

ROCK AND CORAL BORING BIVALVIA (MOLLUSCA)
OF THE MIDDLE FLORIDA KEYS, U.S.A.

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ABSTRACT

Eight species from three bivalve families were collected and/or observed in the Middle Florida Keys. Diagnoses based on shell characters are given for *Botula fusca*, *Lithophaga antillarum*, *L. aristata*, and *L. bisulcata* in the Mytilidae, and *Gastrochaena hians* in the Gastrochaenidae. Shell and anatomical comparisons are made for three members of the Petricolidae, *Petricola lapicida*, *Choristodon robustum*, and *Choristodon* sp. A, which is not attributable to a described Recent *Choristodon* species.

These bivalves bore into limestone and dead coral, and in one case into living coral. Observations substantiated previous findings of primary chemical boring processes in *Botula* and *Petricola*.

Key words: *Botula*, *Lithophaga*, *Petricola*, *Choristodon*, *Gastrochaena*, endolithic, boring bivalves, Florida Keys.

INTRODUCTION

As an expansion of the general bivalve biodiversity study initiated by Mikkelsen & Bieler (2000), we here describe the rock and coral boring bivalve fauna of the Middle Florida Keys. The goal of this publication is to provide a guide to the identification of the rock and coral boring bivalves in the Middle Keys region. Where possible, we have made observations and comparisons of the living animal, the anatomy, and the habitat of each species.

Middle Keys boring bivalves are represented in the families Mytilidae, Petricolidae, and Gastrochaenidae. Turner & Boss (1962) described the lithophagan mytilids throughout the western Atlantic, including the Florida Keys. Coan's (1997) treatment of the eastern Pacific Ocean Petricolidae discussed species that are also found in the Caribbean/Atlantic region. The taxonomy and biology of the Gastrochaenidae are well documented in Carter (1978). Carter also provided a list of coral boring bivalves from Soldier Key, Dade County, Florida, which is only 100 km north of the site of this study (West Summerland Key). Including members in the three aforementioned families, Kleemann (1980, 1990a) discussed the methods of chemical boring of

these bivalves in the Caribbean, eastern Pacific Ocean and the Great Barrier Reef. Morton (1990) presented a global overview of coral-boring bivalves, including those in the western Atlantic Ocean.

MATERIALS AND METHODS

Limestone and coral habitats were examined for boring bivalves, intertidally and subtidally to 3 m in the Middle Florida Keys in July 2002 (Mikkelsen & Bieler, 2004, provide a station listing and map). Individuals were observed and/or collected primarily from the Florida Bay side of West Summerland Key (24°39'N). The limestone at this site is thought to be Key Largo Limestone, which in some cases is overlain by the Miami Oolite facies (M. Campbell, pers. comm., March 2003). Boring bivalves were collected from limestone and dead coral substratum with a rock hammer and chisel. Bivalves occurring in living coral were examined, but not collected. Field observations of the living animal and their burrows were made. In addition, bivalve borers were observed at Bahia Honda State Park (24°39'N), Fat Deer Key (24°40'N), Crawl Key (24°41'N), Grassy Key (24°44'N), Long Key (24°45'N), Planta-

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tion Key (24°50'N), and Lower Matecumbe Key (24°50'N).

Live animals were removed from their burrows, and relaxed in 7% MgCl₂. Observations of the shell, ligament, siphons, mantle, and foot were made while the living animal was in a relaxed state. The right shell valve was carefully removed with a scalpel inserted between the mantle margin and the shell. For selected species, the morphology of the labial palps, ctenidia, and siphons were recorded.

Relaxed specimens were placed in 4% formalin solution, and transferred to 70% ethyl alcohol. Ctenidial and labial palp filament counts were compared between living and preserved specimens.

Voucher specimens for all species collected in this study have been deposited at the Santa Barbara Museum of Natural History (SBMNH).

Each species description includes a short diagnosis, followed by an expanded description of the shell morphology and, where observed, the anatomy. Measurements and localities of specimens examined are given, along with habitats where the species were observed and collected. Additional literature citations are provided for each species, and when necessary additional remarks on the taxonomy or biology of the species are given.

The following abbreviations are used in the text: AMNH, American Museum of Natural History, New York, New York, USA; BMSM, Bailey-Mathews Shell Museum, Sanibel, Florida, USA; FMNH, Field Museum of Natural History, Chicago, Illinois, USA; SBMNH, Santa Barbara Museum of Natural History, Santa Barbara, California, USA. Station numbers listed in the following text refer to International Bivalve Workshop – Florida Keys (IMBW-FK) stations, as maintained by AMNH and FMNH (Mikkelsen & Bieler, 2004).

SYSTEMATIC ACCOUNT

Mytilidae Rafinesque, 1815
Botula fusca (Gmelin, 1791)
Figures 1–4

Diagnosis

Shell highly inflated; exterior dark brown; periostracum silky; beaks terminal, inturned, projecting beyond anterior margin; sculpture of commarginal striae only; without calcareous incrustations on exterior of shell; length of shell to 40 mm.

Description

Exterior – Lateral View: Shell subquadrate-elongate, slightly bent in the middle, slightly flaring posteriorly; beaks terminal, prosogyrate, inturned, pronounced, inflated; region ventral of umbones straight; posterior end rounded; broadly inflated from umbones to posterior margin, with rounded shoulders radiating from umbones to anteroventral and posterior regions, middle region slightly depressed; ventral margin incurved; byssus visible; sculpture of commarginal striae; periostracum chestnut brown, lighter brown in small specimens, strongly adherent; milky white mucus remnants attached to shell.

Dorsal View: Ligament sunken, long, dark brown portion of ligament split for much of length; shell highly inflated.

Ventral View: Umbones and prodissoconch visible from ventral side; ventral margin smooth; commarginal striae more pronounced near posterior margin.

Interior: Shell pearly white internally; periostracum covering hinge under beaks; long thin, sharp posterior lateral tooth; edentulous under umbones; ligament deeply sunken, attached to a rolled nymph on the anterior portion, and a shelf-like nymph posteriorly.

