siphons, broad, U-shaped posteriorly; siphons fused for most of length, long, narrow (Fig. 14F), slightly flaring at ends, inhalant slightly longer than exhalant, externally white, tips sparsely maculated dark brown, internally white to light brown; siphonal tentacles simple, very short, narrow, translucent.

External ventral view: Shell widely gaping, extending almost entire length of shell (Fig. 14H); mantle translucent, with opaque white spots in tissue, completely fused except for small pedal aperture; foot white, with byssal gland apparent as darkened colouration.

Internal view: Internal characters not examined.

*Measurements.* – Dimensions of specimen described (SBMNH 80212): Shell length 6.61 mm, height at widest part 3.01 mm; siphonal length in relaxed condition 6.39 mm.

*Habitat.* – Found boring in living coral at southern (KKB-07) entrance of Kungkrabaen Bay.

*Remarks.* – Seven specimens of this species were found boring into a single coral head, but no other material was collected during the survey.

*Literature.* – Nielsen (1986), Oliver (1992: 198–199).

***Spengleria apertissima* (Deshayes, 1855)**

(Fig. 15A–D)

*Diagnosis.* – Shell ellipsoid, anterior constricted, posterior end subtruncate (Fig. 15A); ventrally gaping for almost complete length of shell; siphons separate, only fused at base (Fig. 15C), long, narrow, constricted at tip, externally white, dark brown at tip, internally dark brown; siphonal tentacles simple, short, broad, some branched, solid dark brown (Fig. 15D).

*Description.* – External lateral view: Shell ellipsoid, anterior constricted, posterior end subtruncate; beaks low, rounded; sculpture of closely spaced, posteriorly squared commarginal ribs (Fig. 15A); periostracum translucent, dull, dehiscent.

External dorsal view: Beaks small, broad, prosogyrate, with distinct gap between beaks; lunule shallow, broad, heart-shaped; ligament long, moderately wide, slightly protruding; periostracum covering posterodorsal gap, only reaching halfway to siphons, narrow, U-shaped posteriorly; siphons separate, only fused at base, long, narrow, constricted at tip, externally white, dark brown at tip, internally dark brown (Fig. 15C); siphonal tentacles simple, short, broad, some branched, solid dark brown (Fig. 15D); exhalant tentacles short, those of inhalant longer.

External ventral view: Widely gaping for entire length of shell; mantle white, completely fused except for small pedal aperture; foot white.

Internal view: Ctenidia long, narrow, extending into base of siphons, very thin, slightly folded, outer demibranch one third width of inner demibranch; lamellae very fine, with nine or ten filaments between bright white longitudinal bands, with strong interlamellae connections between filaments. Labial palps small, narrow, ellipsoid, thin, smooth, dark brown

