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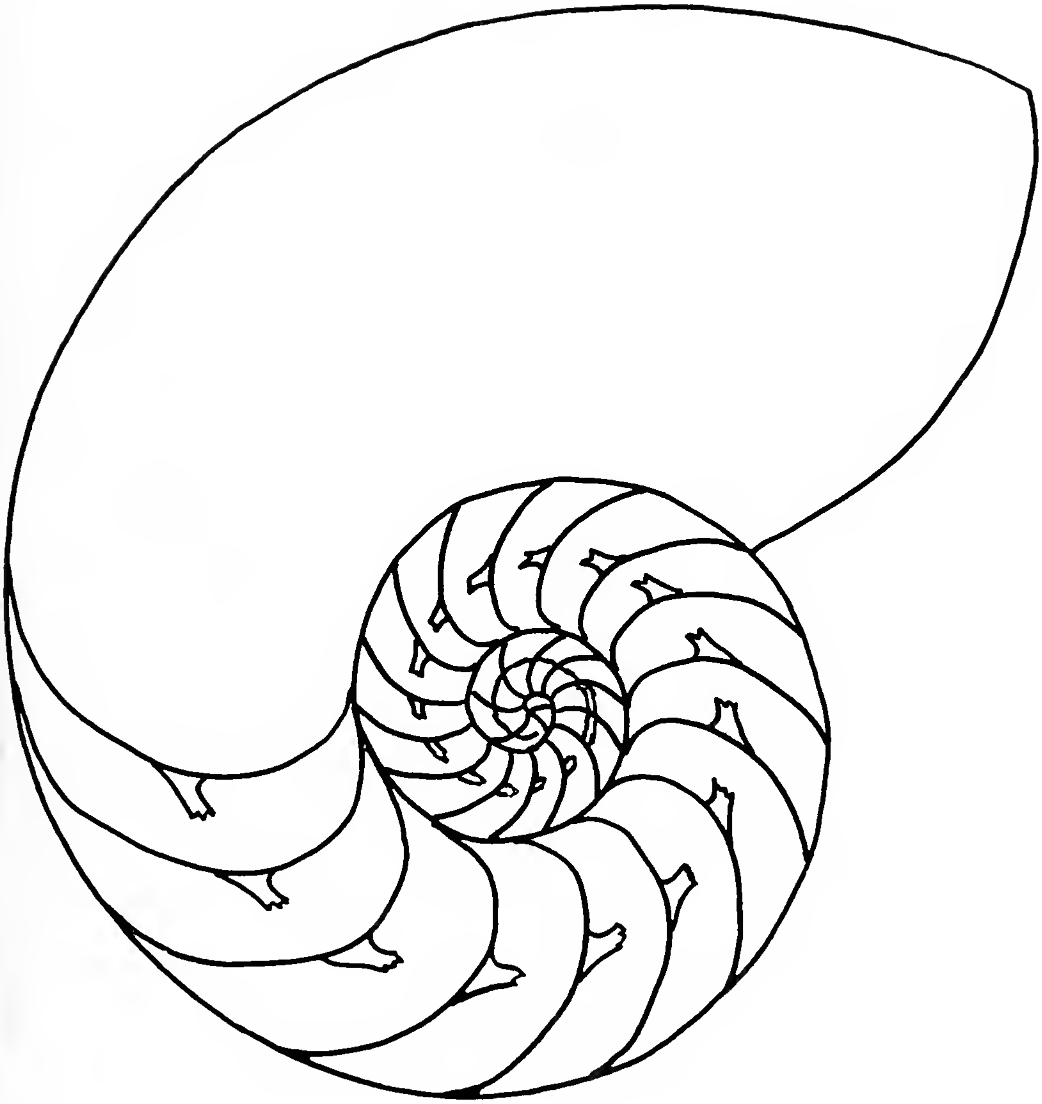

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ANNOTATED CHECKLIST OF FLORIDA ASCOGLOSSAN OPISTHOBRANCHIA

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ABSTRACT

Distribution records are presented for 25 species of Ascoglossa mollusks in Florida, including 8 previously unknown for Florida. About 35 species of Ascoglossa occur in Florida, including undescribed species. The Florida fauna contains significant contributions from the temperate west Atlantic fauna as well as the Caribbean fauna. Habitats, diet, and collection data and techniques are described, brief taxonomic summaries presented, and comparisons drawn between tropical and temperate populations.

The opisthobranch fauna of the Caribbean province is relatively well-known, due largely to the works of Ernst and Eveline Marcus and others (Engel, 1925, 1927; Verrill, 1900, 1901; Mörch, 1863; Edmunds, 1963, 1964). A species list and summary of records of Western Atlantic opisthobranchs including some 20 species of Ascoglossa from Florida has been published by Marcus (1977). Also, Marcus (1980) published a summary of the Western Atlantic species of Elysiidae, including 13 species from Florida. However, distributions of species within Florida are poorly known, with the majority of collections only from south Florida. Further, information about the microhabitats of most species, necessary to effectively collect these species, is virtually non-existent, and many species are known only from preserved material. This paucity of data is especially pronounced in the Ascoglossa, a group well-represented in Florida. During our extensive field collections and laboratory work with Ascoglossa (Clark & Goetzfried, 1978; Clark & Busacca, 1978; Clark *et al.*, 1979; Stirts & Clark, 1980; Jensen, 1980a, b; Clark & Jensen, 1981; Clark *et al.*, 1981; Jensen, 1981a, b; Weaver & Clark, 1981; Clark, 1982; Jensen, 1982, in press a, b; and several papers in preparation), we have come across several species previously unrecorded from Florida. Also, we include new records for species previously reported from Florida. Collection data for these species will be presented in the present study, along with taxonomic and ecological notes on some of the species.

MATERIALS AND METHODS

Most species were collected with suction collectors (Clark, 1971) while snorkeling in shallow water, by vigourously shaking handfuls of algae to dislodge animals. Others were found by maintaining clumps of algae in lighted laboratory aquaria. After 1 or 2 weeks, animals that were

FIG. 1. *Location of study sites in Florida: 1) Haulover Canal, Banana River; 2) Indian River, Melbourne; 3) Sebastian Inlet; 4) Fort Pierce Inlet; 5) Upper Florida Keys; 6) Lower Florida Keys; 7) Tampa Bay.*

too small to see at the time of collecting grew to visible size.

Fig. 1 shows the locations where we collected the ascoglossans mentioned in this study. Collecting data for individual species will be mentioned in the following section.

Drawings of entire animals were made with camera lucida from live specimens relaxed in 8% $MgCl_2.6H_2O$ in seawater. Radular mounts were made as described by Jensen (1981a).

Development patterns are as classified by Bonar (1978): Type 1 (planktotrophic); Type 2 (lecithotrophic, metamorphically competent at, or soon after, hatching); and Type 3 (encapsulated metamorphosis).

LIST OF SPECIES[1]

OXYNOACEA

Ascobullidae

1. *Ascobulla ulla* (Marcus & Marcus, 1970)*

Lobigeridae

2. *Lobiger souverbii* Fischer, 1856*

Oxynoidae

3. *Oxynoe antillarum* Mörch, 1863*
4. *Oxynoe azuropunctata* Jensen, 1980

Juliidae

5. *Berthelinia caribbea* Edmunds, 1963*

ELYSIACEA

Elysiidae

6. *Elysia canguzua* Marcus, 1955**
7. *Elysia cauze* Marcus, 1957*
8. *Elysia chlorotica* Gould, 1870*
9. *Elysia evelinae* Marcus, 1957*
10. *Elysia ornata* (Swainson, 1840)*
11. *Elysia papillosa* Verrill, 1901
12. *Elysia patina* Marcus, 1980*
13. *Elysia picta* Verrill, 1901 (=*E. duis*)
14. *Elysia serca* Marcus, 1955*
15. *Elysia tuca* Marcus, 1967*
16. *Tridachia crispata* Mörch, 1863*
17. *Bosellia corinneae* Marcus, 1973
18. *Bosellia marcusi* Marcus, 1972*
19. *Bosellia mimetica* Trinchese, 1891*

Caliphyllidae

20. *Caliphylla mediterranea* Costa, 1867**
21. *Cyerce antillensis* Engel, 1927*
22. *Mourgona germaineae* Marcus & Marcus, 1970**

Hermaeidae

23. *Costasiella lilianae* (Marcus & Marcus, 1969)**
24. *Hermaea cruciata* Gould, 1870*
25. *Aplysiopsis zebra* Clark, 1982

Stiligeridae

26. *Placida kingstoni* Thompson, 1977**
27. *Ercolania coerulea* Trinchese, 1893*
28. *Ercolania funerea* (Costa, 1867)*
29. *Ercolania fuscata* (Gould, 1870)**
30. *Stiliger fuscovittatus* Lance, 1962**
31. *Stiliger vossi* Marcus, 1960

Habitat Characteristics

Haulover Canal, Titusville, Brevard Co.: This region connects the northern Indian River Lagoon with Mosquito Lagoon, but lacks a direct oceanic connection. Typical annual salinity and temperature ranges are about 20-30‰ and 17-31°C (Gilbert & Clark, 1981), but temperatures as low as 6°C occur in some winters. The substrate is predominantly fine sand, with abundant seagrasses *(Syringodium* and *Halodule)* and a seasonal drift algal community.

Sebastian Inlet, Indian River Co., and Fort Pierce Inlet, St. Lucie Co.: Collections from these areas are mostly from artificial rock-jetty substrates, which are dominated by *Caulerpa racemosa*. At Sebastian Inlet, this alga is seasonal, from about April-November, but *C. racemosa* occurs nearly all year at Fort Pierce. Fort Pierce frequently incurs heavy surf, but the Sebastian Inlet site is somewhat protected by a parallel jetty. Salinity and temperature at Fort Pierce are essentially oceanic, but seasonal runoff can cause rapid and extreme dilution at Sebastian Inlet, which often causes a temporary die-back of *Caulerpa* at the end of summer.

Florida Keys: Substrates vary from calcareous silt to rock, and usually support a rich assemblage of siphonalean algae and *Thalassia*, rarely *Halodule* or *Syringodium*. Salinity usually varies around 35-37‰, and we have measured temperatures as low as 12°C (Feb.) to 35°C (September). Although absolute distance from the Upper to Lower Keys is not large (270 km), the progressively more oceanic location of

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[1] *new distribution within Florida; **new record for Florida.

the Lower Keys makes them somewhat more tropical. Most habitats in the Keys are well-sheltered from waves by offshore reefs. Borrow pits (roadside areas dredged as a source of fill for highway construction) and tidal canals provide areas of higher nutrient levels, and often provide especially rich collecting areas.

1. *Ascobulla ulla* (Marcus & Marcus, 1970)

Synonyms: *Cylindrobulla ulla* Marcus & Marcus, 1970.

New records: Fort Pierce Inlet; Key Largo.

Previous records: Key Biscayne (Marcus, 1972a); Brazil (Marcus & Marcus, 1970).

Habitat: Burrows in sandy substrate surrounding rhizomes of *Caulerpa* spp. At Fort Pierce Inlet, it occurred on *Caulerpa racemosa*, at Key Largo usually with *C. paspaloides*. In aquaria, large animals frequently climb up into assimilators of *Caulerpa*, but usually burrow near rhizoids.

Food: *Caulerpa* spp. (Jensen, 1981a).

Development: Type 3 (Clark & Jensen, 1981).

Taxonomic remarks: The taxonomic position of this species has been previously discussed (Jensen, 1981a).

2. *Lobiger souverbii* Fischer, 1956

Synonyms: *L. sagamiensis* Baba, 1952 (see Baba, 1974).

New records: Fort Pierce Inlet; Sebastian Inlet.

Previous records: Brazil (Marcus, 1957); Curaçao; Guadeloupe; Florida (Marcus & Marcus, 1967); Puerto Rico (Warmke & Almodovar, 1972); Barbados (Marcus & Hughes, 1974); Jamaica (Thompson, 1977); Costa Rica (Houbrick, 1968); Baja California, Mexico (Sphon, 1971); Galapagos (Sphon & Mulliner, 1973); Hawaii (Kay, 1964); Japan (as *L. sagamiense*, Baba, 1952) (Baba, 1974).

Habitat: On *Caulerpa racemosa* on relatively exposed localities.

Food: *Caulerpa racemosa*. Feeding could not be observed directly because the animals always crawled to the side of the alga facing away from the light source. However, emptied algal segments, which could only have been made by *L. souverbii*, have been observed on the *Caulerpa*, and growth was detected when the animals had only this alga to feed on. *L. souverbii* tested the food algae with the lobular extensions of the rhinophores as well as with the oral lobes.

A peculiar characteristic of the radula of this species is that the oldest teeth (in the ascus and some in the descending limb) have bristles on their flanges, whereas the younger teeth (some in the descending and all in the ascending limb) are smooth (Jensen, 1980a). In a juvenile specimen (shell length 1 mm), however, all teeth in the radula had the bristles. Since both juveniles and adults feed on *C. racemosa*, it must be concluded that the bristles must be of help to the small animals, which probably have less musculature in the pharynx and esophagus.

Color patches on the upper surface of the parapodia vary from very pale pink in some specimens to brown in others.

3. *Oxynoe antillarum* Mörch, 1863

Synonyms: *O. aguayoi* Jaume, 1945.

New records: Fort Pierce Inlet; Sebastian Inlet.

Previous records: Key Biscayne (Marcus & Marcus, 1970); Virgin Islands (Mörch, 1863); Brazil; Curaçao; Atlantic side of Panama (Marcus & Marcus, 1970); Puerto Rico (Warmke & Almodovar, 1972); Barbados (Marcus & Hughes, 1974); Costa Rica (Houbrick, 1968); Jamaica (Thompson, 1977); Cuba (as *O. aguayoi*, Jaume, 1945).

Habitat: On *Caulerpa racemosa* at relatively exposed localities.

Food: *Caulerpa racemosea* (Jensen, 1981a).

Development: Type 1 (Clark & Goetzfried, 1978; Clark & Jensen, 1981). This distinguishes *O. antillarum* from *O. azuropunctata* Jensen, 1980 from the Florida Keys. The latter species has type 2 development (Jensen, 1980b; Clark & Jensen, 1981), and occurs mostly on *C. paspaloides* in relatively sheltered habitats (Jensen, 1980b).

Taxonomic remarks: see Jensen, 1980b, 1981a.

5. *Berthelinia caribbea* Edmunds, 1963

New records: tidal canals emptying into Card Sound, Key Largo; Deepwater Cay, Bahamas.

Previous records: Jamaica (Edmunds, 1963; Grahame, 1969; Thompson, 1977); Panama (shells); Brazil (Meeder & Moore, 1972); Puerto Rico (Warmke, 1966); Spanish Harbor Key, Florida (Moore & Miller, 1979).

Habitat: *Caulerpa verticillata* growing on mangrove roots or directly in muddy bottom of tidal canals; uncommon. Most easily found in late autumn, when reduction of *C. verticillata* concentrates animals; not seen in field collections; found only by aquarium culture of algae.

Food: *Caulerpa verticillata* (Edmunds, 1963; Grahame, 1969).

Development: Type 2 (Grahame, 1969; Clark & Jensen, 1981).

6. *Elysia canguzua*, Marcus, 1955

New records: Fort Pierce Inlet.

Previous records: Brazil (Marcus, 1955). This is the first record since the original description.

Habitat: On *Bryopsis plumosa* on exposed outer jetty, and on *Codium* sp. inside inlet in strong current.

Food: *Bryopsis plumosa* and *Codium* sp. Marcus (1955) sketched how they pierced the tip of a utricle of *Codium* and sucked out the contents. When feeding on *Codium* sp., it seemed like *E. canguzua* tried to swallow the whole tip of a utricle by spreading the oral lobes and buccal tube around it. In the laboratory they would also feed on *Bryopsis plumosa* and *Chaetomorpha* sp. In fact, small animals seemed to prefer *Bryopsis* over *Codium*.

Development: Type 1.

7. *Elysia cauze* Marcus, 1957

New records: Fort Pierce Inlet; Sebastian Inlet.

Previous records: Brazil, south Florida (Marcus, 1977).

Habitat: Usually in sheltered areas such as tidal canals in south Florida, on a variety of *Caulerpa* species; especially common on *C. verticillata* as juveniles; occasionally collected on jetties, but only in sheltered areas. We have recently separated three species which closely resemble *E. cauze*; one feeds on *C. racemosa* in the same habitats as *E. cauze*, hence is very difficult to separate from it, but the other two eat *C. prolifera* and *Penicillus dumetosus*, respectively. All four species have the distinctive black margin on the parapodium, which has previously characterized *E. cauze*.

Food: *Caulerpa* spp. (Clark & Busacca, 1978).

Development: Type 3, possibly type 2; the type 1 development reported by Clark *et al.* (1979) appears to belong to the undescribed species mentioned above, and probably does not occur in *E. cauze*.

8. *Elysia chlorotica* Gould, 1870

New records: Sebastian Inlet; Indian River at Melbourne and at Haulover Canal, Titusville.

Previous records: Chesapeake Bay (Marcus, 1972b); Noank, Conn. (Clark, 1975); Minas Basin, Nova Scotia (Bailey & Bleakney, 1967); New Jersey (Franz, 1968); Cape Cod (Russel, 1964); Texas (Boone, 1982).

Habitat: On *Chaetomorpha* sp. in sheltered, estuarine areas.

Food: *Chaetomorpha* sp. (Clark, 1975; West, 1977); *Cladophora* sp. (Clark, 1975; Franz, 1968); *Vaucheria* (Clark, 1975; Russel, 1964; West, 1977).

Development: Type 1 (Clark, 1975).

9. *Elysia evelinae* Marcus, 1957

New records: Key Largo; Fort Pierce Inlet; Haulover Canal.

Previous records: Miami (Marcus & Marcus, 1967); Brazil (Marcus, 1957).