Anatomy

Dorsal View: Foot orange anteriorly, white posteriorly, depressed in an anterior posterior direction, with small heel; distal portion of foot triangular, black; byssus projecting from base of foot; mantle unfused for most of ventral length; posterior rim of mantle is dark brown, remainder of mantle milky white.

Lateral View (with left valve and mantle removed): Anterior adductor muscle large for size of shell; posterior adductor circular, larger than anterior; inner fold of mantle margin very muscular, middle fold thin; labial palps short.

Measurements

Length 29 mm, height 13 mm, width 15 mm; length 17 mm, height 8 mm, width 9 mm; both specimens from West Summerland Key, IMBW-FK-629, 24°39.3'N, 81°18.2'W, collected by P. Valentich-Scott and G. Elisabeth Dinesen (SBMNH 350547, 350548). Additional observations were made at Crawl Key and Bahia Honda State Park. Four additional lots of dry specimens from the Florida Keys were examined (SBMNH).

Habitat

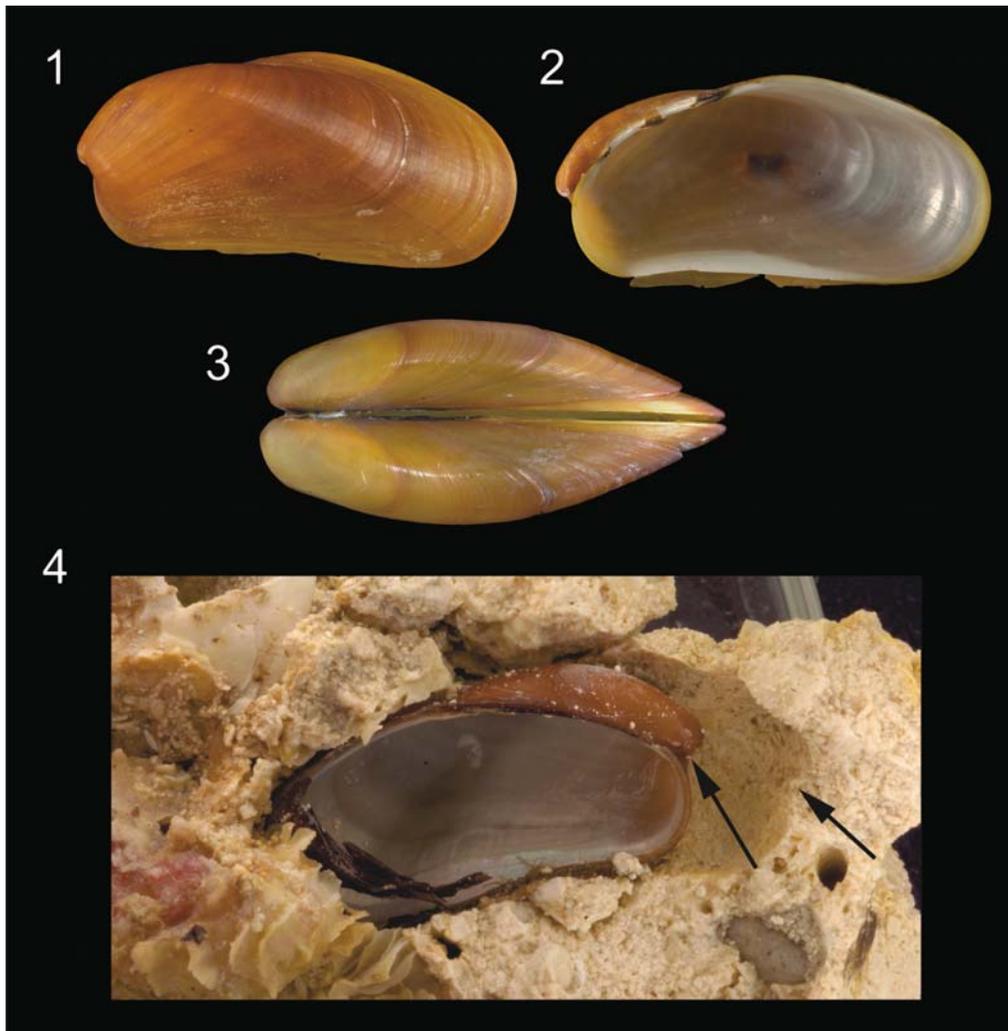
In a mucus nest, boring in soft limestone. Carter (1978) reported in dead coral (*Diploria*).

Remarks

The limestone burrows of several specimens were found with dorsal keels, or with anterior

notches in the limestone under the umbones (Fig. 4). Mechanical boring would not allow these keels or notches to be formed in the borehole. These findings correspond with Wilson & Tait (1984), who suggested that *Botula fusca* only uses chemical means for boring.

There has been much nomenclatural debate as to the correct name for the species in the western Atlantic Ocean. Wilson & Tait (1984)