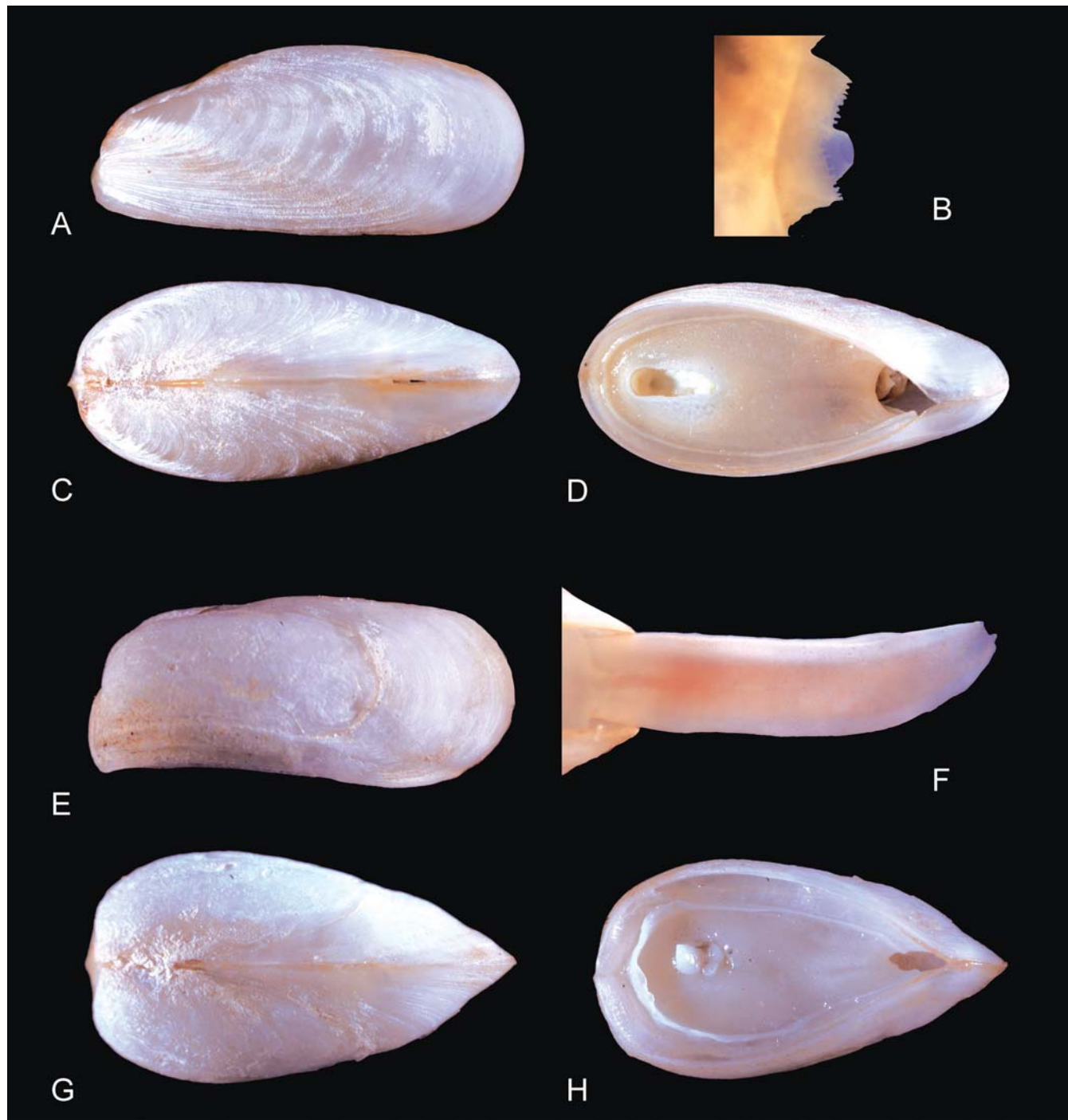


Fig. 14. *Gastrochaena* cf. *pexiphora*, SBMNH 80211, length 12.05 mm, A–D: A, external left valve; B, siphons of living animal; C, dorsal view; D, ventral view. *Gastrochaena dentifera*, SBMNH 80212, length 6.81 mm, E–H: E, external left valve; F, siphon of living animal; G, dorsal view; H, ventral view.