Habitat: Shaded, sheltered areas ("under rocks") with dense growths of centric diatoms (Key Largo), or among epiphytic diatoms on *Bryopsis* spp. or *Caulerpa* spp. also in shaded areas (Fort Pierce Inlet). We first collected *E. evelinae* in a tidal canal on Key Largo. It was found on mixed algae, mostly *Caulerpa verticillata*, but only one or two specimens were collected at a time. After discovering that *E. evelinae* fed on diatoms (Jensen, 1980a, 1981a), it became easier to locate the right habitat, and thus to collect more specimens.

Food: *Biddulphia* sp. (Jensen, 1981a).

Development: Type 2, occasionally type 3 (Clark & Jensen, 1981). The two types of development are often found within the same eggmass. Most larvae hatch as large veligers (length approx. 210 μm) with eyes. They swim little; most of the time they crawl around testing the substrate. Often a few veligers in each egg-mass stay behind and complete metamorphosis within the egg capsule. It is not known what factors determine how many larvae have the latter type of development, but it seems likely that the feeding conditions of the parents are important, because egg-masses laid by starved parents usually all would hatch as type 2 veligers. Development time at room temperature (approx. 20°C) is 12 days to hatching and 12–14 days till metamorphosis is completed.

10. *Elysia ornata* (Swainson, 1840)

New records: Sebastian Inlet; Fort Pierce Inlet; patch reef off Windley Key.

Previous records: Miami (Marcus, 1972a, 1980); Jamaica (Thompson, 1977); Barbados (Marcus & Hughes, 1974); Curaçao; Tobago; St. Vincent; Bermuda (Verrill, 1901; Marcus & Marcus, 1970); Hawaii; Vietnam; Australia (Pease, 1860; Risbec, 1956; Thompson, 1973).

Habitat: On *Caulerpa racemosa* and *Bryopsis plumosa* (FPI), and on *Bryopsis* sp. (Windley Key).

Food: *Bryopsis* spp. (Jensen, 1981a).

Development: Type 1. Egg-mass generally has 2 embryos per capsule as in *E. maoria* (Reid, 1964); some extrazygotic yolk material is present.

Taxonomic remarks: The status of this species has been widely discussed (Marcus & Marcus, 1963; Thompson, 1973, 1977; Marcus, 1977). The teeth of the present specimens were smooth and approximately 150 μm long, thus resembling both the Australian material (Thompson, 1973) and Jamaican specimens (Thompson, 1977).

12. *Elysia patina* Marcus, 1980

New records: Key Largo.

Previous records: "Florida Keys".

Habitat: Common on *Udotea* spp. in very shallow water of tidal canals. This species prefers eutrophic areas with moderate tidal flow.

Food: Presumably *Udotea*.

Development: Type 1.

14. *Elysia serca* Marcus, 1955

Synonyms: *E. clena* Marcus & Marcus, 1970 (Jensen, in press a).

New records: Long Key; Snake Creek Canal (Windley Key); Point Elizabeth and tidal canal on Key Largo; Fort Pierce Inlet; Banana River at Rt. 520; and Indian River at northern end of Merritt Island (Jensen, in press a).

Previous records: Brazil (Marcus, 1955; Horsoe, 1956); Curaçao (Marcus & Marcus, 1970, as *E. clena*); Florida (Marcus, 1972a, as *E. clena*); Barbados (Marcus & Hughes, 1974, as *E. clena*). *Elysia catulus* Gould, 1870 has not been found in Florida, contrary to a statement by Marcus (1980). The southern limit of *E. catulus* probably coincides with that of eelgrass, *Zostera marina* L., in the Carolinas.

Habitat: Seagrass beds, preferably containing *Halophila engelmanni*. In the Florida Keys *E. serca* is most often found on *Thalassia testudinum*.

Food: Seagrasses, i.e. *Halophila engelmanni*, *Halodule wrightii*, and *Thalassia testudinum* (Jensen, in press a).

Development: Type 1 (Clark & Jensen, 1981).

Taxonomic remarks: Will be discussed by Jensen (in press a).

15. *Elysia tuca* Marcus, 1967

New records: Florida Keys, Fort Pierce Inlet.

Previous records: Curaçao; Elliott Key; Big Pine Key; Brazil (Marcus & Marcus, 1963, 1970); Puerto Rico (Warmke & Almodovar, 1972); Barbados (Marcus & Hughes, 1974); Jamaica (Thompson, 1977).

Habitat: Almost always associated with *Halimeda* spp., less frequently on *Penicillus dumetosus* (Lamouroux) Blainville. Occasionally found crawling on coral rocks, on *Caulerpa* spp., or on *Thalassia testudinum* (on which the eggs are often deposited). This is probably the most common ascoglossan in the Florida Keys. The depth range of this species is very broad, from high subtidal to c. 30 m at Deepwater Cay, Grand Bahama. At Fort Pierce, the species occurs in heavy surf on *Halimeda discoidea*, but prefers *H. incrassata* in still waters of the Florida Keys.

Food: *Halimeda* spp., *Caulerpa* spp., *Avrainvillea nigricans*, and *Udotea* sp. (Clark & Busacca, 1978). *Halimeda* spp. is the preferred food of this species (Stirts & Clark, 1980). Its pedal lobes are very weakly developed, and the ventral side of the head is almost continuous with the foot. This is probably an adaptation to feeding on the flat segments of *Halimeda* spp. Like *Lobiger souverbii*, this species crawls away from the light source when placed under the dissection microscope, and thus feeding could not be directly observed.

Development: Type 2 (Clark & Goetzfried, 1978; Clark & Jensen, 1981).

16. *Tridachia crispata* Mörch, 1863

Synonyms: *Elysia crispata*.

New records: Key Largo; Windley Key; Long Key; Big Pine Key; Geiger Key.

Previous records: Venezuela to Columbia; Honduras; Florida; Antilles and Barbados (Marcus & Marcus, 1967; Marcus, 1976, 1977); Jamaica (Thompson, 1977); Curaçao; Bonaire; Haiti (Marcus & Marcus, 1970, Thompson, 1977).

Habitat: Often found straying away from any algae, on bare sand or coral rock ("under rocks"); not uncommon at moderate depths (on coral reefs). Sometimes associated with *Caulerpa verticillata*. The preferred habitat appears to be highly eutrophic areas (i.e. borrow pits, marinas) with dense algal growth, as the densest populations and largest animals occur there. Reef animals may wander far from visible algae, but apparently do require periodic feedings to restore chloroplasts. This species exhibits a pronounced daily activity cycle; usually emerges from crevices in late afternoon, disappearing in mid-morning, depending on light intensity (Weaver & Clark, 1981).

Food: *Caulerpa verticillata* is the principal food of juveniles, but adults will also feed on *Halimeda*, *Bryopsis*, *Cymopolia*, *Penicillus*, and *Batophora* (Clark & Basacca, 1978; Jensen, 1980a).

Development: Type 2, occasionally type 3 (Clark & Jensen, 1981).

Remarks: Juvenile animals closely resemble *Elysia*. They are green with black heads, smooth parapodia and short rhinophores. The parapodia of juveniles (Fig. 2) do not meet at the neck, and are smooth-margined, not ruffled. Separation of certain species of *Tridachia* based on these ontogenetically variable characters may be unsupportable.

18. *Bosellia marcusi* Marcus, 1972

New records: Hens and Chickens Reef off Windley Key; Borrow pit, Grassy Key.

Previous record: Key Biscayne, FL.

Habitat and Food: *Halimeda opuntia* (L.) Lamouroux; this diminutive animal (3 mm) clings tightly to the alga, requiring vigorous shaking to dislodge it, and is easily overlooked because of its size. Uncommon.

Development: unknown; the few large follicles (Marcus, 1973) suggest type 2 or 3.

19. *Bosellia mimetica* Trinchese, 1891

New records: Fort Pierce Inlet.

Previous records: Mediterranean (Portman, 1958); Florida (?Miami) (Marcus & Marcus, 1970; Marcus, 1973); Barbados (Marcus & Hughes, 1974); Brazil (Marcus, 1977).

Habitat: On *Halimeda discoidea* on very exposed rocks in strong surf. Difficult to shake loose from algae; slugs are nearly invisible *in situ*.

Food: *Halimeda* spp. (Portman, 1958; Jensen, 1981a).

Development: Type 1 (Clark & Jensen, 1981).

20. *Caliphylla mediterranea* Costa, 1867

New records: Fort Pierce Inlet; Hens and Chickens Reef, Windley Key.

Previous records: Virgin Islands (Engel, 1927); Brazil (Marcus & Marcus, 1970); Mediterranean (Gascoigne, 1979).

Habitat: On *Bryopsis plumosa* on sheltered/shaded side of rocks on exposed coast.

Food: *Bryopsis plumosa* (Gascoigne, 1979; Brüel, 1904).

Development: Type 1 (Clark & Jensen, 1981).

Taxonomic remarks: Based on morphological comparisons with the description given by Gascoigne (1979), the present material may represent a different species from the Mediterranean.

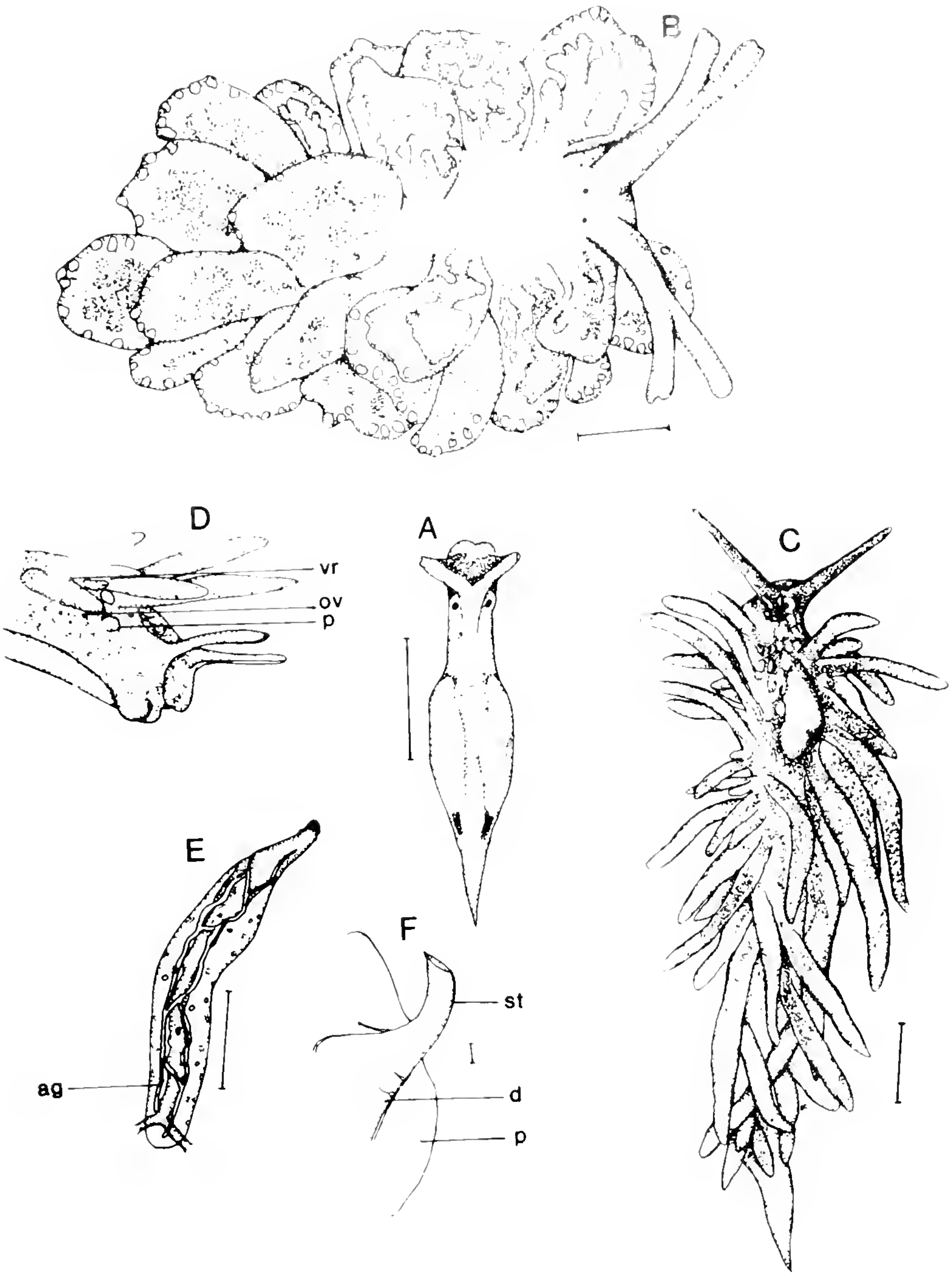

FIG. 2. **A**, *Juvenile* Tridachia crispata; **B**, Mourgona germainae; **C**, Placida kingstoni; **D**, *Right anterior of* P. kingstoni; **E**, *ceras of* P. kingstoni; **F**, *penial stylet of* P. kingstoni. *Scale bar in F = 10μm; all other scale bars = 1 mm; vr = vaginal ridge; ov = oviducal aperture; p = penis; st = stylet; d = duct.*

21. *Cyerce antillensis* Engel, 1927

New records: Fort Pierce Inlet; Key Largo; Windley Key.

Previous records: Virginia Key; Elliott Key (Marcus & Marcus, 1967); Curaçao; Puerto Rico; Tobago (Marcus & Marcus, 1970); Jamaica (Thompson, 1977).

Habitat: Most often on *Penicillus* spp.; occasionally on *Halimeda discoidea* (FPI). Often in areas with strong currents.

Food: *Penicillus* spp., *Udotea flabellum*, *Halimeda* spp. (Jensen, 1981a).

Development: Type 2 (Clark & Goetzfried, 1978; Clark & Jensen, 1981).

Taxonomic remarks: The teeth of the Florida specimens are considerably smaller than those of the Jamaica specimens (Thompson, 1977), and also the bases of the teeth are relatively shorter in the Florida specimens (see also Marcus & Marcus, 1963, 1970). The figure of "*Cyerce cristallina* (Trinchese)" shown by Marcus & Marcus (1967) is actually *C. antillensis;* to our knowledge, *C. antillensis* is the only *Cyerce* known from Florida.

22. *Mourgona germaineae* Marcus & Marcus, 1970

New record: Geiger Key, near end of Key West Naval Air Station Runway.

Previous record: Puerto Rico (Marcus & Marcus, 1970).

Habitat: Exclusively on dense growths of *Cymopolia barbata* in very warm, relatively sheltered, shallow water. We have been unable to find this species in more northerly populations of *Cymopolia*, but these generally regress completely in winter. Occurrence within the *Cymopolia* zone (immediately shoreward of the *Sargassum* zone on hard sand/rock bottom) is sharply demarcated, suggesting water temperature, and especially the thermocline, may control recruitment of this species.

Food: *Cymopolia barbata* (Jensen, 1981a).

Development: Type 1 (Clark & Jensen, 1981). Eyes are present in newly-hatched larvae, but the larvae are morphologically type 1 in other respects, and could not be induced to metamorphose on *C. barbata*.

Taxonomic remarks: This species is probably synonymous with *Cyerce edmundsi* Thompson, 1977 from Jamaica. Thompson mentioned that the cerata of *C. edmundsi* contained branches of the digestive gland, and the teeth closely resemble those of *M. germaineae*. Unfortunately no mention was made of the presence or absence of a large pharyngeal crop, the absence of which characterizes the genus *Mourgona* (Marcus & Marcus, 1970), but the presence of digestive diverticula in the cerata clearly separates it from the genus *Cyerce* (See Swennen, 1961).

Our animals varied from whitish to dark green, depending on the state of the digestive diverticula. The diverticula appear as lobular branches in the flat cerata (Fig. 2). The cerata are highly adhesive and appear to detach defensively; other slugs die when kept in the same container as this species, suggesting that it excretes toxins.

23. *Costasiella lilianae* (Marcus & Marcus, 1969)

Synonyms: *Stiliger lilianae*.

New records: Key Largo; Long Key; Big Pine Key; Geiger Key.

Previous records: Brazil; Puerto Rico (Marcus & Marcus, 1969); Jamaica (Thompson, 1977).

Habitat: Always associated with *Avrainvillea* spp., mostly in sheltered, shallow water; occasionally to 5 m depth (largest animals were found at this depth).

Food: *Avrainvillea* spp. (Clark & Busacca, 1978; Jensen, 1981a).

Development: Type 3 (Clark & Goetzfried, 1978; Clark & Jensen, 1981).

Taxonomic remarks: Possibly this species is a synonym of *Doto ocellifera* Simroth from Bermuda (Clark, in prep.). Thompson (1977) cites Marcus (1976) as authority for Florida distribution, but this citation did not mention *C. lilianae*.

24. *Hermaea cruciata* Gould, 1870

New records: Key Largo; Haulover Canal (Indian River).

Previous records: Chesapeake Bay (Vogel, 1971); Massachusetts (Gould, 1870).

Habitat: In dense growth of red algae in sheltered areas, usually in reduced salinity, in winter (a few specimens in spring and autumn).

Food: *Griffithsia* sp. The rasping movements of the buccal mass were very rapid. No buccal regurgitation was observed, and often a central string of red cytoplasm was left in the algal cell after the animal had moved on to another cell.

Development: Type 1 (Clark & Jensen, 1981).

Taxonomic remarks: This species is probably synonymous with *H. coirala* Marcus, 1955, in which case the range extends to Brazil.

26. *Placida kingstoni* Thompson, 1977

New records: Tampa Bay; Fort Pierce Inlet; Indian River; Key Largo.

Previous records: Jamaica (Thompson, 1977).

Habitat: Strongly seasonal occurrence; spring and fall on *Bryopsis plumosa*, medium exposure; sometimes extremely common on *Cladophora* sp. *(gracilis?)* on oyster shells in the Indian River near Sebastian.

Food: *Bryopsis plumosa* (Jensen, 1981a), occasionally *Cladophora* sp.

Development: Type 1 (Clark & Jensen, 1981).

Taxonomic remarks: This species is morphologically similar to *Placida viridis* Trinchese, but *P. viridis* has paired longitudinal stripes on the sole of the foot.