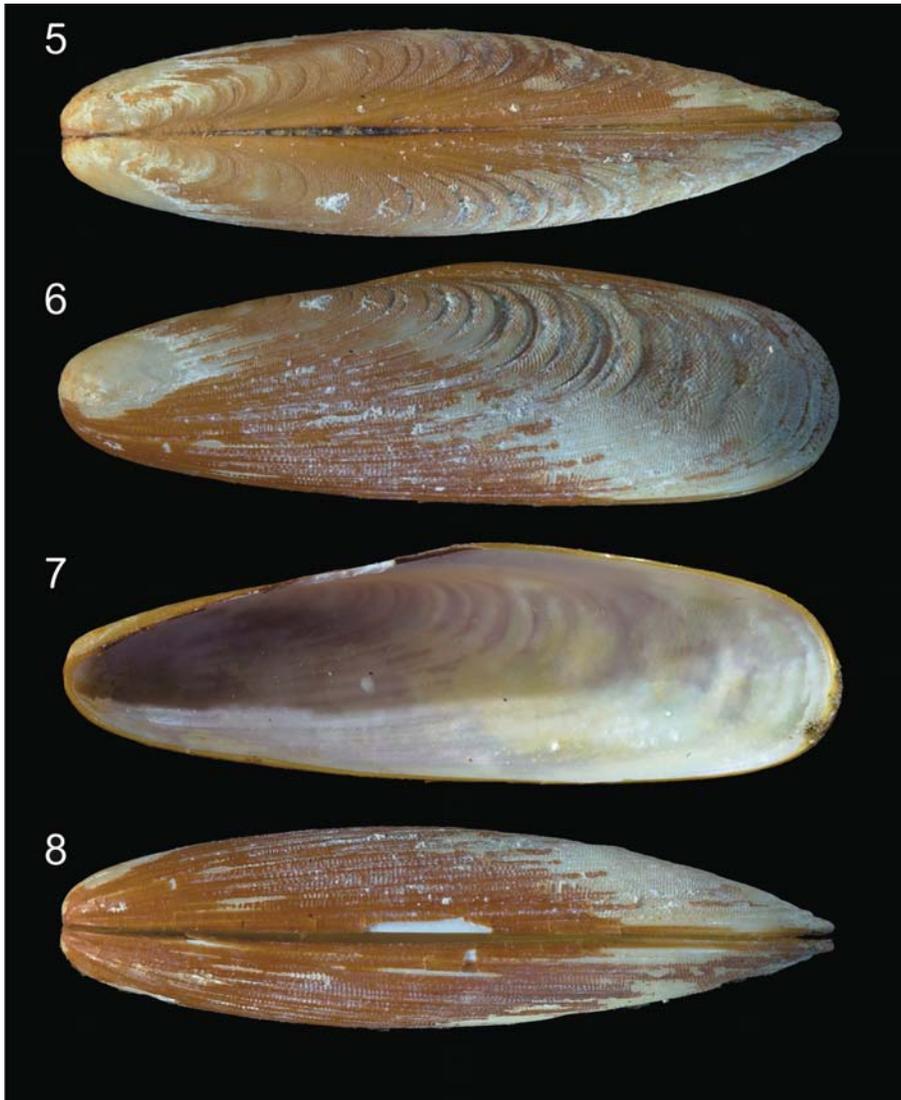
FIGS. 1–4. *Botula fusca*. FIGS. 1, 2: External left valve, internal right valve. West Summerland Key, Monroe County, Florida; 24°39.3'N, 81°18.2'W; subtidal; Station 629; length 28.8 mm; SBMNH 350546; FIG. 3: Dorsal view, Grassy Key, Monroe County, Florida; 24°45'46"N, 80°57'11"W; length 39.6 mm; SBMNH 53503; FIG. 4: In limestone substratum; arrows denote invagination below umbones and corresponding notch in limestone; locality data the same as figures 1–2; length 26.1 mm; SBMNH 350547.

used *Botula fusca* (Gmelin, 1791) as a single global species distributed in the Indian, Atlantic, and Pacific Oceans, and placed *B. cinnamomea* (Gmelin, 1791) in synonymy. Nielsen (1986) contrasted this viewpoint, seeing *B. cinnamomea* as valid, with a broad Northern Hemisphere distribution. In addition, Nielsen designated a lectotype for *B. cinnamomea*, and restricting the type locality of this species to the Nicobar Islands.

Additional morphological, anatomical and genetic studies are needed to solve this global issue.

Literature

Abbott (1974: 436), Keen (1971: 74), Mikkelsen & Bieler (2000), Nielsen (1976), Redfern (2001: 201), Soot-Ryen (1955: 86), Wilson & Tait (1984).



FIGS. 5–8. *Lithophaga antillarum*. Missouri Key, Monroe County, Florida; 24°40.6'N, 81°14.3'W; length 77.9 mm; SBMNH 350549. FIG. 5: Dorsal view; FIG. 6: External left valve; FIG. 7: Internal right valve; FIG. 8: Ventral view.

Lithophaga antillarum (Orbigny, 1853)
Figures 5–8

Diagnosis

Shell elongate, cylindrical; beaks subterminal, but not extending past anterior end; periostracum light to medium brown, dehiscent; sculpture of fine vertical lines over most of shell, and heavy commarginal undulations posterodorsally; without calcareous incrustations on exterior of shell; length of shell to 120 mm.

Description

Exterior – Lateral View: Shell cylindrical, somewhat compressed laterally, sharply rounded anteriorly, broadly rounded posteriorly, slightly flaring in the middle portion; beaks subterminal, small; sculpture of fine vertical lines over entire surface except narrow region from beaks to posterior end, and irregular commarginal striae, commarginal undulations posterodorsally; large portions of shell eroded, especially anteriorly; periostracum dehiscent, medium brown; calcareous incrustations not present on shell, no encrusting extensions.

Dorsal View: Beaks small, not inflated or protruding; dorsal margin not gaping; ligament not visible from dorsal surface; with long narrow escutcheon; lunule not well demarcated; shell widest near midline, tapering posteriorly.

Ventral View: Shell tightly closing, except for very narrow, short pedal gape, and very slight posterior gape; ventral margin slightly beveled inward.

Interior: Interior pearly white, translucent; edentulous; ligament dark brown, deeply sunken, extending from umbones nearly to the shell midline.

Anatomy

Not examined.

Measurements

Length 85 mm, height 25 mm, width 21 mm; specimen collected by José Leal (26 July 2002) at West Summerland Key, IMBW-FK-629, 24°39.3'N, 81°18.2'W at 3 m depth, in soft limestone; deposited as a voucher specimen at the Zoological Museum, University of Copenhagen, Denmark. Also observed at Fat Deer Key. Eight additional lots examined from

Missouri Key (24°40'N) (SBMNH 350549), Vaca Key (24°46'N), and Barbados (all SBMNH), and Lower Matecumbe Key and Townsend Island (BMSM).

Habitat

Boring into soft limestone. Carter (1978) reported in dead coral (*Diploria*), and Scott (1988a) observed in dead coral and rock.

Literature

Turner & Boss (1962), Kleemann (1983, 1984, 1990a, b, 1996), Mikkelsen & Bieler (2000), Morton (1990), Redfern (2001: 201), Warmke & Abbott (1971: 164).

Lithophaga aristata (Dillwyn, 1817)
Figures 9–11

Diagnosis

Shell inflated, cylindrical; beaks subterminal; with heavy calcareous incrustations over most of shell; elongated incrustations posteriorly, forming overlapping scissors-like “forceps”; length of shell to 33 mm.