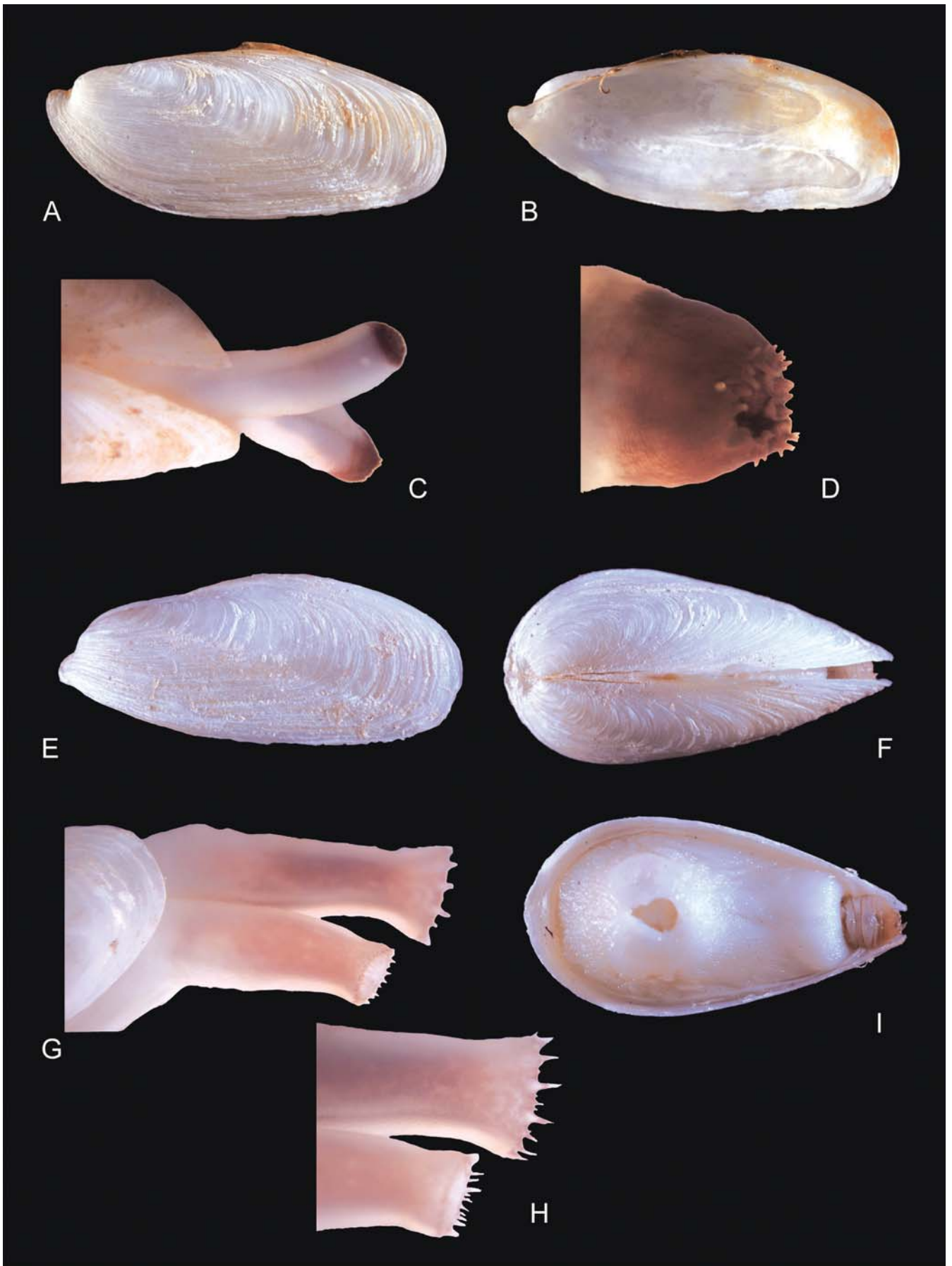


Fig. 15. *Spengleria apertissima*, A–D: A–B, SBMNH 83136, length 17.70 mm: A, external left valve; B, internal right valve; C–D, SBMNH 83137: C, separate siphons of living animal (note black siphon tips); D, close up of siphonal tip of living animal. *Spengleria* sp. 1, SBMNH 80215, length 10.75 mm, E–I: E, external left valve; F, dorsal view; G, separate siphons of living animal; H, detail of siphonal tentacles of living animal; I, ventral view.



on dorsal edge, with about 25 filaments on surface of each palp. Digestive gland small, limited to anterodorsal region, dark green; gonad of mature specimens massive, occupying approximately 25% of mantle cavity, elongate, narrow, dark brown dorsally; cardiac region immediately posterior of digestive gland, reddish-brown, trigonal-elongate.