Description: Pigmentation is somewhat different than Thompson (1977) noted. The chromatophores are typically purplish-grey, and are concentrated on the pericardial hump, ceratal tips, and anterior sides; the anus, penis, oviduct, and vaginal ridge are free of pigment. The genitalia are pseudodiaulic. Cerata are in two densely packed rows; a 9 mm specimen had about 75 cerata. The anus is mid-dorsal, lying slightly posterior to the beginning of the ceratal rows. Digestive diverticula are sparingly branched within the anterior body, and extend into the lower half of the rhinophores. The cerata are very long (half of body length), and contain single unbranched diverticula; each diverticulum is surrounded by a delicate, sparsely anastomosed albumen gland (Fig. 2).

27. *Ercolania coerulea* Trinchese, 1893

Synonyms: *E. costai* Pruvot-Fol, 1951 (Schmekel, 1968), *Stiliger cricetus* Marcus & Marcus, 1970.

New records: Key Largo; Long Key.

Previous records: Key Largo (Marcus & Marcus, 1960); Curaçao (Marcus & Marcus, 1970, as *S. cricetus*), Mediterranean (Schmekel, 1968); Lesser Antilles (Marcus & Marcus, 1963).

Habitat: Often found inside clumps of *Dictyosphaeria cavernosa* and *Valonia* sp., which have to be broken up to reveal the presence of the animals. They occasionally occur intertidally inside these algae in cooler months. Also, sometimes on *Cladophoropsis* sp. In relatively sheltered, very shallow water.

Food: *Valonia* sp., *Dictyosphaeria cavernosa*, and *Cladophoropsis* sp. (Jensen, 1981a).

Development: Type 1 (Clark & Jensen, 1981).

Taxonomic remarks: Synonymy with *E. costai* was discussed by Schmekel (1968). Shape of radular teeth, number of radular teeth and general appearance indicates that it is also synonymous with *Stiliger cricetus*. The specimen described by Marcus & Marcus (1970) was obviously a juvenile.

28. *Ercolania funerea* (Costa, 1867)

New records: Haulover Canal; Indian River at Melbourne; Sebastian Inlet; Key Largo; Geiger Key.

Previous records: Puerto Rico; Curaçao (Marcus & Marcus, 1970); Mediterranean (Schmekel, 1968); Florida (Marcus, 1972a).

Habitat: On dense growths of floating or sessile algae, mostly *Chaetomorpha* spp., and on *Cladophoropsis* sp. growing in very shallow water; occasionally on *Cladophora* spp. The largest specimens occur on *Cladophoropsis* and *Chaetomorpha*. From 1972-1975 this species was extremely common throughout the northern Indian River on *Chaetomorpha*, but this alga has nearly disappeared from the area in recent years.

Food: *Chaetomorpha* spp., *Cladophora* spp., and *Cladophoropsis* sp. (Jensen, 1981a).

Development: Type 1 (Clark & Jensen, 1981).

29. *Ercolania fuscata* (Gould, 1870)

Synonyms: *Stiliger fuscatus*, *?S. evelinae* Marcus, 1959 (see Baba & Hamatani, 1970), *S. vanellus* Marcus, 1957, *?S. talis* Marcus, 1956.

New records: Sebastian Inlet; Key Largo; Windley Key; North Indian River.

Previous records: Noank, Conn. (Clark, 1975); Nova Scotia (Bleakney & Meyer, 1979); Baja California, Mexico (Ferreira & Bertsch, 1975); Chesapeake Bay (Marcus, 1972b, also as *E. vanellus*); Miami (Marcus & Marcus, 1960 as *E. vanellus*); Virginia Key (Marcus & Marcus, 1970, as *E. vanellus*); Jamaica (Edmunds, 1966); Brazil (Marcus, 1957, also as *E. talis*); ?Chile (Marcus, 1959, as *S. evelinae*). Not in Australia as stated by Thompson (1973) (see Gascoigne, 1978), because Thompson's material has propodial tentacles and a broad foot; possibly this animal is an *Alderiopsis*.

Habitat: Most often on *Cladophora* spp., either growing attached to mangrove roots or free floating; occasionally on *Chaetomorpha* sp. (see also Clark, 1975).

Food: *Cladophora* spp. and *Chaetomorpha* spp. (Clark, 1975).

Development: Type 1 (Clark, 1975; Clark & Jensen, 1981).

Taxonomic comments: *S. vanellus* differs from *E. fuscata* only in pigmentation. Populations of *E. fuscata* on *Cladophora* frequently contain specimens with "*vanellus*" pigmentation as well as normal, melanistic *fuscata* specimens; *Chaetomorpha* populations are almost entirely melanistic. Thus, we regard "*vanellus*" as an ecotypic variant of *fuscata*.

30. *Stiliger fuscovittatus* Lance, 1962

New records: Indian River at Titusville.

Previous records: California (Lance, 1962).

Habitat: Single occurrence, on algae attached to marker float.

Food: *Polysiphonia* spp. (Lance, 1962; own obs.).

Development: Type 1 (small eggs).

DISCUSSION

We estimate that there are at least 35 ascoglossan species in Florida; this includes the 25 species for which we have presented new distributional data, 6 additional described species, 3 undescribed *Elysia* species, 2 undescribed *Stiliger* species, and a new *Placida*. This fauna includes nearly all species reported for the greater Caribbean fauna, excepting *Cyerce cristallina* (known from Bermuda; Thompson, 1977), *Costasiella nonatoi* Marcus (Brazil, Puerto Rico; Marcus, 1977), *Volvatella bermudae* Clark, (Bermuda; Clark, 1982), and *Polybranchia viridis* (Deshayes) (Marcus, 1977), when synonomies are accounted for. This high diversity – about 15% of all described species (worldwide) – exists because the Florida fauna includes both truly tropical components (e.g. *Mourgona germainae, Berthelinia caribbea*) and temperate species (e.g. *Hermaea cruciata, Ercolania fuscata*). We attribute part of our success in collecting Florida species to the "island mass effect" – higher nutrient availability in areas near large land masses due to runoff – which seems to favor high recruitment of ascoglossans. Comparable collecting activities in drier, smaller island areas of the Caribbean (e.g. the Bahamas and Virgin Islands) often yield much smaller numbers of individuals and species. This effect is also visible within Florida, as the Lower Keys provides relatively poor collecting. There are as yet no published records for ascoglossans from the northwest coast of Florida (Gulf of Mexico), but the relatively productive waters of this area might provide interesting collections.

Of all Ascoglossa reported from Florida, only the habitat of *Stiliger vossi* remains unknown; this species has not been observed since its original description.

While many of the new records reported here increase known ranges by only about 360–400 km, this involves transition between essentially tropical and subtropical marine habitats, so we regard these new records as significant. Sand-bottom siphonalean algal communities, in which most tropical Ascoglossa occur, are rare or absent in nearshore waters north of Miami. The area between Fort Pierce and Sebastian Inlet marks the northern limit for growth of *Halimeda*, and several *Caulerpa* species do not occur north of Sebastian Inlet (however, *C. ashmeadii* and *C. prolifera* have recently invaded the northern Indian River between Sebastian Inlet and Titusville). Although we have not yet collected species which feed on these algae in the Indian River, we expect that these species (e.g.

Elysia cauze) may extend their ranges into this coastal lagoon.

Nearly every siphonaceous alga we have examined in Florida supports at least one ascoglossan species, though not in all habitats where such algae occur. Even at the range limits of such algae, intensive collecting usually yields animals. Because the Ascoglossa are highly stenophagous, we feel that the ranges of species that occur in Florida are limited primarily by the occurrence of appropriate foods, rather than directly by temperature. In central Florida, many such algae appear to be limited by the occurrence of suitable habitats (e.g. quiet, shallow water, sandy bottom, high salinity), rather than temperature, though Cape Canaveral seems to represent a significant thermal barrier farther north (Parr, 1933).

Several species (*Elysia ornata, Cyerce antillensis, Caliphylla mediterranea, Bosellia mimetica, Aplysiopsis zebra*) occur in very high energy habitats at Fort Pierce or Sebastian Inlet. These species do not seem to possess special adaptations to strong wave action (except *B. mimetica*), but rather seem to exploit microhabitat conditions (eddies, dense algal growth, lees of boulders, submerged tidepools) to avoid wave energy. In the case of *Aplysiopsis zebra*, animals appear to crawl below the sand surface at low tide. Collectors should be aware that exposed coasts do in fact provide suitable habitats for Ascoglossa.

There are noteworthy differences in habitat specificity and population density between temperate and tropical ascoglossans. Northern species may occur seasonally in extremely dense populations (Clark, 1975), but tropical species usually occur in very low densities; we frequently spend hours to collect a hundred specimens in the Florida Keys, but a single handful of algae in New England may contain several hundred animals during seasonal peaks. Also, temperate species occur almost ubiquitously, where suitable foods are found, but tropical populations are frequently strongly clumped, and a distance of as little as 100 m may mean the difference between success and failure in finding a given species, despite uniform occurrence of food algae and apparently similar features of microhabitat. We are unable to explain this variability at present. However, selective predation may be a partial cause, because aquarium culture of food algae shows that juveniles are far more abundant than adults under field conditions.

This clumped nature of tropical populations, combined with patchy occurrence of algal foods, makes tropical populations extremely difficult to quantify. However, our qualitative assessment of most species is that they are typically present all year, with egg production extending over a period of several months; probably most species have the potential to produce several generations per year, though these tend to be clustered during optimal periods of favorable temperature. Most true tropical species seem to reach peak activity in late summer and autumn, when water temperatures reach as high as 32°C.

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A BIOGRAPHICAL SKETCH OF WILLIAM IRVIN UTTERBACK (1872-1949)

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William Irvin Utterback was born 11 October 1872 on a farm near Crawfordsville, Montgomery Co., Indiana. His father, John Walton Utterback, represented the seventh generation of Utterbacks in the United States. The Utterback family tree, in the new world, has its roots in one Hermann Otterbach, a native of Trupbach near Siegen, Germany, who with forty-one other German immigrants set foot on the Virginia coast in April, 1741. This small group

FIG. 1. William I. Utterback, about 1925.

of coal miners and iron workers established the settlement known as Germanna, Virginia. They were given land and conferred tax-free status in return for settling in the outlying areas around Williamsburg and acting as a barrier between marauding indians and the civilized townfolk of British descent. This hardy German stock soon became well known for qualities such as industriousness, literacy and religious endeavors. Early records mention that nearly all members of the colony could read and write.

Very quickly the new arrivals became anglicized in ways, speech and names. Hermann Otterbach became Herman Utterback. The name has remained unchanged and the line continued unbroken to John Walton Utterback (1850-1897). John Walton married Martha Hannah Miller (1854-1936) on December 14, 1871, and ten months later she bore a son christened William Irvin Utterback.

Young Utterback exhibited a propensity for learning, and at the age of eighteen years acquired teaching certification. In the fall of 1890 he began, in a rural Indiana elementary school, a teaching career which would span fifty-five years. In the year 1905, having earned a B.S. degree from Wabash College in 1901, Utterback moved to St. Joseph, Missouri, and took a position as high school biology teacher, a post he would hold intermittently until 1917. At the direction of the Bishop of the Presbyterian Church of Missouri, Utterback traveled in 1907 to Arkansas. He established, and became the first president of, The School of the Ozarks (presently The College of the Ozarks), a Presbyterian denominational school. The years 1908-1911 were spent as an instructor of biology at Westminster College; the following six years (1911-1917) were important in the development of Utterback's scientific career. During this period he returned to his position as biology teacher at St. Joseph High School, but more importantly he enrolled in graduate school at the University of Missouri. Utterback was granted the A.M. degree in 1915, having done a good portion of his graduate work under the direction of Dr. George Lefevre. During the summers of 1913-1914 he had the opportunity of working at the U. S. Fisheries Lab, Fairport, Iowa, where he learned a great deal about freshwater mussel biology and also did much of the work that led to the publication for which he is today most remembered, "The Naiades of Missouri," published in 1916. These middle years of his life were the most productive scientifically and a steady flow of papers, all having to do with the biology of naiades, resulted.

Other significant events in his life occurred during this period. He married Bessie Ruby Austin (1877-1938) in 1905, and from this union came a son William I., Jr. (1907) and a daughter Anna Martha (1908).

In the fall of 1917 the Utterback family moved to Spokane, Washington, where William was again employed as a high school biology teacher at Lewis and Clark High School. Mrs. Utterback was apparently adversely affected by the climate of the Spokane area and Utterback was forced to again relocate.

On October 24, 1919, Utterback accepted a position at Marshall Normal School (presently Marshall University) in Huntington, West Virginia, for which he was paid the princely sum of $2,000 for a ten-month academic year. Professor Utterback from this time forth adopted the Huntington area and remained at Marshall University until his retirement at the age of 73 in 1945.

Professor Utterback was, for many years, the only biologist on staff at Marshall. Old newspaper clippings indicate that he was an interesting, efficient and dedicated staff member. His teaching load included Comparative Anatomy, Embryology, Zoology, Invertebrate Zoology and other courses as student needs dictated. He also served as advisor to pre-medical students.

His advancing age and heavy course load seems to have reduced his energies given to outside research. Few scientific publications were produced during the Marshall years. Professor Utterback was a devoutly religious man and was an elder in the Huntington First Presbyterian Church. His religious beliefs often showed even in his scientific works.

> "Yet in the last analysis we scientists, who deal so much with the material and natural law, may lose sight of the spiritual and supernatural in the fact that the GREAT JEHOVAH (the SELF-EXISTENT ONE) is the Alpha and Omega whether we consider Evolution in the life history of the individual or even of all Phyla."
>
> *Phylogeny and Ontogeny of Naiades, 1928.*

While it is true that the production of scientific papers waned in the later years, he did not stop writing. In two books and several lesser publications he sought to document his ancestory (The Utterback Family 1622-1937), and to bring together his religious beliefs and scientific thinking. Through the book "The Second Triangle" and a lesser publication "The Great Life Cycle" Professor Utterback brings together the concepts of Evolution and Special Creation. His thesis states that Seth, the third born of Adam and Eve, carried the God-created line and blended it, through marriage, with the line of Anthropoid human beings which had evolved through time outside the Garden of Eden.

I have in my possession a mimeographed booklet titled *Single Verse Poems* produced by Utterback about 1930. The following four line verse attests to the conflict which garnered much of his thinking in later life.

Special Creation and Evolution

Special Creation is mutation
By God's almighty hand
Evolution is Revolution
Through laws at HIS command.

Utterback the man

Professor Utterback was deeply involved in many other aspects of community life. He held memberships in the A.A.A.S., the West Virginia Academy of Science, Chi Beta Phi and the American Institute of Geneology. In addition he was an active member of the local chapter of the Sons of the American Revolution, working through the ranks to become chapter president in 1942.

Utterback epitomized the early American naturalist and corresponded regularly with such distinguished biologists as Drs. F. C. Baker, R. E. Coker, A. E. Ortmann, V. Sterki and W. H. Dall, as well as Thaddeus Surber, Bryant Walker and L. S. Frierson. In the summer of 1913-14 he surveyed, in a row boat, three hun-

FIG. 2. William I. Utterback, about 1945.

dred miles of the Osage River of central Missouri; a feat which seems overwhelming in light of present day thinking and technology. The enclosed picture of Utterback in full field regalia says a great deal about Utterback the naturalist.

Upon retirement Professor Utterback moved to Los Angeles, California, where he lived with his daughter until his death on May 16, 1949. The professor was buried May 20, 1949 in Woodmere Cemetery, Huntington, West Virginia.

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THE SOUTH AMERICAN HYDROBIOID GENUS *IDIOPYRGUS* PILSBRY, 1911

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ABSTRACT

The shell and soft parts of the hydrobioid Idiopyrgus *and* I. souleyetianus *Pilsbry, 1911, are described from material from two sites in the state of Minas Gerais, adjacent to the state of Espirito Santo, Brazil, the type locality. Examination of other specimens from the states of Bahia and Mato Grosso indicated a wide geographic distribution in Brazil of species belonging to this genus.* Hydraeme *Haas, 1938, and* Aquidauania *Davis, 1979, are considered synonyms, while* Oncomelania brasiliensis *Rey, 1959, is invalidated.*

There is a great need to stabilize the systematics of some South American hydrobioid freshwater snails, which are actual or potential first intermediate host of the lung flukes, *Paragonimus* spp. Of particular interest are those hydrobioids of Brazil. Pilsbry (1911), created the genus *Idiopyrgus* from the state of Espirito Santo, eastcentral Brazil, with *I. souleyetianus* Pilsbry as type species. The description of the genus and species was based on shell and radular characteristics only. Other species of *Idiopyrgus* were later described: namely *I. pilsbryi* by F. Baker (1913), and *I. walkeri* by Pilsbry (1924). Haas (1938) erected a new genus, *Hydracme*, with *H. rudolphi* Haas as type, from the state of Pernambuco in the northeast. Rey (1959) described *Oncomelania brasiliensis* from the Paraguay river drainage in Campo Grande, the state of Mato Grosso. The general anatomy of the reproductive systems as well as the radula were presented. On the basis of a preliminary examination of snails from the same state in Brazil, but from the Aquidauana river drainage Davis (1979) believed that Rey's hydrobioid snails should belong to a new pomatiopsine genus *Aquidauania* Davis, rather than to the Oriental genus *Oncomelania*. Davis's account was very brief, and he reserved further information on his genus until more material becomes available.

Specimens collected by the writer in the states of Minas Gerais and Bahia, and specimens given to him from Mato Grosso, made it possible to revise the systematics of this hydrobioid group from Brazil. Emphasis is made in this report on a complete description of Pilsbry's *Idiopyrgus* and *I. souleyetianus* and on synonymizing certain other genera in the same geographic area.

Genus *Idiopyrgus* Pilsbry, 1911

Shell dextral, turreted; spire long with convex whorls and deep sutures. Aperture obliquely ovate, its basal margin being rounded and advanced; peristome simple or slightly thickened within. Operculum horny, paucispiral.