Description

Exterior – Lateral View: Shell elongate ovate to cylindrical, sharply rounded anteriorly, tapering posteriorly; beaks subterminal, usually eroded; sculpture of fine commarginal striae; periostracum dark brown; heavy calcareous incrustations over entire surface, eroded in some spots; incrustations extending past the posterior end, forming overlapping, scissors-like projections.

Dorsal View: Beaks usually eroded, not extending past the anterior margin; ligament black, sunken anteriorly, becoming visible near shell midline.

Ventral View: Shell tightly closing, without visible pedal gape; ventral margin nearly straight; posterior scissors-like incrustations easily viewed from this orientation.

Interior: Shell very thin, fragile, translucent, slightly pearly white, slightly flaring dorsally; edentulous; posterior end of shell tapering, with calcareous extensions.

Anatomy not examined. Morton (1993) discussed various aspects of the anatomy, including a discussion on the formation of the scissors-like “forceps”.



FIGS. 9–11. *Lithophaga aristata*. West Summerland Key, Monroe County, Florida; 24°39.3'N, 81°18.2'W; subtidal; Station 629; length 9.9 mm; SBMNH 350550. FIG. 9: Dorsal view; FIG. 10: Ventral view; FIG. 11: External left valve.

Measurements

Length 9.9 mm, height 4.1 mm; specimen collected by Diarmaid O'Foighil (27 July 2002) at West Summerland Key, IMBW-FK-629, 24°39.3'N, 81°18.2'W (SBMNH 350550). Two additional Florida lots were examined, along with 50 lots from the eastern Pacific Ocean (all SBMNH).

Habitat

Boring into limestone and coral. Coan et al. (2000) reported boring into shell in the eastern Pacific Ocean.

Literature

Coan et al. (2000: 181), Keen (1971: 70), Kleemann (1983, 1990a, b, 1996), Mikkelsen & Bieler (2000), Morton (1993), Redfern (2001: 202), Turner & Boss (1962), Yonge (1955).

Lithophaga bisulcata (Orbigny, 1853)
Figures 12–15

Diagnosis

Shell cylindrical, with flare along dorsal margin, tapering posteriorly; with feathery calcar-

eous incrustations along posterodorsal slope; incrustations extending evenly past posterior end of shell; length of shell to 45 mm.

Description

Exterior – Lateral View: Shell cylindrical, tapering posteriorly, anteriorly rounded; dorsal and ventral margin parallel for the anterior half of the shell, flaring posterodorsally and then tapering posteriorly; beaks broad, slightly projecting, near anterior end, not terminal; sculpture of fine commarginal striae, with broad keel running from just posterior of beaks to posterior end; periostracum chestnut dark brown; surface anterior of keel with fine granular concretions except in the umbonal region and ventral margin, posterior of keel with heavy concretions, concretions becoming heavier posteriorly, feathery concretions posteriorly, posterior concretion extension short with fine granules.

Dorsal View: Ligament deeply sunken in deep long escutcheon; anterior end triangular; gaping posteriorly; concretions along entire dorsal surface.

Ventral View: Ventral margin slightly incurved to slightly bowed, smooth; shell narrowly gaping posteriorly; posteroventral calcareous incrustations with zipper-like pattern.



FIGS. 12–15. *Lithophaga bisulcata*. Missouri Key, Monroe County, Florida; 24°40.6'N, 81°14.3' W; length 45.0 mm; SBMNH 350551. FIG. 12: Dorsal view; FIG. 13: External left valve; FIG. 14: Internal right valve; FIG. 15: Ventral view.

Interior: Shell dark brown, translucent, with slight sheen; edentulous; ligament deeply sunken, extending from beaks to the end of dorsal flare (well posterior of midline); beaks near anterior end, but not subterminal; anterior end broadly rounded, dorsal flaring, posterior tapering; calcareous incrustations

straight off posterior end, not forming forceps.

Anatomy

Not examined. Scott (1988a) detailed much of the anatomy of this species.

Measurements

Length 21 mm (4 mm are the forceps concretions); height 6.5 mm; width 6 mm; specimen collected by Diarmaid O'Foighil (27 July 2002) at West Summerland Key, IMBW-FK-629, 24°39.3'N, 81°18.2'W. Six additional Florida lots examined (SBMNH), including specimens from Missouri Key (SBMNH 350551).

Habitat

Boring into limestone. Scott (1988a) reported from living and dead coral, and rock.

Literature

Kleeman (1983, 1990a, b, 1996), Mikkelsen & Bieler (2000), Morton (1990), Redfern (2001: 202), Scott (1985, 1988a, b), Turner & Boss (1962), Warmke & Abbott (1971; 164).

Petricolidae Orbigny, 1840

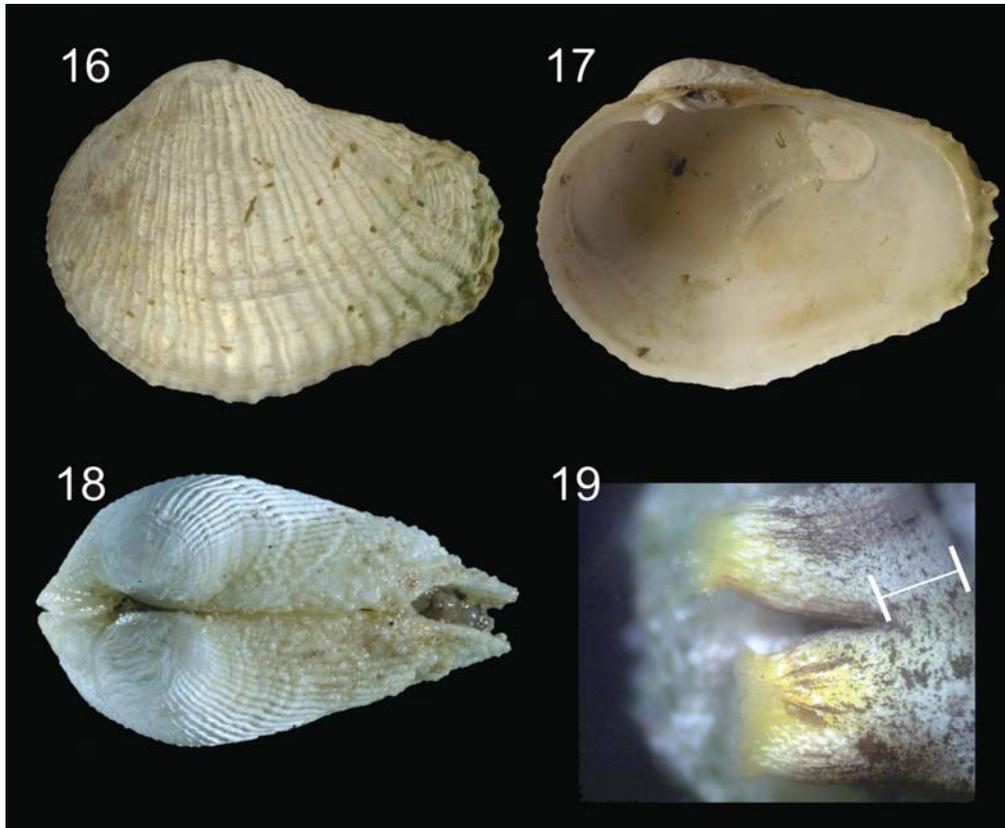
Choristodon robustum (G. B. Sowerby I, 1834)
Figures 16–19, Table 1