Shell white, porcellaneous; hinge edentate; pallial sinus deep, very narrow along entire length, pointed anteriorly; anterior adductor muscle very small, at extreme end, posterior adductor muscle large (Fig. 15B).

**Measurements.** – Dimensions of specimen described (SBMNH 80213): Shell length 20.3 mm, height at widest part 8.5 mm; siphonal length in preserved condition 10.0 mm.

**Habitat.** – Found boring in living coral at southern (KKB-07) entrance of Kungkrabaen Bay, and on offshore coral reefs (KKB-13).

**Literature.** – Nielsen (1986), Swennen et al. (2001: 98).

***Spengleria* sp. 1**  
(Fig. 15E–H)

**Diagnosis.** – Shell ellipsoid, anterior slightly constricted and turned ventrally, posterior end narrowly rounded (Fig. 15E); ventrally gaping for almost complete length of shell (Fig. 15I); siphons separate for entire length, long, narrow, slightly flaring at ends (Fig. 15G), externally white, translucent at tip, internally maculated dark brown; siphonal tentacles maculated brown and white, simple, short, narrow (Fig. 15H).

**Description.** – External lateral view: Shell ellipsoid, anterior slightly constricted and turned ventrally (Fig. 15E), posterior end narrowly rounded; beaks moderately low, rounded; sculpture of closely spaced commarginal ribs, stronger ventrally; periostracum translucent, dull, dehiscent.

External dorsal view: Beaks large, broad, prosogyrate, with no gap between beaks (Fig. 15F); lunule deep, broad, heart-shaped; ligament short, narrow, slightly protruding; periostracum covering posterodorsal gap almost reaching siphons, moderately wide, U-shaped posteriorly; siphons separate for entire length, long, narrow, slightly flaring at ends, externally white, translucent at tip, internally maculated dark brown; siphonal tentacles maculated brown and white, simple, short, narrow; inhalant siphon with few large tentacles with two or three smaller tentacles between them; exhalant siphon with very small subequal tentacles (Fig. 15H).

External ventral view: Widely gaping; mantle dark yellow, completely fused except for small pedal aperture; foot white.

Internal view: Internal characters not observed.

**Measurements.** – Dimensions of specimen described

(SBMNH 80215): Shell length 10.56 mm, height at widest part 4.86 mm; siphonal length in relaxed condition 5.46 mm.

**Habitat.** – Found boring in living coral at northern entrance of Kungkrabaen Bay (KKB-05).

**Remarks.** – This species appears to be undescribed. We can find no similar species in the Indo-Pacific literature. In that we only collected a single specimen, a new species description will need to await further material.

## DISCUSSION

The 21 species of coral-boring bivalves reported herein exceeds the diversity in localized and broad-scale surveys reported in the Indo-Pacific region. Reporting the highest diversity adjacent to our study area, Nielsen (1986) documented 18 species of coral borers from Phuket Island in the Andaman Sea, Thailand. Surprisingly, Swennen et al. (2001) only reported nine species in the southwestern Gulf of Thailand. However, this broad overview of the region did not specifically document coral-associated molluscs.

To the west of Thailand, Oliver (1992) described and illustrated 19 species of coral-boring bivalves. To the east, 17 species were reported off Vietnam (Hylleberg & Kilburn, 2003) and 15 species from Chinese waters (Qi, 2004). Finally to the south, the diversity in Australia is probably greatly underestimated at 19 species (Lamprell & Whitehead, 1992; Lamprell and Healy, 1998).

By contrast, only eight species were reported in the Florida Keys, in the tropical western Atlantic Ocean (Valentich-Scott & Dinesen, 2004), although that study only included borers in dead coral.