Tentacles slender; foot with pedal crease. Central tooth of radula with few cusps (5 to 7) on the upper reflection, and also few cusps, 9 and 16 on marginals; outer marginal scoop-like. Female oviparous; bursa copulatrix large, with spermathecal duct arising from its middle portion and extending separately from pallial oviduct with which it usually unites near female genital opening. Sperm duct arises from spermathecal duct close to bursa copulatrix and joins visceral oviduct. Verge large, curved and simple, that is, devoid of any appendages or papillae. Snails are aquatic in freshwater.

Idiopyrgus souleyetianus Pilsbry, 1911

Specimens examined for the description of *I. souleyetianus* are from the Brazilian states of Minas Gerais, Mato Grosso and Bahia: Sete Lagoas and Pedro Leopoldo, Minas Gerais; Ceroula stream in Campo Grande, Mato Grosso; and the following localities in western Bahia: reservoir behind dam at São Desideiro; side road ditch in outskirts of Barreiras; pond about 10 miles south of Barreiras; and irrigation canal near São Desideiro.

Redescription of shell – Shell (Fig. 1 B) turreted with 6 to 7½ rounded, convex and smooth whorls; sutures deep. Adult shells measuring 4 to 6.5 mm (average 5.5) in height, and averaging 2.1 mm in width. In old specimens spire becomes eroded and thus shortened. Shell with a small umbilical chink behind aperture at columellar margin. Aperture obliquely ovate, basal margin rounded with slight expansion; outer lip slightly thickened within, sometimes reflected, but always retracted upward forming a rounded sinus just below upper insertion. Operculum corneous, transparent, paucispiral, with the nucleus near columellar margin.

Description of soft parts – Animal grayish black; tentacles slender, with their distal two-thirds black. Eyes each with an "eye brow" of white-yellowish color. Snout slightly bilobed anteriorly. Foot elongate, truncate anteriorly and tapering posteriorly beyond attached operculum. Foot with pedal crease (Fig. 1 D), and there is a suprapedal fold continuous with operculigerous lobe. Omniphoric groove present between suprapedal fold and snout. Gill with about 50 lamellae, high near origin on left side close to mantle collar and tapers posteriorly. Central tooth of radula with 2 or 3 cusps on each side of a larger cusp on the upper reflection, and with 2 or 3 basal cusps. Lateral tooth with 7 cusps and inner marginal tooth with 9 cusps. Outer marginal scoop-like, with about 16 cusps.

Female oviparous. Ovary yellowish, having a few branches embedded in the apical portion of the digestive gland. Oviduct tubular at its visceral portion and convoluted in the region of kidney, then enlarges to form a saccular and wide posterior portion of pallial oviduct (Fig. 1 A). The latter extends, almost of the

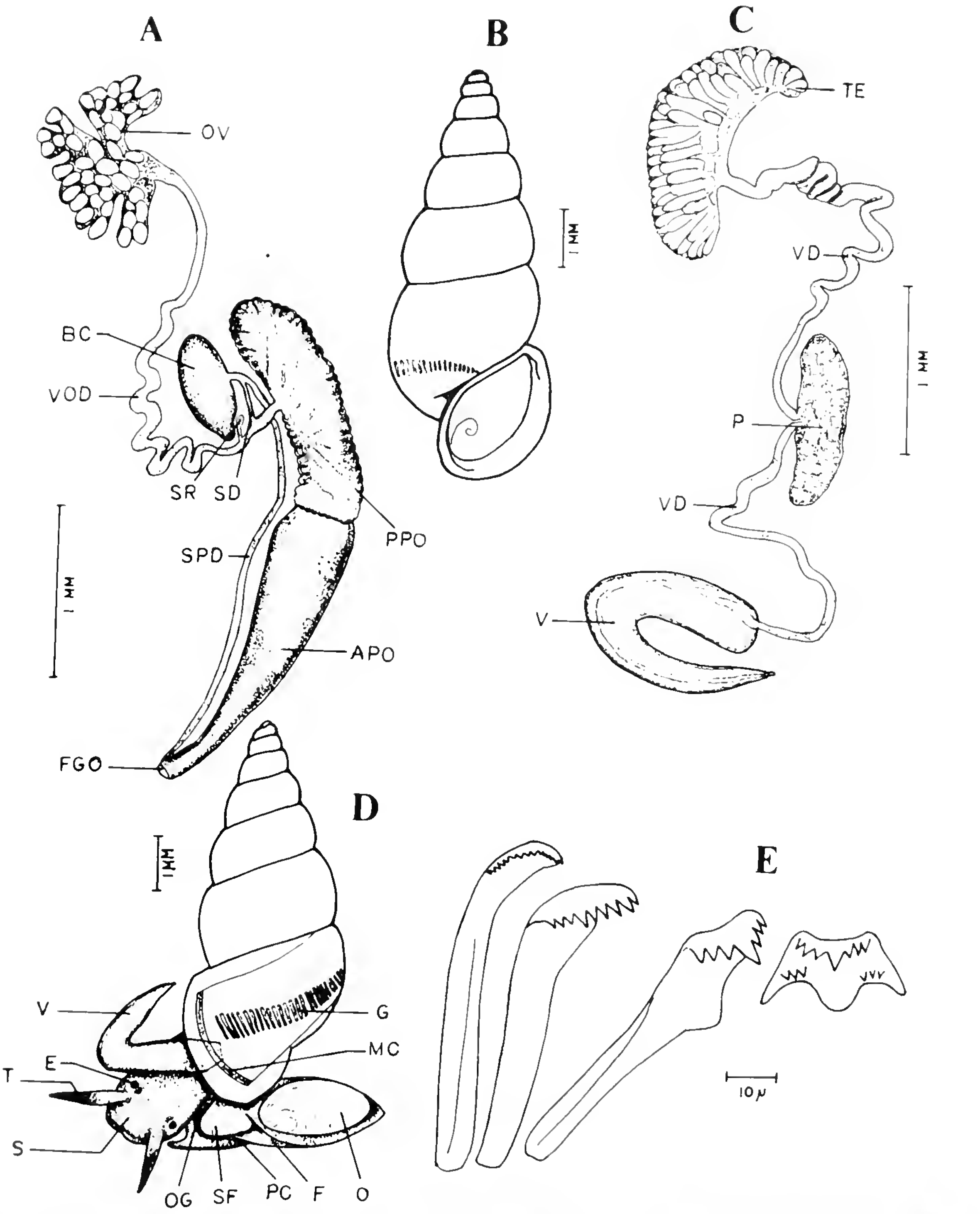

FIG. 1. Idiopyrgus souleyetianus *Pilsbry, 1911.* **A,** *Female reproductive organs.* **B,** *Female snail, apertural view.* **C,** *Male reproductive organs.* **D,** *Male snail showing verge, snout, foot, operculum and gill.* **E,** *Radula. APO, anterior pallial oviduct; BC, bursa copulatrix; E, eye; F, foot; FGO, female genital opening; G, gill; MC, mantle collar; O, operculum; OG, omniphoric groove; OV, ovary; P, prostate; PC, pedal crease; PPO, posterior pallial oviduct; S, snout; SD, sperm duct; SF, suprapedal fold; SPD, spermathecal duct; SR, seminal receptacle; T, tentacle; TE, testis; V, verge; VD, vas deferens; VOD, visceral oviduct.*

same diameter, as the anterior portion of pallial oviduct to female genital opening on right side of anal opening at mantle collar. Bursa copulatrix large, oval near posterior pallial oviduct. Spermathecal duct arises from middle of bursa and runs anteriorly along pallial oviduct and joins the latter immediately before female genital opening. In a few specimens, however, spermathecal duct opens separately to outside. Sperm duct arises from spermathecal duct close to bursa and opens in the tubular visceral oviduct, close to opening of short stalk of seminal receptacle.

In the male, testis embedded in apical portion of digestive gland. Testis larger than ovary of female and consists of digitiform diverticula which end in small ducts that unite to form vas deferens. The latter, convoluted at its beginning, eventually reaches a kidney-shaped prostate gland. After receiving secretions from prostate gland vas deferens proceeds anteriad, along esophagus until it reaches base of verge, and proceeds inside it running along convex margin to tip. Base of verge fleshy, almost flattened and curves to form a cylindrical terminal portion which tapers to tip where it forms a minute knob-like structure. Verge simple throughout, devoid of any appendages or papillae (Fig. 1 C and D).

DISCUSSION

No important morphological differences were found among the hydrobioid material examined from the Brazilian states of Minas Gerais, Bahia and Mato Grosso. It is to be noted that Minas Gerais is adjacent to the state of Espirito Santo where the Rio docé is the type locality of *Idiopyrgus souleyetianus*. The Mato Grosso material was examined previously by Rey (1959), who designated *Oncomelania brasiliensis* for the specimens from the Paraguay river drainage in Campo Grande county, and by Davis (1979), who designated *Aquidauania brasiliensis* for the specimens from Aquidauana river drainage. The writer agrees with Davis that the specimens cannot be considered an *Oncomelania* because of their aquatic rather than amphibious habitat, and that the bursa copulatrix complex differs from that of *Oncomelania*. Davis (1979), however, did not study in detail the anatomy of the Campo Grande material but relied on Rey's (1959) description. Despite this he erected a new genus *Aquidauania*. Based on the morphological information given in the present paper I consider Pilsbry's genus and species, *Idiopyrgus souleyetianus*, which were described on the basis of the shell and radula only, to extend west, from Espirito Santo, Minas Gerais and Bahia, into Mato Grosso. I, therefore, invalidate *Oncomelania brasiliensis* Rey, 1959, and place *Aquidauania* Davis, 1979 into synonymy with *Idiopyrgus*.

Another hydrobioid genus which was described from the same geographic area is *Hydracme*, with *H. rudolphi* as type, from São Francisco river near Jatoba, state of Pernambuco (Haas, 1938). This new name was based on a series of specimens taken from a fish stomach. Taylor (1966) correctly synonymized *Hydracme* with *Idiopyrgus* because of the great variation he encountered when examining a large series of topotypes. The variation within this series, and among other lots representing undescribed species from the states of Paraiba and Pernambuco, effaces the supposed distinctions between *Hydracme* and *Idiopyrgus*. However, Taylor, apparently using shell features alone, placed the genus *Idiopyrgus* under his subfamily Littoridininae (family Hydrobiidae), together with *Littoridina*, *Durangonella*, *Pyrgophorus*, *Mexipyrgus* and others. It has been pointed out in the description of *Idiopyrgus* in the present report that the verge is simple, without papillae, lobes or appendages, thus differing completely from the latter genera in the Littoridininae.

Two other species of *Idiopyrgus* have been described on the basis of the shell alone, namely *I. pilsbryi*, from north bank of chief affluent of Papary lake near its mouth, state of Rio Grande do Norte by F. Baker (1913), and *I. walkeri*, from Rio de Valhas, tributary to São Francisco river at Lassance, state of Minas Gerais by Pilsbry (1924). Probably these two species should remain valid until their anatomy is elucidated.

Certain morphological features of *Idiopyrgus*, as presented in this paper, place it in the family Pomatiopsidae, subfamily Pomatiopsinae, rather than in the Hydrobiidae, as defined by Davis (1979). The pomatiopsine hydrobioids have a spermathecal duct which is separated from the pallial oviduct, and is derived not from the ciliated ventral channel as found in the Hydrobiidae, but from elongation of a bud from the bursa copulatrix; males have a simple verge, that is, with one duct and is devoid of appendages or lamellae; there is a pedal crease; the central tooth of the radula lacks the pronounced lateral angles of *Hydrobia*, and there are two or more pairs of basal cusps, the largest arises from the face of the tooth, a condition not seen in *Hydrobia*, other pairs arise from the face or from the lateral angle.

ACKNOWLEDGMENTS

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VITRINIZONITES LATISSIMUS (PULMONATA: ZONITIDAE) AND *VERTIGO CLAPPI* (PUPILLIDAE) FROM EASTERN KENTUCKY

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The Blue Ridge Snail, *Vitrinizonites latissimus* (Lewis), has been previously reported from the Blue Ridge Physiographic Province of Tennessee and North Carolina, and from the Ridge and Valley of Virginia (Hubricht, 1970, 1971, 1973; Pilsbry, 1946). Pilsbry (1946) reported its occurrence from the Cumberland Plateaus near Gurley, Alabama, based on four specimens in the collections of the Academy of Natural Sciences of Philadelphia. Recent collecting by the senior author in the vicinity of that locality has failed to yield *V. latissimus*, and its current status in Alabama is uncertain. According to Pilsbry (1946) it is generally distributed at elevations above 2000 feet, being restricted to moist places with abundant moss cover. Hubricht (1961) expressed the belief that *Vitrinizonites uvidermis* Pilsbry represents gerontic in-

FIGS. 1 *and* 2. 1, *Ventral view of* Vitrinizonites latissimus *(Lewis) from Pine Mountain. Width: 18.9 mm.* 2, Vertigo clappi *Brooks and Hunt from Pine Mountain. Height: 1.5 mm.*

dividuals of *V. latissimus* which have resorbed the calcareous layers of the shell. All individuals examined from Kentucky localities had rigidly calcified shells.

Vertigo clappi Brooks and Hunt is known from Marion County, West Virginia, in the Allegheny Plateaus, and from Jefferson, Greenbrier, Hampshire, and Pendleton counties, West Virginia, and Loudon County, Virginia in the Ridge and Valley (Briscoe, 1963; Brooks and Kutchka, 1938; MacMillan, 1949). Little is known about its habitat preference or other aspects of its ecology.

We have recently collected specimens of *V. latissimus* from Pine and Big Black Mountains, Harlan County, Kentucky, and *Vertigo clappi* from Pine Mountain, Harlan County, Kentucky. These collections represent significant extensions of the known ranges of the two species and are the first verifiable reports of either species in the Cumberland Plateaus.

Pine Mountain is a northwest-facing monoclinal mountain extending some 200 km along the northwest edge of the Cumberland overthrust block. Elevation varies from approximately 650 m in the southwestern half to about 850 m in the northeast. The Pine Mountain site is located along U. S. Hwy. 421, 0.6 km southeast of its junction with Ky. Hwy. 221, elevation about 700 m, lat. 36°53′57″N, long. 83°20′15″W. The site is a north-facing mountainside of mesic woods with numerous moss-covered boulders of Pennington limestone. Specimens of *V. latissimus* were collected exposed on vegetation when active in humid weather, and beneath moss mats and in leaf litter when not active. *Vertigo clappi* was found only beneath moss mats and accumulated detritus on top of limestone boulders. Other land snails collected at this site are listed in Table 1. Further collecting at four sites of similar elevation and exposure along Pine Mountain from U. S. Hwy. 421 to U. S. Hwy. 119 near Whitesburg, Ky. yielded no further specimens of either species. The distribution of these two species on Pine Mountain would thus appear to be very patchy.

Big Black Mountain is a maturely dissected residual mass of horizontally bedded Pennsylvanian sandstones and shales rising to an elevation of about 1260 m, some 250 m above the adjacent Cumberland peneplain. *Vitrinizonites latissimus* was initially collected at two sites by members of the Eastern Kentucky University malacology class (B. Branson, pers. comm.), and has been subsequently collected by the authors at two additional sites. Three of the sites are along Ky. Hwy. 160, and range in elevation from 1005 m to 1200 m. The fourth site was near the summit, elevation 1240 m. All sites were of mesic woodland with varying degrees of exposed sandstones and shales. *Vitrinizonites latissimus* was not abundant at any site on Big Black Mountain, but appears to be rather widely distributed.

The apparent disjunctions of the Kentucky populations of these two snail species from the main part of their ranges, along with their restriction to higher elevations, suggests that these populations may represent relicts of a formerly widespread distribution. Davis and Barbour (1978) summarized evidence for the refugial nature of Big Black Mountain with respect to vascular plants, birds, mammals, and carabid beetles. Twenty-three species of plants and animals of northern or Appalachian affinities are largely restricted in their Kentucky distribution to Big Black Mountain. A number of

TABLE 1. *Land snails collected with* Vitrinizonites latissimus *(Lewis) and* Vertigo clappi *Brooks and Hunt at Pine Mountain, Kentucky.*

Hendersonia occulta (Say)
Pomatiopsis lapidaria (Say)
Carychium nannodes Clapp
Carychium clappi Hubricht
Cionella morseana Doherty
Columella simplex (Gould)
Gastrocopta pentodon (Say)
Gastrocopta contracta (Say)
Gastrocopta corticaria (Say)
Vertigo gouldi (Binney)
Haplotrema concavum (Say)
Pallifera secreta Cockerell
Philomycus venustus Hubricht
Punctum blandianum (Pilsbry)
Discus nigrimontanus (Pilsbry)
Discus patulus (Deshayes)
Anguispira mordax (Shuttleworth)
Succinea ovalis (Say)
Striatura meridionalis (Pilsbry and Ferriss)
Ventridens collisella (Pilsbry)
Gastrodonta interna interna (Say)
Paravitrea capsella (Gould)
Paravitrea subtilis Hubricht
Paravitrea multidentata (Binney)
Mesomphix cupreus (Rafinesque)
Mesomphix perlaevis (Pilsbry)
Mesomphix inornatus (Say)
Glyphyalinia rimula (Hubricht)
Glyphyalinia cumberlandiana (Clapp)
Guppya sterkii (Dall)
Euconulus fulvus (Müller)
Allogona profunda (Say)
Triodopsis albolabris (Say)
Triodopsis denotata (Ferussac)
Triodopsis tridentata (Say)
Triodopsis vulgata Pilsbry
Mesodon inflectus (Say)
Mesodon appressus (Say)
Mesodon sayanus (Pilsbry)
Mesodon zaletus (Binney)
Stenotrema stenotrema (Pfeiffer)
Stenotrema edvardsi (Bland)

these species of small mammals have been reported to occur on Pine Mountain as well (Caldwell, 1980). Many of these populations presumably represent once more widely distributed Pleistocene relicts.

Branson and Batch (1968) noted that the land snail faunas of Pine and Big Black Mountains bear a closer affinity to the faunas of the Eastern Division of the Cumberland Subregion of Pilsbry (1900) than to the Western Division. This view is supported, and our collections provide further evidence of this region's faunal affinities to the Ridge and Valley and Blue Ridge Physiographic Provinces.