Diagnosis

Shell ovate-elongate to trigonal, moderately inflated; inequilateral, posterior end much longer; anterior broadly rounded, posterior end tapering; sculpture of strong, irregular radial ribs, most prominent on the central portion of the shell; anterior and posterior ends gaping; siphons fused for nearly half length; length of shell to 43 mm.

Description

Exterior – Lateral View: Shell ovate to trigonal; moderately inflated; inequilateral, posterior end much longer; anterior end rounded, posterior end attenuate; umbones prosogyrate;



FIGS. 16–19. *Choristodon robustum*. West Summerland Key, Monroe County, Florida; 24°39.3'N, 81°18.2'W; subtidal; Station 629. FIGS. 16, 17: Length 20.2 mm; SBMNH 350554; FIG. 16: External left valve; FIG. 17: Internal right valve; FIG. 18: Length 19.8 mm; dorsal view; SBMMH 350553; FIG. 19: Siphons of living animal, demarcation showing region of siphonal fusion; SBMNH 350552.

TABLE 1. Characteristics of members of the Petricolidae from the Middle Florida Keys.

Species	Shell shape / sculpture	Exhalant siphonal tentacles	Inhalant siphonal tentacles	Siphonal fusion	Outer labial palps	Ctenidia color	Demibranch plicae	Foot
<i>Choristodon robustum</i>	ovate-elongate to trigonal, posterior end much longer; strong, irregular radial ribs	simple, white papillae along rim	short, simple papillae along rim	siphons fused for half length of inhalant siphon	light pink to yellow; small size, with 14 plicae	creamy white	inner demibranch: 20 plicae, outer demibranch: 20 plicae	white color, laterally compressed; long sole; toe small, sharp and pointed; heel small, pointed
<i>Choristodon</i> sp. A	ovate, subequilateral, anterior with flange; fine radial ribs anteriorly, becoming stronger posteriorly	simple, short papillae with dark brown spots; inner papillae are white, flower-like	simple, short papillae with dark brown spots; inner papillae are white, flower-like	siphons only fused at basal part	light orange; small size; 16 plicae	light pink to creamy white	inner demibranch: 16 plicae, outer demibranch: 12 plicae	white color; thick, broad; toe broad, short; without heel
<i>Petricola lapicida</i>	subquadrate; fine divaricate ribs, radial ribs posteriorly	tentacles are of several types, some simple bifurcations, others heavily branched	tentacles of two types, (1) simple, pointed, not bifurcate, with small lobes on side, (2) very short tentacle nobs	not fused	white; medium size; with 32 plicae	dark orange	inner demibranch: 52 plicae, outer demibranch: 40 plicae	peach color; compressed laterally; pointed toe

beaks broad, projecting; sculpture of irregular radial ribs, weak anteriorly, strong posteriorly; posterior ribs prominent, broad, rounded, groove between ribs shallow, broad; anterior ribs very weak, barely visible at anterior end; mid portion ribs gradually increasing in size and height, sharp, thin; commarginal striae closely spaced, making surface weakly cancellate, slightly lamellate posteriorly.

Dorsal View: Shell moderately inflated, slightly compressed posteriorly; shell inequivalve, right side larger; shell gaping anterior and posterior of beaks; ligament short, external, sunken, on nymph; lunule small, deep; prodissoconch large.

Ventral view: Widely gaping except for midline; terminal end of radial ribs intermesh at midline; right valve convex posteriorly; left valve concave posteriorly; posterior end twisted to the left; inequivalve, left valve smaller.

Interior: Hinge plate short; three cardinal teeth in left valve – two anterior teeth short, stout, posterior tooth larger, plate-like, pointing posteriorly; right valve with two cardinal teeth – anterior tooth short, wide, stout, posterior tooth very small, thin, plate-like; ligament in two parts, outer section beginning just below beaks, light brown, inner section attached to nymph, black.

Pallial sinus broad, shallow, not extending to beaks (about 1/3 distance between adductors); right valve pallial sinus slightly broader than that of left valve; pallial line continuous in sinus region, patchy along ventral margin; anterior adductor muscle scar long, moderate in width, pointed dorsally and ventrally; posterior adductor muscle scar nearly circular; left valve with two small pedal retractor scars posterodorsally; inside shell surface chalky; inner margin weakly and irregularly crenulate behind umbonal midline, inner margin non-crenulate anteriorly.

Anatomy (Table 1)

External View: Siphons translucent pale yellow/orange on outer section, milky white near mantle, with small white granules in tissue, and brown streaks and blotches; exhalant siphon much narrower than inhalant; inhalant siphon with short, simple papillae along rim; exhalant with simple papillae along rim; middle mantle fold light orange distally, rim plicate.