The comprehensive reports by Morton (1983b, 1990) illustrate the need to calibrate the identifications of the coral-associated bivalves within the Indo-Pacific region. Many species discussed in this publication were listed as synonyms by previous and subsequent workers. Additional taxonomic study of the coral borers and their coral hosts on a much broader geographic scale is necessary to truly delineate the Indo-Pacific fauna. Observation and documentation of the living animals, in particular their siphons, will aid in their consistent identification throughout the region.

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## THAI ABSTRACT

คณะผู้วิจัยรายงานผลการสำรวจหอยสองฝาที่เจาะและฝังตัวอยู่ในก้อนปะการังบริเวณน้ำขึ้นง และบริเวณใต้ระดับน้ำจากบริเวณภาคตะวันออกเฉียงใต้ของประเทศไทย จำนวนทั้งสิ้นยี่สิบเอ็ดชนิด โดยกล่าวถึงรายละเอียดของเปลือกและลักษณะของหอยที่มีชีวิตหลายชนิด หอยดังกล่าวสามารถจำแนกออกเป็น 5 วงศ์คือ มิทิลิดี เพทริโคลิดี แพร์ฟิซิดี โพลเลคิเดี และ แกสโตรคินีดี งานวิจัยเรื่องนี้ให้รายละเอียดของลักษณะที่อาศัยในหอยหลายชนิดเป็นครั้งแรก นอกจากนี้จำนวนชนิดของหอยกลุ่มดังกล่าวจากพื้นที่ทำการเก็บตัวอย่างนับว่ามีความหลากหลายสูงกว่าที่มีการรายงานไว้สำหรับพื้นที่อินโด-แปซิฟิก รายงานฉบับนี้ยังมีกรกล่าวถึงรายละเอียดและลักษณะเฉพาะของหอยสองฝาชนิดใหม่ที่ค้นพบในการศึกษาครั้งนี้คือ *Botula kleemanni* Valentich-Scott