ACKNOWLEDGMENTS

The authors are most grateful to Charles K. Smith for photographing the *Vitrinizonites latissimus*, and to SEM operator Henry Southgate for the micrograph of *Vertigo clappi*. SEM costs were underwritten by the University of Kentucky Graduate School.

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PEASISTILIFER EDULIS, A NEW EULIMID PROSOBRANCH, PARASITIC ON AN INDO-PACIFIC HOLOTHURIAN

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ABSTRACT

Peasistilifer edulis *new species is described from NE Australia and New Caledonia. It closely resembles previously described species of the genus but has a taller spire and a proportionally smaller aperture.* P. edulis *lives as an ectoparasite on the Indo-Pacific* Holothuria (Halodeima) edulis *(Lesson) and sucks body fluid from the lacunae in the body wall of the host.*

The family Eulimidae is a large group of mesogastropods with highly variable morphology whose species are ecto- or endoparasites of echinoderms. A review of the genera is given by Warén (*in press*). The new species described here was found some years ago when the senior author prepared a study on the biology and anatomy of *Mucronalia nitidula* Pease, 1860 (Hoskin and Cheng 1969, 1970). Later, Warén (1980) described the genus *Peasistilifer* with *M. nitidula* as type species and listed other species belonging to the genus.

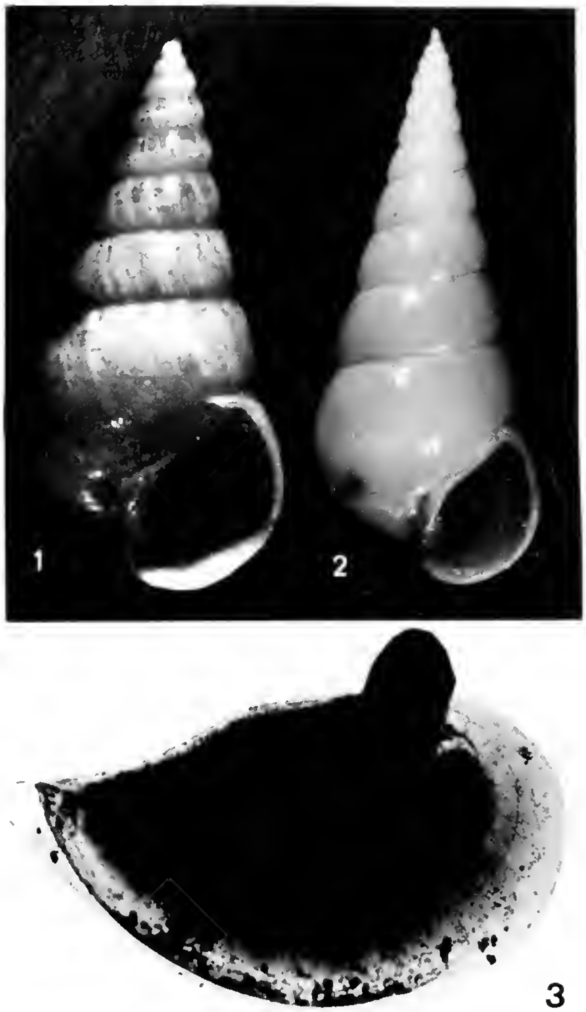
Peasistilifer edulis *n. sp.*

Description – Shell straight, conical, high and pointed, rather solid, opaque, very polished and white. The larval shell consists of about 2.5 whorls (Fig. 3) and its height is 320-340 μm. The whorls are slightly convex, perfectly smooth, more cylindrical than the postlarval whorls, and differentiated from them by a distinct scar. An adult female has 10.5 postlarval whorls, the first of which increases its diameter very rapidly; later whorls increase slowly and regularly. The postlarval whorls are unusually convex for the family. Their largest diameter is about 1/3 the height of a whorl from the lower suture. Except for a few indistinct incremental lines, they are perfectly smooth and polished. There are no growth scars of the kind characteristic of many eulimids. The aperture is low and rounded. The outer lip, seen from the side, protrudes slightly at the suture, is shallowly sinuated below the suture, protrudes again at the middle of its height, and is slightly retracted below this point (Fig 4.). Some New Caledonia specimens have a broad and shallow umbilicus behind the low part of the parietal callus; in others (the type specimens) the callus forms an expanded pad covering this area.

Dimensions – Females are 1.5-1.7 times larger than males but slightly narrower in proportion to their height (Figs. 1 and 2). A large female (Fig. 2), height 9.69 mm, diameter 4.74 mm; aperture height 2.50 mm, breadth 1.79 mm. Holotype, found to be male, height 5.48 mm, diameter 2.75 mm, height of the aperture 1.05 mm, breadth 0.55 mm.

Soft parts – The tentacles and the area around the posterior pedal gland are light-yellow; other soft parts are more or less colorless. (In *P. nitidula* there is one reddish spot in front of each eye, on the tentacle, a series of red spots along the rectum, and a reddish line along the osphradium. Remaining parts of the body are white.) The tentacles are rather long and slender with large black eyes at their bases. The male has a large penis behind and to the right of the right tentacle. The foot is rather small but functional and is equipped with anterior and posterior pedal glands. The pedal gland opens into a furrow on the underside of the foot and produces a filament of mucus used for attachment to the host. There is a distinct propodium.

On the sides of the foot are two pedal flaps. The left one is larger and extends from the



FIGS. 1-3. **1** *and* **2,** Peasistilifer edulis, *shell.* **1,** *Holotype, Heron Island, SE Australia. USNM 787954. Height 5.48 mm, male. When collected the shell was white and highly polished. Apparent markings due to preservation damage.* **2,** *Female, Ilot Maitre, New Caledonia, 9.69 mm high. (Photographs not to scale.)* **3,** *Operculum of* P. edulis. *Height 1.81 mm. Extreme tip broken; dashed line indicates broken part.*

posterior end of the opercular lobe along the side of the foot, ending between and just to the right of the proboscis and the left tentacle; its anterior part is drawn out into a short tongue. The right flap is smaller and thinner and does not reach as far posteriorly as the left one. It also lacks the tongue-shaped anterior end, but ends in the corresponding position on the right side. These flaps are highly muscular and probably cover the base of the shell when the snail is parasitizing.

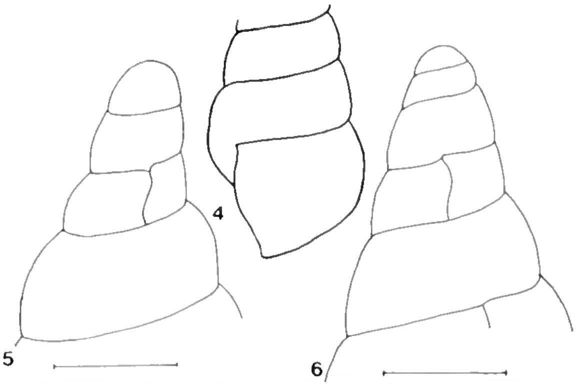
The proboscis is long (but proportionately shorter than in *P. nitidula*) and may not be completely retractile; it was partly extended in preserved *P. edulis* specimens, whereas in *P. nitidula* it was completely retracted. The operculum is large, paucispiral and equipped with a large bulbous muscular attachment deeply inserted into the opercular lobe (Fig. 5). The operculum has radial growth lines and a few spiral lines, one of which is predominant. A distinctly thinner zone along the outer edge acts as a packing to ensure tight fitting of the operculum.

Type locality – On reef flat, Heron Island, Queensland, Australia; attached to body wall of *Holothuria (Halodeima) edulis* (Lesson). Specimens were collected by the senior author, December 1967.

Holotype – One large male specimen from the type locality, U.S. National Museum of Natural History (USNM), Division of Mollusks, reg. no. 786715 (Fig. 1).

Paratypes – Six specimens from the type locality, USNM, 787954; one large female (Fig. 2) and one male from the body wall of *H. edulis*, Îlot Maître, off Noumea, New Caledonia, April 27, 1978, 1 m deep, on the reef flat, coll. P. Bouchet, material in Muséum National d'Histoire Naturelle, Paris; a few specimens from Suva, Fiji, January 1967, coll. G. Hoskin; specimens destroyed during anatomical study.

Biology – *P. edulis* lives as an ectoparasite on



FIGS. 4-6. **4,** *Sinuation of outer lip of* P. edulis. **5,** *Apex of* P. edulis. *Scale line 250 μm.* **6,** *Apex of* P. nitidula. *Scale line 250 μm.*

its host, *H. edulis*. It penetrates the tissues of the holothurian with the proboscis until it reaches a suitable lacuna from which to suck body fluid. The dual functions of the proboscis are attachment and provision of food.

After removal from its host, *P. edulis* has obvious difficulties reattaching. Four specimens were removed and isolated for 2 hours. When replaced on the host, none attached during 2.5 hours of observation. In a similar test, 10 specimens of *P. nitidula*, isolated for 7 days, reattached after about 30 minutes. In another test, four specimens of *P. edulis* and 16 of *P. nitidula* were placed in the center of a tank with a specimen of *H. edulis* caged in one end and a specimen of *Holothuria atra* caged in the other end. Ten of 16 *P. nitidula* reattached to *H. atra* after a mean of 32 minutes, whereas only one *P. edulis* reattached (after 44 minutes) during the 2.5-hour experiment. All specimens moved to the vicinity of the normal host species. When given a choice between *H. atra* and *H. edulis*, *P. nitidula* attached itself to *H. atra;* when given access only to *H. edulis*, it parasitized this species after a few hours' delay.

These tests demonstrated a distinct difference between *P. edulis* and *P. nitidula* in ability to reattach. It may be that the proboscis of *P. edulis* becomes injured when removed from the host. Such injury has been observed in several species of *Melanella*, which also parasitize holothurians.

All specimens of *P. edulis* were obtained from a few hundred *H. edulis;* the junior author obtained 660 specimens of *P. nitidula* from about 1800 *H. atra*, which were examined for parasitic snails in NE Australia, New Caledonia, and the Loyalty Islands. No snails were found on the "wrong" host. Apparently there is a high degree of host specificity in the choice of host in the two species. The junior author encountered no specimens of *P. nitidula* or *P. edulis* during his examination of about 3000 specimens of other holothurians. The size and the number of whorls in the larval shell indicated that *P. edulis* has planktotrophic larval development.

Remarks – *P. edulis* can be recognized among eulimids parasitic on holothurians by its operculum which has a peg or bulbous attachment (present only in *Peasistilifer*), by its distinctly convex whorls with their largest diameter well below the middle, by the high number of whorls, and by its tall, conical spire. The larval shell of *P. nitidula*, the species of *Peasistilifer* that *P. edulis* most closely resembles, consists of 3.5 whorls rather than 2.5 (Figs. 3 and 6) and is proportionately broader than that of *P. edulis*.

Large females of *P. edulis* resemble species of *Niso* in the shape of the shell, but *Niso* species usually have flat whorls, a very broad umbilicus, a keeled shell base, and a more or less distinct axial sculpture of sharp but indistinct straight or curved lines. The shells of *Niso* species are usually brightly colored and they do not have opercula with pegs.

In some specimens of *P. edulis* the umbilicus is well-developed (Fig. 2); in others it is completely absent (Fig. 1). However, we believe that this is an intraspecific variation, not an indication that two species are involved, because there are also intermediate specimens. If this assumption is wrong and there are two species in our material, the name *P. edulis* should be used for the form without umbilicus, because the holotype belongs to that form.

ACKNOWLEDGMENTS

We thank Dr. P. Bouchet for the sample of *P. edulis* from New Caledonia and the staff of Heron Island Research Station, Queensland, Australia, for making working facilities available to us during visits there. The East-West Center in Hawaii supported the field study of the senior author and provided financial assistance; the Department of Zoology, University of Hawaii, provided research facilities during part of this study.

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"TEREBRA" COSENTINI PHILIPPI, 1836, AN AMERICAN COLUMBELLID SPECIES

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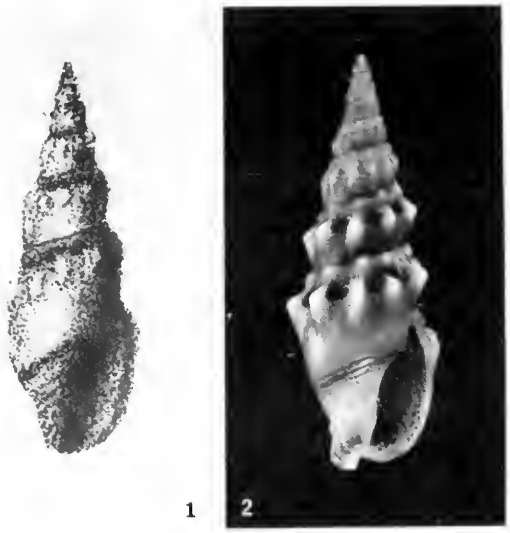
ABSTRACT

Terebra cosentini *Philippi, 1836, an alleged Mediterranean species, is shown to be the correct name for the tropical amphiamerican columbellid generally known as* Mazatlania aciculata *(Lamarck, 1822), and should be excluded from Mediterranean faunal lists.*

The alleged occurrence of a species of *Terebra* in Sicily has long been controversial for Mediterranean conchologists. Although this occurrence has been denied by a number of malacologists, the species *T. cosentini* is still quoted in modern checklists of the Mediterranean fauna (Parenzan 1970; D'Angelo & Gargiullo 1978; Piani 1980 who recognizes its columbellid nature).

De Blainville (1830: pl. 6C, fig. 1) was the first author to record the presence of this species in the Mediterranean under the name *Buccinum aciculatum* Lamarck, 1822, originally described from an unknown locality. Blainville's only two specimens are said to have been received from Prof. Bonelli from the Provence coast. A few years later Philippi (1836: pl. 11, fig. 29) introduced the name *Terebra cosentini* with Naples, Italy, as the type locality. In volume 2 of his work, he himself synonymized his *T. cosentini* with *T. aciculata* (Lamarck). Naples is not mentioned any longer, but the species "is said to live in Tarento" Sicily. A year later, the same species is again described as *Buccinum pulchellum* by Calcara (1845:41, pl. 4, fig. 23), with Palermo, Sicily, as type locality.



FIGS 1 *and* 2. Mazantlania cosentini *(Philippi, 1836).* **1**, *Copy of Philippi's figure 29:17 mm.* **2**, *Specimen from Las Caracas, Districto Federal, Venezuela: 14.2 mm.*

From the mid-19th century onwards, we do not know any original record of this species in the Mediterranean until modern checklists. Monterosato, who extensively collected and published on the Sicilian malacofauna denied (1872:59) the Mediterranean origin of the species. Over the last years, we have visited a number of Italian private collections, and corresponded with a number of collectors in southern Italy. We could not find any specimens with accurate Mediterranean locality data. Shells of this species are rare in collections and always seem to originate from exchanges and/or from 19th century collections. They are always accompanied by such locality data as "Mediterranean" or "Sicily". A number of such samples are present in MNHN collections. Needlessly to add, we have never encountered *T. cosentini* ourselves in the Mediterranean. With this evidence we feel certain that the species must be excluded from the Mediterranean fauna.

The name *Terebra aciculata* (Lamarck) was first associated with a locality by Hinds (1843): west coast of central America. Despite Philippi's synonymizing, both *aciculata* and *cosentini* were kept separate in the major 19th century monographs, due to their widely separate geographical ranges. A little later, Dunker (1853) described *Terebra nodosoplicata* from an unknown locality. He compared his new species with *Terebra cosentini* Philippi and with *Buccinum clavula* Menke, the latter name being apparently a manuscript one. The new taxon was not figured and has always been regarded as a synonym of *T. aciculata* (Lamarck).

The subgeneric name *Euryta* was introduced by H. & A. Adams (1858) for a small group of *Terebra* comprising *aciculata* Lam., *consentini* [sic] Phil., *fulgurata* Phil., *granulosa* Lam. The name being preoccupied by *Euryta* Gistel, 1848, the new name *Mazatlania* was proposed by Dall (1900) without in either case a type species being designated. Thiele (1929) figured a radula of *Mazatlania aciculata* (Lamarck) and transferred the subgenus to the family Columbellidae, as a subgenus of *Pyrene*. The designation of *aciculata* as type-species of *Mazatlania* by Wenz (1941:1142) appears to be the first valid one.

Examination of samples of *M. aciculata* from both sides of central America and comparison with specimens from historical collections labelled as "Mediterranean" *T. cosentini* leaves no doubt as to their synonymy.

However, the name *Buccinum aciculatum* Lamarck, 1822, is preoccupied by *Buccinum aciculatum* Gmelin, 1791. Thus the correct name for the amphi-American species generally known (Radwin 1978:336) as *Mazatlania aciculata* is *M. cosentini* (Philippi, 1836). We give here a copy of the original figure by Philippi and illustrate a specimen from Venezuela, close to the type locality as restricted by Radwin.

In conclusion, the synonymy of this columbellid species can be summarized:

Mazatlania cosentini (Philippi, 1836)

Buccinum aciculatum Lamarck, 1822 (non *B. aciculatum* (Gmelin, 1791)
Terebra cosentini Philippi, 1836
Buccinum pulchellum Calcara, 1845 (non *B. pulchellum* de Blainville, 1829, nec *B. pulchellum* Dujardin, 1837)
Terebra nodosoplicata Dunker, 1853
Mazatlania hesperia Pilsbry & Lowe, 1932 (*fide* Radwin, 1968).

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Riassunto (Italian Summary)

Terebra cosentini Philippi, 1836, una pretesa specie mediterranea, é dimostrato essere il corretto nome per il Columbellide tropicale, sia atlantico che pacifico, generalmente conosciuto come *Mazatlania aciculata* (Lamarck, 1822), e dovrebbe essere escluso dalle liste di faune mediterranee.