Internal View: Outer and inner mantle fold very thick milky white, middle fold plicate, light orange with sporadic white granules towards the siphons, middle mantle fold near siphons

dark brown; mantle fused from siphons to line below umbones; pedal gape relatively short extending from below beaks to anterior margin; labial palps small, with 14 plicae; siphons fused for approximately half of their length; ctenidia creamy white; ctenidial plicae parallel to dorsal margin; outer demibranch 2/3 length of inner demibranch; plicae much larger and wider than *P. lapicida*, approximately 20 plicae on outer demibranch, about 20 on inner demibranch; foot white, laterally compressed, long sole, toe small, sharp, pointed; with small pointed heel.

Measurements

Length 19 mm, height 14 mm, width 10 mm; specimen collected by P. Valentich-Scott and G. Elisabeth Dinesen at West Summerland Key, IMBW-FK-629, 24°39.3'N, 81°18.2'W (SBMNH 350552).

Habitat

Shallow, unlined burrows in limestone rocks. Carter (1978) reported (as *Rupellaria typica*) in dead coral (*Diploria*).

Literature

Coan (1997), Keen (1971: 199), Lamy (1923), Redfern (2001: 240), Warmke & Abbott (1971: 199, as *Rupellaria typica*).

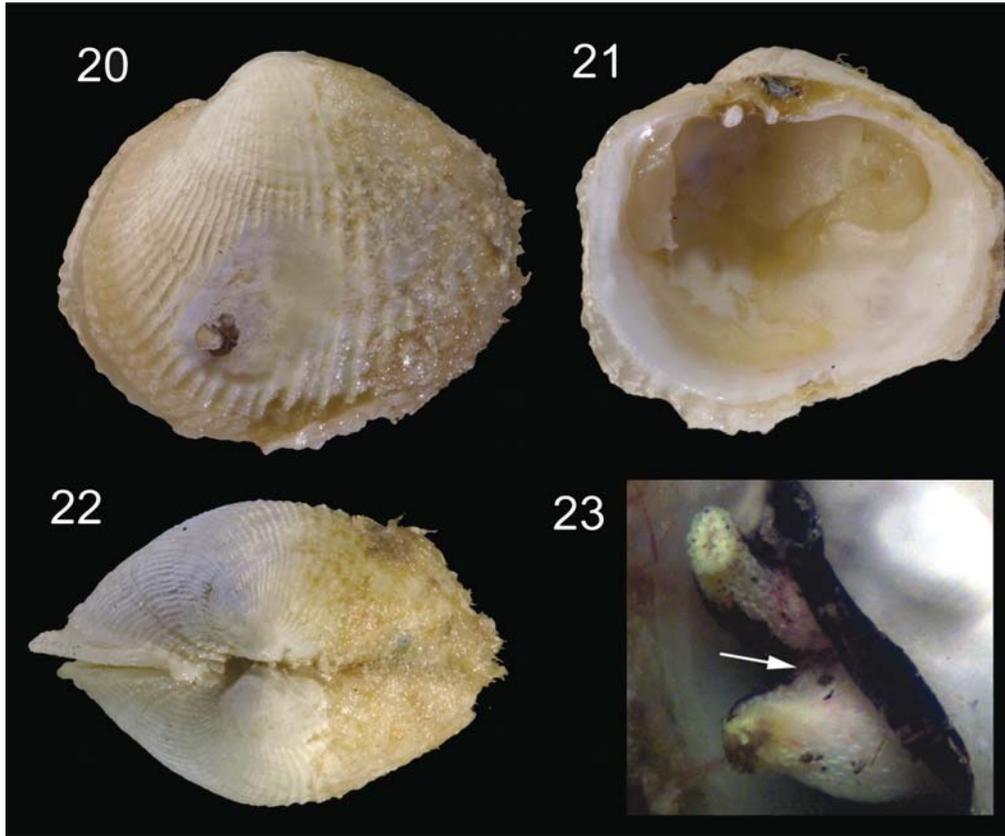
Choristodon sp. A
Figures 20–23, Table 1

Diagnosis

Shell ovate, inflated; subequilateral; anterior end with flange, extending well beyond inner shell margin; sculpture of fine radial ribs on anterior portion, stronger radial ribs posteriorly; anterior end slightly gaping, posterior end tightly closed; siphons only fused basally; length of shell to 23 mm.

Description

Exterior – Lateral View: Shell ovate, highly inflated, anterior end broad, posterior end slightly tapered; subequilateral, posterior end slightly longer; posterodorsal margin straight; anteroventral margin flared laterally; beaks broad, inflated, prosogyrate; lunule deep; sculpture of pronounced radial flat-topped ribs, interspaces deep, wide, overlain by fine commarginal striae.



FIGS. 20–23. *Choristodon* sp. A. West Summerland Key, Monroe County, Florida; 24°39.3'N, 81°18.2'W; subtidal; Station 629; length 22.8 mm; SBMNH 350556. FIG. 20: External right valve; FIG. 21: Internal left valve; FIG. 22: Dorsal view; FIG. 23: Siphons of the living animal, arrow showing fusion only at base of siphon (SBMNH 350555).

Dorsal View: Ligament deeply sunken, short; shell gaping anteriorly, but closed posteriorly; equivalve.

Ventral View: Anterior end slightly gaping, posterior end tightly closed.

Interior: Right valve with two cardinal teeth, with large stout anterior tooth, fairly large plate-like posterior tooth; left valve with 3 cardinal teeth, anterior tooth small, stout, middle tooth large stout, posterior tooth thin plate-like.

Anatomy (Table 1)

Siphons small, short; space between siphons dark brown, dorsal of exhalent siphon dark brown, remaining area around siphons white; rim of both siphons with simple, short papillae with dark brown spots; inner papillae white, flower-like; siphons only fused for a short distance be-

yond mantle; posterior portion of mantle very dark brown; outer fold thick, smooth; middle mantle fold thinner than outer, slightly plicate, pigmented towards siphons; inner mantle fold thick, milky white, smooth; pedal gape short anteriorly; inner mantle fold unfused along anterior margin, but fused for remainder of ventral margin; labial palps small, short, with 16 plicae; ctenidia pale pink to creamy white; outer demibranch with 12 plicae, inner demibranch with 16 plicae; foot thick, broad, without heel, with broad, short anterior end.