## LITERATURE CITED

- Bieler, R., K. Chalermwat, P. M. Mikkelsen & F. E. Wells, 2008. International Marine Bivalve Workshop 2005: introduction and summary. *Raffles Bulletin of Zoology*, Supplement **18**: 1–6.
- Carter, J. G., 1978. Ecology and evolution of the Gastrochaenacea (Mollusca, Bivalvia) with notes on the evolution of the endolithic habitat. *Peabody Museum of Natural History Bulletin*, **41**: 1–92.
- Carter, J. G. T. McDowell & N. Namboodiri, 2008. The identity of *Gastrochaena cuneiformis* Spengler, 1783, and the evolution of *Gastrochaena Rocellaria*, and *Lamychaena* (Mollusca, Bivalvia, Gastrochaenoidea). *Journal of Paleontology* **82**(1): 102–117.
- Deshayes, G. P., 1830. *Encyclopédie Méthodique ou par Ordre des Matières. Histoire Naturelle des Vers, des Mollusques ... Volume 2*. Mme. V. Angasse, Paris. 594 pp.
- Deshayes, G. P., 1855 (“1854”). Descriptions of new shells from the collection of Hugh Cuming, Esq. *Proceedings of the Zoological Society of London*, **1854**(22): 317–320; (280): 321–336; (281): 337–352; (282): 353–368; (283): 369–371.
- Dufo, H., 1840. Observations sur les Mollusques marins, terrestres et fluviatiles des îles Séchelles et des Amirantes. *Annales des Sciences Naturelles*, **2** (Zoologie), **14**: 166–221.
- Dunker, W. [G.] B. R. H., 1882. *Novitates Conchologicae. Abbildung und Beschreibung neuer Conchylien. Supplement 7. Index molluscorum maris Japonici*. Fischer, Cassel. vii + 301 pp., 16 pls.
- Fischer, P., 1887. Sur un nouveau type de mollusques. *Journal de Conchyliologie*, **35**(3)27]: 201–206.
- Fischer, P., 1891. *Catalogue et Distribution Géographique des Mollusques Terrestres, Fluviatiles et Marins d’une Partie de l’Indo-Chine (Siam, Laos, Cambodge, Cochinchine, Annam, Tonkin)*. Société d’Histoire Naturelle d’Autun, France. 193 pp.
- Gmelin, J. F., 1791. *Caroli a Linné ... Systema Naturae per Regna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis . . . Editio decima tertia, aucta, reformata. Volume 1, Part 6*. G. E. Beer, Lipsiae [Leipzig]. Pp. 3021–4120.
- Gray, J. E., 1840. *Synopsis of the Contents of the British Museum, 42nd edition*. British Museum, London. 370 pp.
- Hylleberg, J. & R. N. Kilburn, 2003. Marine molluscs of Vietnam. Annotations, voucher material, and species in need of verification. *Phuket Marine Biological Center Special Publication*, **28**: 1–300.
- Hylleberg, J. & J. Knudsen, 2001. Translations into English of Lorenz Spengler’s papers on bivalves (1783–1798). Part 5. – 1793: the genera *Chaena* and *Mya*. *Phuket Marine Biological Center Special Publication*, **25**(2): 571–584.
- Kleemann, K. H., 1980. Boring bivalves and their host corals from the Great Barrier Reef. *Journal of Molluscan Studies*, **46**: 13–54.
- Kleemann, K. H., 1983. Catalogue of Recent and fossil *Lithophaga* (Bivalvia). *Journal of Molluscan Studies*, supplement **12**: 1–46.
- Kleemann, K. H., 1984. *Lithophaga* (Bivalvia) from dead coral from the Great Barrier Reef, Australia. *Journal of Molluscan Studies*, **50**: 192–230.
- Kleemann, K. H., 1990a. Boring and growth in chemically boring bivalves from the Caribbean, eastern Pacific and Australia’s Great Barrier Reef. *Senckenbergiana Maritima*, **21**(1/4): 101–154.
- Kleemann, K. H., 1990b. Evolution of chemically-boring Mytilidae (Bivalvia). In: Morton, B. (ed.), *The Bivalvia – Proceedings of a Memorial Symposium in Honour of Sir Charles Maurice Yonge, Edinburgh, 1986*. Hong Kong University Press, Hong Kong. Pp. 111–124.
- Knudsen, J. & K. R. Jensen, 2001. Translations into English of Lorenz Spengler’s papers on bivalves (1783–1798). Part 3. – 1788: *Pholas siamensis* with notes on the type specimen. The oldest marine bivalve with a type locality in the Gulf of Thailand. *Phuket Marine Biological Center Special Publication*, **25**(2): 547–556.
- Lamarck, J. B. P. A. de M. de, 1809. *Philosophie Zoologique, ou Exposition des Considérations Relatives à l’Histoire Naturelle des Animaux...* Dentu, Paris. 422 + 450 pp.
- Lamprell, K. & T. Whitehead, 1992. *Bivalves of Australia, Volume 1*. Crawford House, Bathurst, New South Wales. 182 pp.
- Lamprell, K. & J. Healy, 1998. *Bivalves of Australia, Volume 2*. Backhuys Publishers, Leiden. 288 pp.