A NEW SPECIES OF *COLUMBARIUM* (GASTROPODA: MURICACEA) FROM OFF EASTERN AUSTRALIA

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The genus *Columbarium* Martens 1881 (as defined by Darragh, 1969) is represented in the Recent fauna by eight species, which inhabit outer continental shelf and upper continental slope communities off South Africa, eastern Australia, New Zealand and Japan. Trawling operations off the southern coast of Queensland have brought to light a remarkable new species of *Columbarium*, which more closely resembles several Tertiary species than any in the Recent fauna. This new species is described herein.

Columbarium harrisae *new species*

Figs. 1-4

Description – Shell large (to 110 mm), heavy, fusiform; spire angle 37°–42°; protoconch of 2 whorls, large, bulbous, glassy, with deviated, disjunct apex; transition to teleoconch indistinct, marked by gradual acquisition of a peripheral keel and axial growth lines; teleoconch with up to 8 sharply shouldered whorls; suture adpressed; siphonal canal long, straight, heavy; spiral scupture of 2–4 cords on body whorl and 20–26 finer threads on siphonal canal; axial growth lines produce 21–24 short, open spines per whorl along the shoulder, with corresponding scales on each of the spiral cords and threads; shell color white with brown spots between spines and scales; aperture ovate; outer lip smooth; columella smooth, with a raised peristomal plate that forms a notch below the suture, and extends along the inner edge of the siphonal canal; operculum corneous, sharply ovate, with terminal nucleus; periostracum and soft parts unknown.

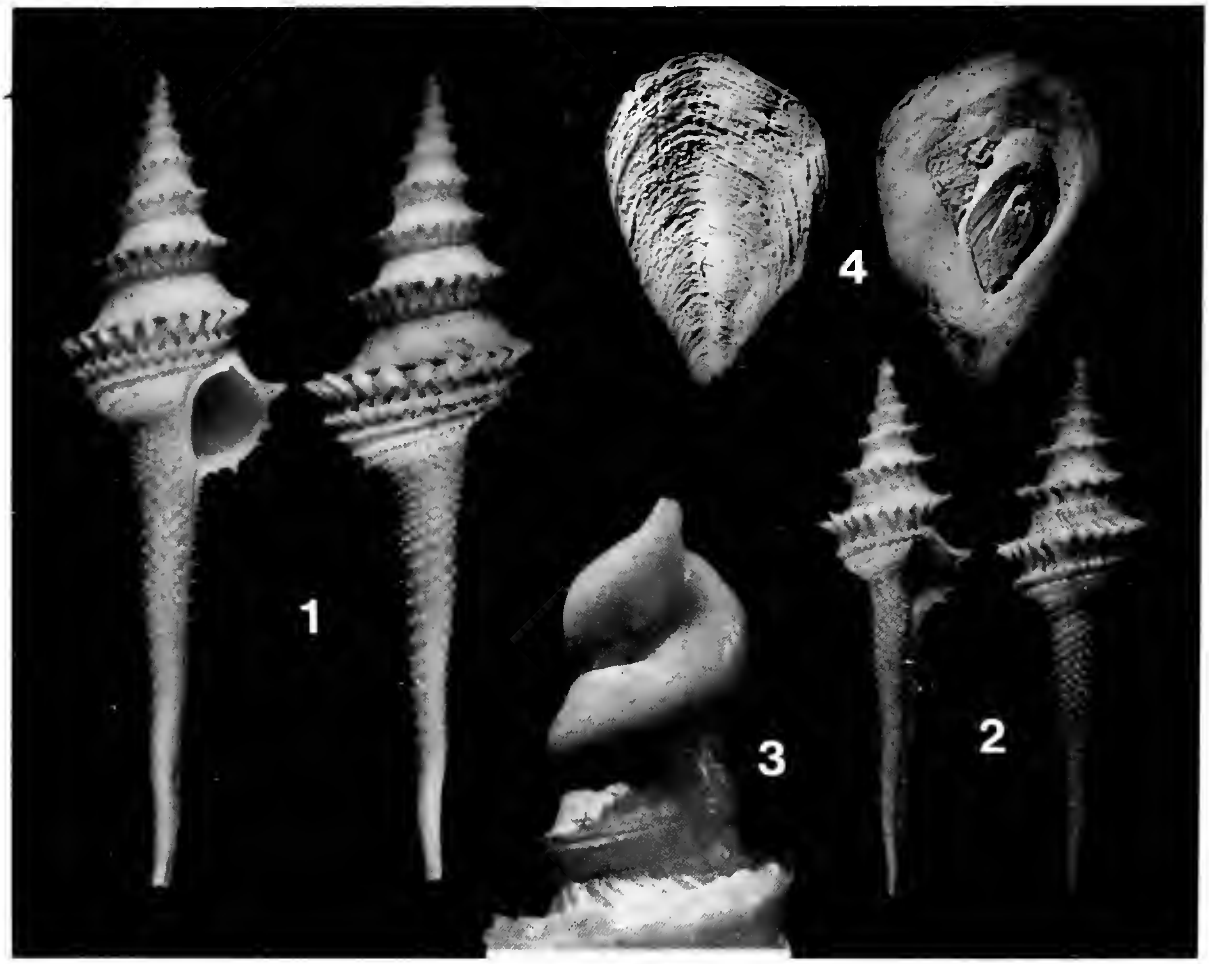
Type material – Holotype - United States National Museum, Washington, D.C. (USNM 806997) length 106 mm; Paratype 1 - (USNM 806998) length 70 mm; Paratype 2 - Delaware Museum of Natural History, Greenville, Delaware (DMNH 153524) length 99 mm; Paratype 3 - The Australian Museum, Sydney, Australia length 73 mm.

Type locality – East of Lady Musgrave Island, Queensland, Australia, in 140 fathoms (256 meters).

Range – Specimens have also been taken off Lady Elliot Island, Queensland, Australia, in 150 fathoms (275 meters) (Trevor, 1982).

Remarks – The large size, high spire, heavy shell, stout siphonal canal and characteristic protoconch readily distinguish this new species from all other Recent members of the genus. *Columbarium harrisae* most closely resembles *C. vulneratum* (Finlay and Marwick, 1937) from the Paleocene of New Zealand, from which it differs by its larger size and more elongate shell. Young specimens of *C. harrisae* lack the raised peristomal plate, and bear a strong resemblance to *C. rugatum* (Aldrich, 1886), from the Lower Eocene of Alabama, but may easily be discerned on the basis of protoconchs.

The high spire, thick shell and prominent spiral sculpture are primitive characters within the Columbariinae, being shared by such groups as *Histricosceptrum*, *Peristarium* and *Coluzea*.



FIGS. 1–4. Columbarium harrisae *new species.* **1,** *Holotype, USNM 806997, dredged east of Lady Musgrave Island, Queensland, Australia, in 256 meters (1.0X).* **2,** *Paratype 1, USNM 806998, same locality and depth (1.0X).* **3,** *Protoconch of paratype 1 (10.0X).* **4,** *Operculum of paratype 1 (5.0X).*

Such features of the Pacific species of *Columbarium* as enlarged protoconch, reduced spiral ornament, lower spire, and long, thin siphonal canal are modifications that have arisen since the closing of the Tethys Sea. *Columbarium harrisae* appears to be an offshoot from a primitive stock and not closely related to the other Australian members of the genus.

This new taxon honors Valerie Harris of Caloundra, Queensland, who generously provided the type material. Thanks are due Richard M. Kurz, Wauwatosa, Wisconsin, who provided additional material and information.

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PELYCIDIIDAE, A NEW FAMILY OF ARCHAEOGASTROPOD MOLLUSCS

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ABSTRACT

A new family is proposed for Pelycidion *Fischer (* = Allixia *Cossmann and* Nannoteretispira *Habe), a genus of minute gastropods previously associated with the Rissoacea (Mesogastropoda). The radula is rhipidoglossate and the elongate-pupiform shell lacks a nacreous layer. The family has a world-wide distribution in warm temperate to tropical areas and is also known from the Tertiary of France. It is provisionally placed in the superfamily Trochacea.*

A generic review of the Rissoidae currently in progress has shown that many genera included in that family are wrongly placed. A few cannot be easily located in any known family and one of these, *Pelycidion* Fischer, is the subject of this review of the group.

Pelycidion venustulum was first named from Hong Kong and Senegal, West Africa. This minute, tall-spired species has been included in the Rissoidae by Thiele (1929), Wenz (1939), Coan (1964) and Ponder (1967). Cossmann (1921) was apparently not aware of the existance of *Pelycidion* but included, in the Hydrobiidae, *Allixia*, a genus he had previously (1913) named. This genus name is based on an Eocene species (Fig. 1A, B) from the Paris Basin and is, in shell characters, identical with *Pelycidion*. *Allixia* recently has been transferred to the Rissoidae (Gougerot, *et al.*, 1975). Another genus name, *Nannoteretispira* Habe, 1961, is also based on a shell (Fig. 1E) virtually identical to that of the type species of *Pelycidion*. A radula and operculum of a single dried animal loaned by Dr. J. McLean was examined and the radula was found to be rhipidoglossate. Because no archaeogastropod family can be used to accommodate the shell seen in *Pelycidion*, or has the same radular details, a new family is proposed for it below.

Thiele (1929) and Wenz (1939) list *Epigrus* Hedley as a synonym of *Pelycidion*. The type species (*Rissoina cylindracea* T. Woods, 1878) of that genus, however, is much larger than species of *Pelycidion* and has a taenioglossate radula (personal observation).

Abbreviations

AMS – The Australian Museum, Sydney
IRSB – Institut Royal des Sciences Naturelles de Belgique, Brussels
LACM – Los Angeles County Museum of Natural History, Los Angeles
NSMT – National Science Museum, Tokyo
OM – Zoology Museum, Oxford University, Oxford
USNM – National Museum of Natural History, Washington, D.C.

Family **Pelycidiidae** *family nov.*

Diagnosis – Shell minute, elongate pupiform, imperforate, with smooth or finely spirally striate teleoconch; protoconch paucispiral or multispiral, with reticulate or spiral sculpture. Aperture subcircular, simple, peristome continuous. No inner nacreous layer. Operculum horny, circular, with central nucleus. Radula rhipidoglossate, c.15 + 2 + 1 + 2 + c.15, central teeth simple, without lateral thickening, about ½ size of lateral teeth, central and lateral teeth multicuspate, marginal teeth small, unicuspid. Head-foot and anatomy unknown.

Remarks – The new family is distinguished from other rhipidoglossate families by the combination of characters given in the diagnosis. Its relationships are obscure although it can be regarded as trochacean. A rather heterogeneous family that appears to show some similarities, the Skeneidae, has radulae with short central

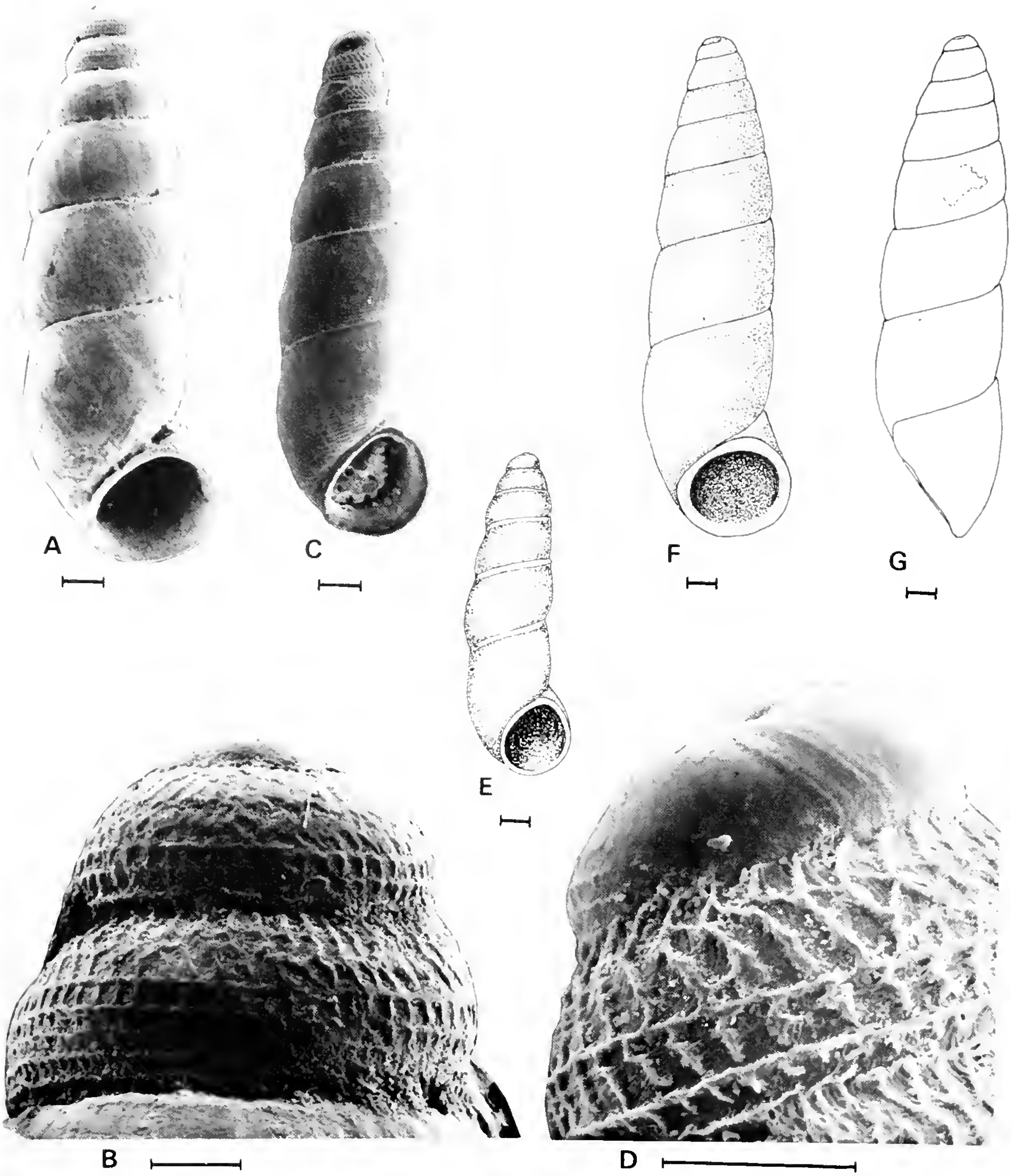

FIG. 1. *Shells of* Pelycidion. **A, B,** Pelycidion acicularis *(Cossmann), Bercheres, Eure-et-Loir, Paris Basin, France (Lutetien, Eocene);* **B,** *detail of protoconch;* **C, D,** Pelycidion xanthais *(Watson), Masthead Island, Queensland, Australia, 31–36 m (AMS);* **D,** *detail of protoconch;* **E,** Pelycidion *sp. Dahomey, West Africa, 55 m (LACM);* **F, G,** Pelycidion venustulum *Fischer (*in *Folin & Perier), Baie di Cansado, Cap Blanc, Mauritania, West Africa (IRSB).* H. Pelycidion japonicus *(Habe), holotype. Scales: shells = 0.1 mm; protoconchs = 0.05 mm.*

teeth with lateral thickenings and, as in the other trochacean families, the marginal teeth are multicuspate. Skeneids have 2-4 pairs of lateral teeth and the shell has no inner nacreous layer. The shells of the Skeneidae are usually depressed-trochiform to subplanate and frequently umbilicate. In addition the protoconch is paucispiral in all known species. The radulae of Liotiidae, Trochidae and Turbinidae have more than 3 pairs of lateral teeth. The Phasianellidae and Turbinidae have calcareous opercula and differ markedly in radular features. The only trochacean genus that is similar in general shell features is *Halistylus* Dall. This genus has a markedly different radula from *Pelycidion*, having very long marginal teeth and weakly-defined, broad-lateral and central teeth each with only a single, weak cusp (personal observation).

Genus ***Pelycidion*** Fisher
(*in* Folin & Périer, 1873)

Type species – *Pelycidion venustulum* Fischer (*in* Folin & Périer, 1873, p. 182) by monotypy. Recent, Senegal, West Africa (here restricted). *Synonymy*–

Pelycidion Fischer (*in* Folin & Périer, 1873): 316: *nomen nudum*.

Pelecydium err. auct.

Allixia Cossmann, 1913: 141. Type species: *Allixia acicularis* Cossman, 1913; original designation. Middle Eocene, Parish Basin.

Nannoteretispira Habe, 1961: 273. Type species: *Nannoteretispira japonica* Habe, 1961; original designation. Recent, Japan.

Diagnosis – Shell minute, elongate-pupoid, with subcircular aperture with simple peristome, outer lip prosocline; protoconch of 1½ to about 3 whorls, weakly spirally sculptured if paucispiral, complexly sculptured with raised reticulate threads if multispiral, nucleus smooth or minutely pitted (Figs. 1B, D, 2C, D, 3C, D). Teleoconch of several (about 5-6) whorls, apparently smooth or with spiral striae (Figs. 1A, C, E-G, 2A, B, 3A, B, E). Head-foot unknown. Operculum: circular, with central nucleus, horny, number of whorls not known (Fig. 2E).

Radula – Rhipidoglossate, with relatively large central teeth 4 + 1 + 4, rather long, parallel-sided, cusps small and sharp, primary cusp about twice length of adjacent cusps. Lateral teeth elongate, with narrow, long, simple bases and recurved cutting edge bearing long, sharp cusps; inner lateral teeth with c.6 cusps, outer lateral teeth with wider cutting edge than inner lateral teeth and with c.9 cusps. Marginal teeth small, curved, with a single cusp, c.15 per ½ row (Fig. 21, G).

Distribution and members of the genus *Pelycidion* – **Indo-Pacific:** *(Mucronalia xanthais* Watson, 1886 (Fig. 1C, D) ? = *N. japonica* Habe, 1961 (Fig. 1E)); **South Africa:** *(Nodulus africanus* Bartsch, 1915 = *N. curiosus* Turton, 1932 and *N. becki* Turton, 1932); **eastern Pacific:** *(Nodulus kelseyi* Bartsch, 1911); **Caribbean:** *(Nodulus megalomastomus* Olsson and McGinty, 1958 (Fig. 3A)); **West Africa:** *(P. venustulum* (Fig. 1F, G) and *P.* sp. (Fig. 3B-D)); **Eocene France:** *(A. acicularis* (Fig. 1A) (see Gougerot *et al.* 1975 for a recent revision of the Tertiary (Eocene- Pliocene) species and subspecies from France)).