Measurements

Length 25 mm, height 20 mm, width 16 mm; specimen collected by P. Valentich-Scott and G. Elisabeth Dinesen at West Summerland Key, IMBW-FK-629, 24°39.3'N, 81°18.2'W (SBMNH 350555).

Habitat

Boring into limestone, adjacent to *Choristodon robustum*. We found many shells of this species to be heavily bored by sponges and polychaetes.

Remarks: Coan (1997) placed *Choristodon typica* Jonas, 1844, in synonymy with *C. robustum*, based on the figure provided by Jonas (Coan, 1997: fig. 43). The species we describe above is distinct, conchologically and anatomically, from *C. robustum* (e.g., shell outline and sculpture, siphonal fusion, siphonal tentacles). As yet, we have not found a described species to correspond with our material. However, our specimens are very similar to the species illustrated by Narchi (1974), which he identified as *C. typica*. The Florida Keys species is not the same as Redfern's (2001: 240) *Petricola* sp. from the Bahamas,

nor *P. stellae* (Narchi, 1975) from Brazil (Narchi, 1975).

Table 1 compares anatomical characters of the two species of *Choristodon* found in the Middle Florida Keys, along with *Petricola lapicida*.

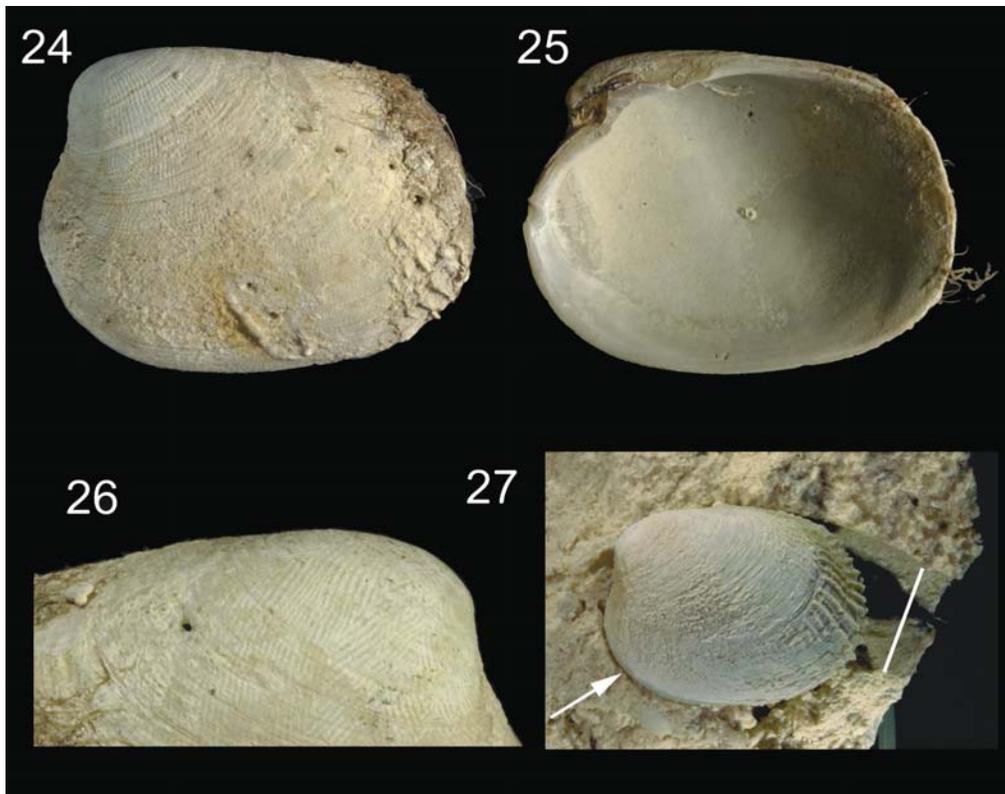
Literature

Narchi (1974).

Petricola lapicida (Gmelin, 1791)
Figures 24–27

Diagnosis

Shell subquadrate; inequilateral, posterior end much longer; sculpture of fine divaricate ribs over entire surface, and partial radial ribs near the posterior margin; siphons not fused; length of shell to 30 mm.



FIGS. 24–27. *Petricola lapicida*. West Summerland Key, Monroe County, Florida; 24°39.3'N, 81°18.2'W; subtidal; Station 629; length 27.3 mm; SBMNH 350343. FIG. 24: External left valve; FIG. 25: Internal right valve; FIG. 26: Detail of external of right valve showing divaricate markings; FIG. 27: Preserved animal in limestone burrow, arrows denote burrow tightly fitting around animal (anteriorly), and the constricted posterior portion of the burrow; SBMNH 350559.

Description

Exterior – Lateral View: Shell subquadrate, strongly prosogyrate, beaks broad, inflated; inequilateral, posterior end much longer, beaks almost at anterior end; anterior end rounded; posterior end truncate; posterodorsal margin nearly straight; sculpture very fine, divaricate ribs over most of surface (Fig. 26); posterodorsal region with few pronounced, sharp radial ribs, terminating before margin, sometimes wavy near ventral margin (eroded in some), interspaces between radial ribs wide, flat.

Dorsal View: Inflated anteriorly, more compressed posteriorly; equivalve; ligament deeply sunken, short; lunule deeply excavated posteriorly beneath ligament.

Ventral View: Without ventral gape.

Interior: Hinge plate short, triangular; periostracum in lunular region; ligament deeply sunken, seated on a elongate infolded nymph, in two sections, both dark brown; left valve with two teeth, anterior tooth large, rectangular, posterior tooth small, thin, plate-like; right valve with two teeth, anterior small peg-like, posterior larger but plate-like; pallial sinus very broad, shallow, not reaching beaks; ventral pallial line slightly patchy, continuous in sinus area; anterior adductor muscle scar long, narrow (slightly broader than *C. robustum*); posterior adductor circular.