- Lamy, É., 1919. Les Lithodomes de la Mer Rouge (d'après les matériaux recueillis per M. le Dr. Jousseume). *Bulletin de Muséum d'Histoire Naturelle, Paris*, **25**(4): 252–257.
- Lamy, É., 1920. Révision des Cypricardiacea et des Isocardiacea vivants du Muséum d'Histoire Naturelle. *Journal de Conchyliologie*, **64**[(4)18](4): 259–307, pl. 8.
- Lamy, É., 1923. Révision des *Petricola* vivants du Muséum National d'Histoire Naturelle de Paris. *Journal de Conchyliologie*, **67**[(4)21](4): 309–359.
- Lee, S. Y. & B. Morton, 1985. The Hong Kong Mytilidae. In: Morton, B. & D. Dudgeon (eds.), *The Malacofauna of Hong Kong and Southern China II*. Hong Kong University Press, Hong Kong. Pp. 49–76.
- Lynge, H., 1909. The Danish Expedition to Siam, 1899–1900. IV. Marine Lamellibranchiata. *Kongelige Danske Videnskabernes Selskabs Skrifter, 7. Raekke, Naturvidenskabelig og Mathematisk Afdeling, Kjøbenhavn*, **5**(3): 97–299, Pls. 1–5.
- Morton, B., 1982. Pallial specializations in *Gastrochaena (Cucurbitula) cymbium* Spengler 1783 (Bivalvia: Gastrochaenacea). In: Morton, B. & C. K. Tseng (eds.), *The Marine Flora and Fauna of Hong Kong and Southern China, Volume 2, Ecology, Morphology, Behaviour and Morphology*. Hong Kong University Press, Hong Kong. Pp. 859–873.
- Morton, B., 1983a. Evolution and adaptive radiation in the Gastrochaenacea (Bivalvia). *Journal of Molluscan Studies*, supplement **12A**: 117–121.
- Morton, B., 1983b. Coral-associated bivalves of the Indo-Pacific. In: Russell-Hunter, W. P. (ed.), *The Mollusca, Volume 6 (Ecology)*. Academic Press, Orlando, Florida. Pp. 139–224.
- Morton, B., 1990. Corals and their bivalve borers – the evolution of a symbiosis. In: Morton, B. (ed.), *The Bivalvia – Proceedings of a Memorial Symposium in Honour of Sir Charles Maurice Yonge, Edinburgh, 1986*. Hong Kong University Press, Hong Kong. Pp. 11–46.
- Morton, B. & P. J. B. Scott, 1980. Morphological and functional specializations of the shell, musculature and pallial glands in the Lithophaginae (Mollusca: Bivalvia). *Journal of Zoology, London*, **192**: 179–203.
- Morton, B. & P. J. B. Scott, 1988. Evidence for chemical boring in *Petricola lapicida* (Gmelin, 1791) (Bivalvia: Petricolidae). *Journal of Molluscan Studies*, **54**: 231–237.
- Nielsen, C., 1986. Fauna associated with the coral *Porites* from Phuket, Thailand. (Part 1): Bivalves with description of a new species of *Gastrochaena*. *Phuket Marine Biological Center Research Bulletin*, **42**: 1–24.
- Okutani, T. (ed.), 2000. *Marine Mollusks in Japan*. Tokai University Press, Tokyo. 1175 pp.
- Oliver, P. G., 1992. *Bivalved Seashells of the Red Sea*. National Museum of Wales, Cardiff & Hemmen, Wiesbaden. 330 pp.
- Orbigny, A. d', 1840. *Voyage dans l'Amérique Méridionale ... exécuté pendant les années 1826... 1833, .... 5(3) [Mollusques]:* xliii + 758 pp., 85 Pls [in Atlas]. Bertrand & Strasbourg (Levrault), Paris. Pp. 377–424, Pls 53, 67, 70, 71 (1840).
- Philippi, R. A., 1846–1847. *Modiola*. *Abbildungen und Beschreibungen neuer oder wenig gekannter Conchylien*, **2**(5): 147–50, Pl. 1 (1846); **3**(1): 19–22, Pl. 2 (1847).
- Qi, Z. (ed.), 2004. *Seashells of China*. China Ocean Press, Beijing. 418 pp., 193 pls.