Material examined – *P. venustulum;* one lot so named, Dautzenburg Colln. (IRSB, IG10591) one specimen (LACM). *N. japonica;* holotype and paratype (NSMT, 39823). *N. africanus;* holotype (USNM, 250422), 4 specimens (BMNH), 3 specimens (OM). *N. curiosus* and *N. becki* Turton, 1932; types (OM). *N. kelseyi;* holotype (USNM, 111369), a few lots ex LACM (AMS). *A. acicularis;* 1 lot ex J. le Renard (AMS). *M. xanthais;* several lots (AMS). *N. megalomastomus;* holotype and paratype (ANSP); two specimens ex D. Moore (AMS).

Remarks – Fischer records his species *(P. venustulum)* from Hong Kong and Senegal, West Africa. No type material has been located but 4 specimens, only one of which is in reasonably good condition, are identified as this species in the Dautzenberg collection (IRSB, IG10591). These specimens (Fig. 1F, G) from the mission Gruvel (1909-1910) from dredgings in Baie di Cansado, cap Blanc, south of Port-Etienne (now Nouadhibou), Mauritania, West Africa (*ex* Bavay), agree closely with the original description of the species and with *Nannoteretispira japonica* Habe (Fig. 1E) and with *Mucronalia xanthias* Watson (Fig. 1C, D). Another specimen, in better condition, from 12 miles E.

FIG. 2. Pelycidion *cf.* kelseyi *(Bartsch), W. side of East Island, San Benito Islands, Baja California, Mexico (LACM).* **A-E**, *shells;* **B**, *microsculpture;* **C, D**, *protoconch;* **D**, *microsculpture of protoconch;* **E**, *operculum, inner side;* **F, G**, *radula. Scales: A, C, E = 0.1 mm; B, D = 0.01 mm; F, G = 0.001 mm.*

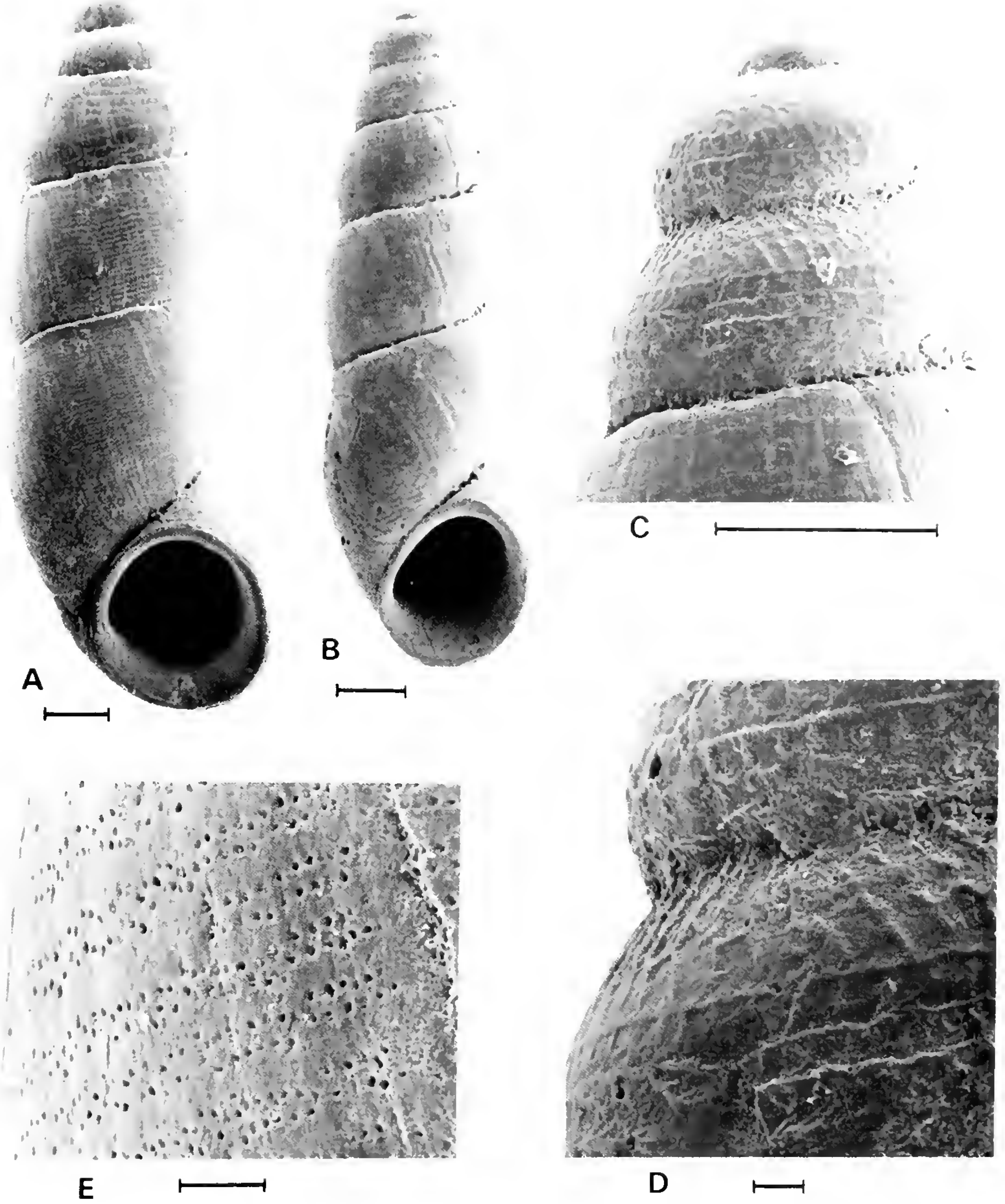

FIG. 3. **A,** Pelycidion megalomastoma *(Olsson & McGinty), shell, 2 m, Glovers Reef Lagoon, N.E. British Honduras (AMS).* **B-D,** Pelycidion *sp., 55 m, 19 km, E. of Cotonou, Dahomey, West Africa (LACM).* **B,** *shell;* **C,** *protoconch;* **D,** *protoconch microsculpture;* **E,** *teleoconch microsculpture. Scales: A, B, C = 0.1 mm; D, E = 0.01 mm.*

of Cotonou, Dahomey, West Africa (6°24′N, 2°31′E), 55 m. (Fig. 2E) is smaller and has fewer whorls. It is possibly a different species (Fig. 3B-D). Specimens of *Allixia acicularis* Cossmann (Fig. 1A, B) also appear to be congeneric as do several other species listed above. The variation in the sculpture and number of whorls of the protoconch is not considered to be important at the generic level in view of the close similarity of the other shell features.

The interspecific differences in the protoconch are probably due to the adoption of different life history strategies. The West American species and its Caribbean analogue have a paucispiral protoconch with a large initial whorl (Figs. 2C, 3A) suggesting that direct development occurs in these species. A multispiral protoconch (Figs. 1B, D, 3C) suggests a planktotrophic larval stage. This type of protoconch is atypical of the Archaeogastropoda but is commonly encountered in the Mesogostropoda, Neogastropoda and Heterogastropoda.

The original figure of *P. venustulum* shows a shell with a markedly convex inner lip. It is here assumed that this feature is erroneously depicted. This inaccuracy presumably led Tryon (1887) to suggest that *Hemistomia* Crosse, a genus in the Hydrobiidae, might be a synonym of *Pelycidion.*

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DEPTH DISTRIBUTION AND DENSITY OF FRESHWATER MUSSELS (UNIONIDAE) COLLECTED WITH SCUBA FROM THE LOWER WISCONSIN AND ST. CROIX RIVERS

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ABSTRACT

Using SCUBA diving, the depth distribution and density of freshwater mussels (Unionidae) in the Wisconsin and St. Croix rivers were examined. Depth is a factor in determining the distribution of mussels only because it is a reflection of current velocity and substrate type. The distribution of freshwater mussels in lotic habitats was most closely correlated with composition of the substrate. The greatest species diversity as well as both the highest mean (3.7/m²) and maximum (60/m²) densities included substrates with a mixture of particle sizes from mud to boulder. Only species of Anodonta *and* Lampsilis *were characteristic inhabitants of mud and/or stable sand substrates. The mean density was significantly lower in a mud-sand bottom, with a value of 0.9 mussels/m². Mussels were absent in a shifting sand substrate. Baker (1928) reported a total of 28 species from the Wisconsin River and 15 species from the St. Croix River, whereas 25 and 14 species, respectively, were collected during this study.*

Few studies treating the freshwater mussels (Unionidae) of Wisconsin have been conducted since Baker (1928) published his comprehensive monograph. Of the nearly 60 forms reported (approximately 45 species using present concepts of a species), most formerly occurred or currently occur in the Mississippi River and/or in two of its major tributaries, the Wisconsin and St. Croix rivers. Because an excellent summary of the unionids of the Mississippi River in the vicinity of Prairie due Chien, Wisconsin, was recently published by Havlik and Stansbery (1977), the emphasis of this study is on the latter two rivers.

SCUBA diving has been used successfully to study lacustrine molluscs (Cvancara, 1972; Pace *et al.*, 1975, 1979; Ghent *et al.*, 1978). The use of SCUBA provides quantitative data on the depth distribution and density of mussels as well as in situ habitat observations. However, because poor visibility and strong currents usually limit its use in lotic habitats, comparative data are few.

Methods and Materials

SCUBA diving was conducted during low water periods in August and September 1978 at five sites along the Wisconsin and St. Croix rivers (Fig. 1). Because of the paucity of the molluscan fauna in the heavily impounded middle one-third of the Wisconsin River, only localities well below the last dam were examined.

Fourteen transects, each measuring 2 m by 20 m, were examined during a total of 26 hours of diving time. The transect lines were constructed of nylon rope 6 mm in diameter and weighted at 5 m intervals with 2 kg lead weights. Plastic milk cartons were attached at 10 m intervals to serve as buoys and the entire transect was anchored in place with stakes. At each site, transects were established at several depths with maximum depths of 2.5 m and 3.5 m in the Wisconsin and St. Croix rivers, respectively. Because seasonal fluctuations in water level in the Wisconsin and St. Croix rivers can be substantial, depth determinations are not absolute. All collection depths represent low water levels,

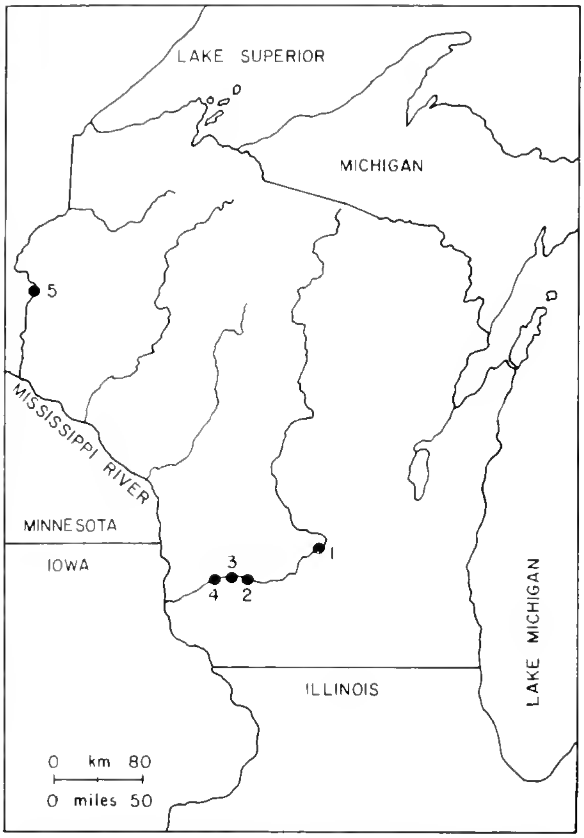

FIG. 1. *Collection localities on the Wisconsin (1-4) and St. Croix (5) rivers. Localities are identified in the text.*

and high water levels may be an additional 1 to 2 m. All mussels collected within each 40 m^2 transect were placed in bags and transported back to the laboratory for identification. Densities were determined at random within each transect using a 0.25 m^2 wire frame. A number of physico-chemical parameters were measured at each site using Hach colorimetric and titrametric procedures. A determination was made of the type of substrate at each transect using the following modification of the Wentworth scale for particle size: mud < 0.06 mm; sand 0.06–2.0 mm; gravel 2.0–64.0 mm; and boulder > 64.0 mm.

Mussels were also qualitatively collected by hand at several additional sites. Although these data are not quantitative in relation to surface area sampled and collection methods varied, they are used because they include species not encountered while diving.

Voucher specimens have been deposited in the Museum of Natural History, University of Wisconsin-Stevens Point.

Collecting Stations

The following localities, identified in Fig. 1, were examined for mussels:

1. Wisconsin River at County Park in Dekorra. (Columbia Co.)
2. Wisconsin River at intersection of Wisconsin Highways 60 and 00. (Richland Co.)
3. Wisconsin River at intersection of Wisconsin Highways 60 and E at public landing. (Richland Co.)
4. Wisconsin River at intersection of Wisconsin Highways 60 and TX at wayside. (Richland Co.)
5. St. Croix River, T. 35 N, R. 19 W, Sec. 9. (Polk Co.)

Results and Discussion

Physico-chemical determinations at each locality are presented in Table 1. Because these data represent only a single test at each locality, water quality data compiled by the U.S. Geological Survey (1978) for the water year 1977 are also included for the purpose of valid comparison. When compared with the most current data for those physico-chemical parameters that affect the physiological ecology of freshwater mussels, all of the parameters measured were within currently accepted levels for the successful propagation and growth of freshwater mussels as summarized by Fuller (1974). The current at all sites was moderately swift with an average surface velocity of 0.6m/sec.

The depth distribution for 21 species in different types of substrates for all transects is summarized in Table 2. Seven species are not included, because too few individuals were collected, and are discussed separately below. Mussels were not located uniformly across the river bed. In a lake study, Harman (1972) quantitatively demonstrated the relationship between mollusc distribution and substrate patterns as well as the correlation between species diversity and substrate diversity. Thus depth is a factor in governing the horizontal distribution of mussels primarily because it is a reflection of

TABLE 1. *Physico-chemical data for localities on the Wisconsin (1-4) and St. Croix (5) rivers. Localities 1-5 are identified in Fig. 1 Data for localities 6 (Wisconsin River at Muscoda) and 7 (St. Croix River at St. Croix Falls) are from the U.S. Geological Survey (1978) and are mean values representing measurements for the water year October 1976 to September 1977.*

	Locality Number						
Parameter	1	2	3	4	5	6	7
pH	6.7	6.8	6.6	6.8	6.6	7.9	7.5
Temperature (°C)	23	23	24	26	19	18.5	18
Turbidity (FTU)	9	26	20	25	30	7	3
Dissolved Oxygen (mg/l)	11.0	9.5	11.0	12.0	10.0	9.4	8.9
Total Hardness (mg/l $CaCO_3$)	55	70	95	90	50	128	88
Total Alkalinity (mg/l $CaCO_3$)	30	20	30	20	20	102	82
Carbon Dioxide (mg/l)	2.0	2.0	3.0	2.0	2.0	4.7	6.7
Sulfate (mg/l)	---	7.0	---	3.0	2.0	19.6	6.3
Chloride (mg/l)	12.5	12.5	10.0	15.0	5.0	13.6	3.2
Silica (mg/l SiO_2)	3.0	2.6	4.0	2.8	1.7	4.5	11.6
Secchi Disc (cm)	--	51	30	45	90	--	--

gradations in current velocity and substrate type.

In my study, a greater species diversity and mean and maximum density of mussels were associated with those transects that included a bottom with a mixture of particle sizes ranging from sand to boulder (Table 2). Only seven of the 28 species collected were found in a mud-sand substrate. Based upon the percent of the individuals of each species collected in each substrate type (Table 2), of these seven species a mud-sand substrate was the typical habitat for only *Anodonta grandis, Lampsilis anodontoides,* and *L. radiata.* The remaining four species were more abundant in a mixed sand-gravel-boulder substrate (Table 2). The mean density for each substrate type at each depth also illustrates these conclusions (Table 3). The maximum density recorded was 60 mussels/m² at a transect depth of 1.7 m in a sand-gravel-boulder substrate.

Cvancara (1972) and Ghent *et al.* (1978) compared the adaptive morphology of several species of unionids from diverse habitats by measuring shell width and angle of the ventral margin. The greater obesity and ventral angle exhibited by *A. grandis* and *L. radiata* are believed to be morphological adaptations permitting them to present a wide surface to a soft substrate in ponds, sloughs, and pools (Ghent *et al.*, 1978). Conversely, a narrow ventral angle is ideally suited to a gravel bottom in running water. The results of my SCUBA study further substantiate this interpretation because the same two species were the most abundant in and characteristic of predominately mud and sand substrates (Table 2). (A discussion of these data is the subject of a future paper.) The lowest mean density/m² occurred in a mud-sand bottom (Table 3).

Only six of the 28 species collected during this study (*A. plicata, E. dilatatus, F. flava, A. grandis, A. carinata,* and *L. radiata*) exhibited a distribution that included all substrate types except shifting sand. Mussels were absent entirely in a shifting sand bottom. Therefore, depth is only a factor in determining the density and distribution of freshwater mussels as a reflection of current velocity and substrate type.