Anatomy (Table 1)

Mantle fused from beak to anteroventral margin, small fusion just anterior of inhalant siphon; mantle open over entire ventral region from inhalant siphon to anterior margin; mantle without papillae; most of mantle milky white, except near siphons where it is dark brown in color; mantle swollen anteroventrally, possibly a pallial gland; outer mantle fold very thin; middle fold muscular, tapering on margin, wavy, inner fold thin; mantle filled with white granules; labial palps white, medium length, pointed ventrally, with 32 plicae; smooth dorsally and anterior portion of palp; ctenidia dark orange; plicae parallel to dorsal surface; outer demibranch extending to middle of inner demibranch; plicae number on demibranchs – inner 52, outer 40; siphons transparent dark gray, with embedded white granules; exhalant siphon circular in outline with tentacles of several types, some with simple bifurcations, others heavily branched; inhalant siphon elongate-ovate, gray with white

spots; inhalant siphonal tentacles of two types, large compared to exhalant, simple, pointed (not bifurcate), with small lobes on side; also very short tentacle nobs projecting; inhalant siphon three times as large in diameter as exhalant; siphons barely extending beyond shell margin; foot compressed laterally, peach color, very flexible, pointed at tip.

Measurements

Length 27 mm, height 20 mm, width 13 mm, specimen collected by P. Valentich Scott and G. Elisabeth Dinesen at West Summerland Key, IMBW-FK-629, 24°39.3'N, 81°18.2'W (SBMNH 350558).

Remarks

Field observations of the burrow of *Petricola lapicida* have shown it lives in a constricted, flat burrow (Fig. 27). This strongly suggests the species burrows through chemical means only, and agrees with the findings of Morton & Scott (1988) and Morton (1990). Comparisons between the functional morphology of *P. lapicida* and *P. pholadiformis* were presented by Purchon (1955).

Habitat

Shallow burrow in limestone. Carter (1978) reported this species in dead coral (*Diploria*).

Literature

Abbott (1974), Bromley (1978), Kleemann (1990a), Lamy (1923), Morton (1990), Morton & Scott (1988), Redfern (2001: 240), Robertson 1963, Warmke & Abbott (1971: 191).

Gastrochaenidae Gray, 1840
Gastrochaena hians (Gmelin, 1791)
Figures 28–30

Diagnosis

Shell ovate, white; incurved and widely gaping ventrally; widely gaping posteriorly; beaks terminal.

Description

Exterior – Lateral View: Shell inflated, ovate elongate; posterior end rounded, flaring; anterior end narrow pointed; beaks terminal,

pointed, prosogyrate; prodissococh large, smooth; widely gaping anteroventrally, invaginate; shell color translucent white; sculpture of commarginal striae, stronger anteroventrally, without radial elements; shell thicker along ventral gape.

Dorsal View: Highly inflated, more compressed posteriorly; right valve overlapping the left; left valve slightly concave posteriorly; ligament external, protruding, long, one third of shell length; valves slightly gaping posterior to ligament.

Ventral View: Periostracum thin, milky white, translucent, dehiscent; outer mantle fold thick, projecting beyond valve margin, wide gape, not fused for half shell length; middle mantle edge fused except for small pedal gape near shell midline; posterior end tightly closed, right valve overlapping left; posteriorly periostracum projecting beyond shell margin.

Interior: Not examined.

Anatomy

See Carter (1978) for discussion of *Gastrochaena* anatomy and shell features, along with diagnostic characters of related species.

Measurements

Length 11 mm, maximum height 6 mm, width 4.5 mm, ligament length 4.5 mm, gape length 8 mm, gape width 4 mm; specimen collected by Lisa Kirkendale on 27 July 2002, at Fiesta Key, IMBW-FK-644, 24°50.4'N, 80°47.0'W (SBMNH 350345). Three additional specimens were collected by the authors from West Summerland Key, IMBW-FK-629.

Habitat

In calcareous lined burrows in living and dead coral, and limestone. Carter (1978) reported in dead coral (*Diploria*).

Remarks

Coan, et al. (2000: 494, left specimen) illustrated a Florida specimen of *Gastrochaena* as *G. ovata*, but this specimen is actually *G. hians*.

Literature

Carter (1978), Morton (1983, 1990), Redfern (2001: 242).



FIGS. 28–30. *Gastrochaena hians*. Fiesta Key Causeway, Monroe County, Florida Keys; 24°50.4'N, 80°47.0'W; subtidal; station 644; length 11.8 mm; SBMNH 350345. FIG. 28: Dorsal view; FIG. 29: Ventral view; FIG. 30: Lateral view of left side.

DISCUSSION

The rock and coral boring bivalves of the Middle Florida Keys are diverse and numerous. With a modest sampling effort, eight species representing three families were observed and collected. While quantitative studies were not undertaken, several limestone rocks had more than 50 individuals/m². However, there was a distinct patchiness to the distribution of these borers, even with seemingly identical substrata in adjacent areas. Often, large limestone boulders were completely void of bivalve borers, where adjacent rocks were riddled with petricolids, mytilids, and gastrochaenids.

Careful examination of the living bivalves and boreholes has confirmed the boring mechanisms of two species. In agreement with Wilson & Tate (1984) and Kleemann (1990a), our observations indicate that *Botula fusca* is a chemical borer (Fig. 3). Similarly we have found strong indications of chemical boring in *Petricola lapicida* (Fig. 27), concurring with Morton & Scott (1988). Lithophagans were relatively rare in our sampling areas, and we were unable to make definitive conclusions on habitat or boring mechanisms of these species.

Far outside the scope of this paper are conclusions about the localized or global distributions of many boring bivalve species. Among the different lineages of boring bivalves, several are thought to be represented by a single genus with one or only a few species, and distributed worldwide (Morton, 1990). Morton further discussed the evolutionary events and implications, which could explain both the presence of true cosmopolitanism of some species and restricted regional distribution of other species.

Nomenclatural inconsistency by researchers may account for confusion between cosmopolitan distributions and localized endemism within the boring bivalve lineages. This is easily understood, as the majority of boring bivalve species names (and most marine bivalves) were originally designated exclusively based on shell characters. The shell morphology of boring bivalves has shown intraregional variation as large as interregional variation (Coan, 1997). This could be due to worldwide conspecificity, as has been suggested for *Botula fusca* by Wilson & Tait (1984), with shell plasticity as a consequence of individual morphometric adaptation to their boring habitat. The use of shell features to discriminate between the species within different lineages of boring bivalves still needs confirmation from other methods (e.g., gross anatomy and histology, molecular sequencing and analyses).

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