- Rafinesque, C. S., 1815. *Analyse de la Nature, ou Tableau de l'Univers et des Corps Organisés*. Palerme. 224 pp.
- Ramesh, D. A., R. Jeyabaskaran & A. L. P. Pandian, 1996. Gastropods and bivalves associated with reef building corals, Palk Bay, southeastern India. *Phuket Marine Biological Center Special Publication*, **16**: 257–260.
- Reeve, L. A., 1857–1858. Monograph of the genus *Lithodomus*. *Conchologica Iconica; or, Illustrations of the Shells of Molluscos Animals*, **10**: 5 pls.
- Scott, P. J. B., 1980. Associations between scleractinians and coral-boring molluscs in Hong Kong. In: Morton, B. (ed.), *The Malacofauna of Hong Kong and Southern China*. University of Hong Kong Press, Hong Kong. Pp. 121–138.
- Sowerby, G. B., I, 1824. *The Genera of Recent and Fossil Shells, for the Use of Students in Conchology and Geology, Part 23*. London.
- Sowerby, G. B., II, 1849. Monograph of the genus *Pholas*, *Triumphalia*, *Xylophaga*. *Thesaurus Conchyliorum; or Figures and Descriptions of Recent Shells*. **2**(10): 485–505, Pls. 102–108.
- Sowerby, G. B., II, 1872. Monograph of the genus *Pholas*. *Conchologica Iconica; or, Illustrations of the Shells of Molluscos Animals*, **18**: 12 pls.
- Spengler, L., 1783. Beskrivelse over en nye slaegt af toskallede muskeler, som kan kaldes *Gastrochaena*, i tre foranderlige arter, hvoraf hver boer i et forskielligt ormehuus. *Det Kongelige Danske Bidenskabers Selskabs Skrifter, Nye Samling*, **2**: 174–183, 1 pl.
- Spengler, L., 1788. Beskrivelse over en meget sielden sexskallet Pholade, tillage med Dyret fra den Siamske Havbugt. Med Aftegninger. *Det Kongelige Danske Bidenskabers Selskabs Skrifter, Nye Samling*, **3**: 128–138, 1 pl.
- Sturany, R. W., 1899. Expedition S. M. Schif 'Pola' in das Rothe Meer. 14. Lamellibrachiaten des Rothen Meeres. *Denkschriften der Mathematisch-Naturwissenschaftlichen Klasse der Kaiserlichen Akademie der Wissenschaften*, **69**: 255–295.
- Swennen, C., R. G. Moolenbeek, N. Ruttanadukul, H. Hobbelink, H. Dekker & S. Hajisamae, 2001. The molluscs of the southern Gulf of Thailand. *Thai Studies in Biodiversity [The Biodiversity Research and Training Program, Bangkok]*, **4**: 1–210.
- Valentich-Scott, P., 2003. A taxonomic, distributional and bibliographic checklist of Hong Kong bivalve molluscs and research published on them from 1971–2000. In: Morton, B. (ed.), *Perspectives on Marine Environment Change in Hong Kong and Southern China, 1977–2001*. University of Hong Kong Press, Hong Kong. Pp. 259–310.
- Valentich-Scott, P. & G. E. Dinesen, 2004. Rock and coral boring Bivalvia (Mollusca) from the middle Florida Keys, U.S.A. *Malacologia*, **46**(2): 339–354.
- Wilson, B. R. & R. Tait, 1984. Systematics, anatomy and boring mechanisms of the rock-boring mytilid bivalve *Botula*. *Proceedings of the Royal Society of Victoria*, **96**(3): 113–125.
- Wong, P. S., 1982. The morphology and population dynamics of *Aspidopholas obtecta* (Bivalvia: Pholadidae) boring into the Pacific oyster (*Crassostrea gigas*) in Hong Kong. *Journal of Zoology*, **198**(4): 495–513.
- Yonge, C. M., 1955. Adaptation to rock boring in *Botula* and *Lithophaga* (Lamellibranchia, Mytilidae) with a discussion on the evolution of this habit. *Quarterly Journal of Microscopical Science*, **96**(3): 383–410.