Many of the distributional records in Baker's

TABLE 2. *Depth distribution of freshwater mussels for each substrate type: number of individuals, with % of the species population for each depth-substrate combination in parentheses. Data are composite totals for each species at all transects. *No transects were established at depths between 2.0 and 2.7 m. Genera are identified in Table 4. (m = mud; s = sand; g = gravel; b = boulder.)*

	Depth (m)*				Substrate
Species:	1.0-1.3	1.3-1.7	1.7-2.0	2.7-3.3	Type
A. plicata	4(2)				m-s
	2(1)	28(18)			m-s-g
		53(32)	47(28)	31(19)	s-g-b
E. dilatatus	2(2)				m-s
	3(3)	7(7)			m-s-g
		42(43)	19(19)	25(26)	s-g-b
F. flava	1(1)				m-s
	5(4)	12(10)			m-s-g
		49(43)	42(37)	6(5)	s-g-b
Q. metanerva	8(7)	11(9)			m-s-g
		84(72)	14(12)		s-g-b
Q. pustulosa	11(6)	16(9)			m-s-g
		75(40)	83(43)	3(2)	s-g-b
T. verrucosa	5(3)	20(13)			m-s-g
		69(44)	62(40)		s-g-b
A. marginata		4(29)			m-s-g
		8(57)	2(14)		s-g-b
A. grandis	4(66)				m-s
		1(17)			m-s-g
			1(17)		s-g-b
L. costata				8(100)	s-g-b
S. undulatus	1(8)	3(25)			m-s-g
		6(50)	2(17)		s-g-b
A. carinata	3(10)				m-s
			6(20)	21(70)	s-g-b
L. radiata	18(40)				m-s
	1(2)				m-s-g
			5(11)	21(47)	s-g-b
L. ventricosa	5(4)	12(10)			m-s-g
		41(33)	66(53)		s-g-b
L. fragilis	1(4)				m-s-g
		12(52)	10(44)		s-g-b
L. recta	2(2)	1(1)			m-s-g
		49(55)	37(42)		s-g-b
O. reflexa	4(14)	2(7)			m-s-g
		4(72)	2(7)		s-g-b
O. olivaria	5(7)	2(3)			m-s-g
		44(59)	22(30)	1(1)	s-g-b
P. alata		1(8)			m-s-g
		1(8)	8(62)	3(22)	s-g-b
P. laevissima		1(25)			m-s-g
			3(75)		s-g-b
T. donaciformis	1(17)	1(17)			m-s-g
		4(66)			s-g-b
T. truncata		7(70)	3(30)		s-g-b

TABLE 3. *Mean density of freshwater mussels for each depth-substrate combination. Data include all transects. (M = mud, s = sand; g = gravel; b = boulder.)*

	Depth (m)			
Substrate type:	1.0-1.3	1.3-1.7	1.7-2.0	2.7-3.3
m-s	0.9/m^2			
m-s-g	1.4/m^2	3.1/m^2		
s-g-b		3.6/m^2	3.7/m^2	3.1/m^2

(1928) survey of Wisconsin were based upon localities along the Wisconsin and St. Croix rivers. Baker (1928) reported 28 species from the Wisconsin River and 15 species from the St. Croix River, while during this study 25 and 14 species, respectively, were collected. A summary of these records is presented in Table 4. Although the Baker (1928) records are difficult to compare because some species were listed simply as being statewide or as occurring in the Mississippi River system, these data do reveal some changes in species distribution and abundance, especially with regard to several of the species not included in Table 2.

Although Barnes (1823) cited the Wisconsin River as the type locality for *C. verrucosa* (= *tuberculata*), this species was not collected by Baker (1928) nor by me. *Cyclonaias tuberculata* has also been extirpated from the Mississippi River at Prairie du Chien (Havlik and Stansbery, 1977), where it was last collected by Ellis in 1930 (van der Schalie, 1950). Today, *C. tuberculata* may be restricted to the St. Croix River and populations here may represent the last significant ones within the State.

Baker (1928) noted that *F. ebena* was rare in both the Mississippi and Wisconsin rivers. Williams (1978) recently collected two individuals from the St. Croix River near Hudson,

TABLE 4. *The freshwater mussels recorded from the Wisconsin and St. Croix rivers by Baker (1928) and Stern (this study). Asterisk (*) denotes those species listed simply as statewide by Baker (1928). Classification follows that of Ortmann (1910) and the species are arranged alphabetically under each subfamily.*

	Baker	Stern	Baker	Stern
Family Unionidae				
Subfamily Unioninae				
Amblema plicata s.l.	X	X	X	X
Cyclonaiae tuberculata			X	X
Elliptio dilatatus	X	X		
Fueconaia ebena	X			
Fusconaia flava s.l.	X	X	X	X
Plethobasua cyphyua	X	X		
Pleurobema coccineum	X	X		
Quadrula metanerva	X	X		
Quadrula pustulosa	X	X	*	X
Quadrula quadrula	X	X		
Tritogonia verrucosa	X	X	*	
Subfamily Anodontinae				
Alasmidonta marginata	X	X		
Anodonta grandis s.l.	X	X	*	X
Anodonta imbacillis	X		*	X
Arcidens confragosus		X		
Lasmigona costata	X		*	X
Simpsoniconcha ambigua	X			
Strophitus undulatus	X	X		
Subfamily Lampsilinae				
Actinonaias carinata	X	X	X	X
Carunculina parva	*			
Lampsilis anodontoides		X		
Lampsilis radiata	X	X	X	X
Lampsilis ventricosa	X	X	*	X
Leptodea fragilis	X	X		
Ligumia recta	X	X	*	X
Obliquaria reflexa	X	X	*	X
Obovaria olivaria	X	X		
Proptera alata	X	X	*	X
Proptera laevissima	*	X	X	
Truncilla donaciformis	X	X		
Truncilla truncata	X	X		

Wisconsin and Havlik and Stansbery (1977) reported it from the Mississippi River at Prairie du Chien. No shells were found while diving.

Plethobasus cyphyus has been extirpated from the Mississippi River at Prairie du Chien (Havlik and Stansbery, 1977), where it was last collected by Shimek (1921). Baker (1928) reported it from Lake Pepin to the north and indicated that it was common in the Wisconsin River. Only two live specimens were collected in the Wisconsin River while diving, both from a sand-gravel-boulder substrate in water 1.3-1.7 m deep. Because a greater number of subfossil shells were also collected, the species is probably disappearing from Wisconsin waters.

Baker (1928) reported several "forms" (= ecophenotypes) of *P. coccineum* from the Wisconsin River. Havlik and Stansbery (1977) found only one shell at Prairie du Chien. While diving, a total of only three live individuals were collected. Where collected live, *P. coccineum* was found in water 1.3-1.7 m deep in a mixed mud to boulder bottom.

Baker (1928) stated that *Q. fragosa (= quadrula)* in Wisconsin was restricted to the Wisconsin River drainage. Although he also recorded two other closely related forms from the State, they were also confined to single drainages. Baker (1928) noted that *Q. quadrula* s.l. (sensu lato – in the broad sense) was neither widely distributed nor abundant. Only one live specimen was found while diving in the Wisconsin River during this study. It was collected from a sand-gravel-boulder substrate in 1.5 m of water. Havlik and Stansbery (1977) found no *Q. fragosa* at Prairie du Chien and concluded that this ecoform is now reduced or estirpated throughout much of its range.

Like *A. grandis*, *A. imbecillis* is a typical inhabitant of quiet pools in a mud or stable sand bottom. Baker (1928) noted that it was widely scattered throughout the State and rare when found. A single individual of *A. imbecillis* was collected in shallow water (1 m) in a mud-sand bottom from the St. Croix River.

Baker (1928) reported *Arcidens confragosus* only from the Mississippi River, where it still occurs (Havlik and Stansbery, 1977). One live and two subfossil specimens were collected during this study from the Wisconsin River. Throughout most of its range, it is most abundant in a mud bottom in sluggish water at shallow depths (<1 m), but in the Wisconsin River it was collected from a sand-gravel bottom in a moderate current at a depth of 1.7 m. An emphasis on collecting in the former habitat might reveal *A. confragosus* in larger numbers.

Baker (1928) collected several shells, but no living specimens, of *S. ambigua* on a gravel bar in 0.3 m of water in the Wisconsin River. Only a single specimen was collected by Ellis in 1930 in the Mississippi River at Prairie du Chien (van der Schalie, 1950). *Simpsoniconcha ambigua* was probably never common, and it was not encountered while diving. It has a unique glochidial host, the mudpuppy *Necturus maculosus*. An examination of those sites at which its amphibian host is known to occur might help to clarify the distribution of this unionid. Stansbery (1970, 1971) has noted that *S. ambigua* may be endangered throughout its entire range. Its distribution is sporadic and, when encountered, it is seldom abundant.

The absence of *L. anodontoides* in the Wisconsin River puzzled Baker (1928) because the river seemed "ecologically well suited for the species." *Lampsilis anodontoides* was collected during this study while wading in shallow water (0.3 m) in a stable sand bottom. Despite its apparent ability to adjust to a variety of habitats from mud to sand to gravel bottoms, in either a swift or slow current, and at varying depths (Baker, 1928; Murray and Leonard, 1962; Parmalee, 1967), no live individuals were collected while diving.

Most of the faunal changes over the last 50 years, as discussed above, are attributable to man's activities, including changes in water quality, elimination of host fishes, commercial overexploitation, and/or the creation of large impoundments that profoundly and permanently alter habitats. The construction of over one dozen dams along a 125-mile stretch of the middle one-third of the Wisconsin River illustrates the latter factor.

In a recently completed survey, Mathiak (1979) reported five species *(Quadrula nodulata, Anodontoides ferussacianus, Lasmigona complanata, L. compressa,* and *Lampsilis higginsi)* from the Wisconsin River that were neither reported by Baker (1928) nor collected while diving. Most of these were found just upstream from the confluence of the Wisconsin and Mississippi rivers and thus represent recent range extensions.

It is apparent that several species are now rare and in danger of being extirpated from Wisconsin waters. However, it is encouraging that not only is the same basic fauna still represented some 50 years after Baker's (1928) study, but that there has been the establishment of additional species as well.

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A PRE-EUROPEAN OCCURRENCE OF *GLEBULA ROTUNDATA* (BIVALVIA: UNIONIDAE) IN ARKANSAS

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Department of Zoology
University of Arkansas
Fayetteville, Arkansas 72701

Glebula rotundata (Lamarck) is reported for the first time from Arkansas. It is distributed from eastern Texas to the Apalachicola River in Florida (Clench and Turner, 1956) and has been found primarily within about 200 km of the Gulf of Mexico (Parker, personal communication); although, Branson (1969) reported a specimen from the Neosho River system in Oklahoma. Speculation on the presence of *G. rotundata* in Arkansas had been made by Call (1895) and Gordon, *et al.* (1980).

A specimen of *Glebula rotundata* (University of Colorado Museum no. 30468) was identified from a group of about 6000 specimens collected from the Tillar Farms locality, Drew County, of the Arkansas Archaeological Survey. The site represents a silted-in oxbow of Bayou Bartholemew and dates from between 1400 and 1600 A.D. All specimens represent a naturally occurring assemblage and did not represent an Indian midden. The site is within the region of the state in which Call (1895) expected *G. rotundata* to be found. Living specimens have not been found, as yet, in Bayou Bartholemew.

I would like to thank Dr. Neal Trubowitz, Arkansas Archaeological Survey, and Dr. Marvin Jeter, University of Arkansas-Monticello, for information concerning the Tillar Farm locality and Mr. Robert S. Parker, Freeport Sulphur Co., Belle Chasse, La. for distributional information.

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RECENT DEATHS

Harry S(tephen) Ladd, retired paleontologist, died November 30, 1982, at the age of 82, in Bethesda, Maryland. Although primarily an expert on Pacific Island coral reefs and the Tertiary mollusks of the Southwest Pacific, Dr. Ladd was well-known to malacologists, and was always helpful to the many students that visited the U.S. National Museum. He was born Jan. 1, 1899, in St. Louis, Missouri, and obtained his Ph.D. at the University of Iowa. He spent two years mapping the geology of the Lau Group in Fiji. He began his distinguished career at the U.S. Geological Survey in 1940, and continued research at the U.S. National Museum until 1978. He received the Distinguished Service Award of the Interior Department in 1965 and the Paleontological Society Medal in 1981. He published over 60 articles, mainly on fossil mollusks, and was a contributor to *The Nautilus*. Additional information in *American Malacologists*, p. 334, and the *Washington Post*, p. B18 of Dec. 8, 1982.

Charles B. Wurtz, consulting biologist, environment ecologist, and former Associate Editor of *The Nautilus* (1958–74), died October 21, 1982, at the age of 65, in Philadelphia, PA. Son of a physician, he was born Dec. 6, 1916, in Philadelphia. He was a student of land mollusks under Drs. H. A. Pilsbry and H. B. Baker, and received his Ph.D. in 1955 at the University of Pennsylvania. He led many limnological surveys for the Academy of Natural Sciences of Philadelphia from 1948 to 1954, and later began his own environmental consulting service. He taught biology at La Salle College from 1963 to 1971. Dr. Wurtz published about 70 articles, many of them appearing in *The Nautilus*. "Chuck" as he was known to his many friends was always helpful to fellow biologists. His infectious laugh, good cheer and keen mind will be missed by many. He is survived by his wife, Elsa M. Hofheinz Wurtz. Additional information in *American Malacologists*, p. 489 and *La Salle* (Quarterly College Magazine), Fall 1966, vol. 10, pp. 8–12.

Charles B. Wurtz (1916–1982)

William E(rwood) Old, Jr., malacologist, died of a heart attack, on December 31, 1982, at age 54, in New York City. He was born April 14, 1928, in Norfolk, Virginia, and attended the College of William and Mary. He served in the Army during the Korean War. Bill Old joined the American Museum of Natural History in 1960, and became a specialist in marine mollusks, publishing many papers, some in conjunction with W. K. Emerson. Bill was extremely devoted to his science, and was well-known as a

William E. Old, Jr. (1928–1982)

shell show judge in many parts of the United States. He was constantly assisting amateur, as well as professional, malacologists. He went on several expeditions, including ones to the Galapagos and Mexico, and helped build the American Museum's mollusk collection into a leading research resource. Friends of Bill Old may make tribute to his memory by contributing to the William E. Old Malacology Fund, c/o Dr. W. K. Emerson, American Museum of Natural History, Central Park West, NY, NY 10024.

–R.T.A.

BOOK REVIEWS

Sea Shells of Southern Africa by Richard Kilburn and (illus. by) Elizabeth Rippey. 249 pp., 46 pls. of colored paintings, text drawings. Macmillan South Africa (in the U.S.: International scholarly Book Services, P.O. Box 1632, Beaverton, OR 97075). $49.95.

This is by far the best of the recent guides to the shelled mollusks of this region. About 600 species are illustrated, described, and are with comparative and habitudinal remarks. Authors and dates accompany the scientific names. Excellent diagnostic drawings of bivalve hinges make identifications easier. Dr. Kilburn has added professional taxonomic information throughout the book. The introductory chapters have an excellent historical account and a good coverage of collecting and curatorial methods. The colored paintings are adequate for identification purposes. This book joins the ranks of other fine faunal guides, such as those of Keen, Kay and Powell. –R. Tucker Abbott, *American Malacologists, Inc.*

Seashells of Oman by Donald and Eloise Bosch (edited by Kathleen Smythe). 206 pp., numerous color photos. Longman Group, Ltd., London and New York. $35.00.

This is a beautifully illustrated book on 258 species of gastropods and 96 bivalves found in the southeastern Arabian Peninsula. Authors, dates and correct scientific names, together with habitudinal information make this a recommended book for this area. –R.T.A.

Seashells of the Arabian Gulf by Kathleen Smythe. 123 pp., 20 pls. (8 in color). Allen and Unwin, Inc., Winchester, MA. $25.00.

This small, simple guide covers only a few species and is poorly illustrated. The price is forbidding. –R.T.A.

The Freshwater Molluscs of Canada by Arthur H. Clarke. 446 pp., 179 pls. (plus 50 in color). University of Chicago Press, 5801 S. Ellis Ave., Chicago, IL 60637, $39.95. In Canada: National Museum of Natural Sciences, Ottawa, Canada KIA 0M8. $39.95.

At long last Canada has a complete and well-illustrated handbook for the identification of its 179 species of freshwater mollusks. Dr. Clarke has considerably expanded the coverage of his 1973 monograph of the 103 species found in the more northerly Canadian Interior Basin. This new book is for the layman and biologist not familiar with mollusks. Excellent photographs, including SEM views of minute species, ecological notes and easily interpreted distributional maps accompany each species. A two-page spread is devoted to each species. The colored paintings of 50 Unionidae mussels are superior to anything previously published on the subject. The onerous synonymies and detailed locality records of a monograph are omitted.

Perhaps a little more attention could have been given to generic differentiation, particularly in the Lymnaeidae, and perhaps in some future edition the details of live gastropods and bivalve larvae will be given. This is an excellent popular guide, and its price is in keeping with today's publishing costs. –R.T.A.

James Graham Cooper – Pioneer Western Naturalist. By Eugene Coan. 1982. 255 pp., 23 figures, map. A Northwest Naturalist Book, University Press of Idaho, University Station, Box 3368, Moscow, Idaho 82843. $11.95.

It is fortunate that natural historians often have a need to know details concerning early workers in their fields of endeavor. Dr. Eugene Coan is one such scientist who, dismayed by the lack of information on James G. Cooper, an important contributor to knowledge about our country's natural history during the 19th Century, set about to fill that hiatus by collecting the data which grew into the volume cited above. The book was meticulously researched in museums, libraries, and archives throughout the country resulting in a much more complete picture than had previously existed of Cooper's life, work, and travels from 1830 to 1902. The biography is replete with direct quotations from Cooper's writings and those of others, interspersed with the author's comments which maintains the continuity. Each chapter is documented with extensive notes.

Cooper, a physician, is perhaps best known for his participation in the Pacific Railroad Survey, 1853-1855, but he also took part in a number of other major and minor expeditions to various portions of the United States. From an early age he was fascinated with collecting and studying natural objects, and apparently also inspired others to collect specimens for him to study. He lived during what has been called the "Golden Age" of biological observation when many new species were being described from world-wide explorations. He knew and corresponded with important naturalists of his day such as Baird, Dall, Carpenter, and others who encouraged his surveys. Much of Cooper's malacological work was devoted to Recent land and freshwater mollusks, although he frequently described fossils and marine species.

Assembled in the book are extensive lists of the zoological taxa Cooper described carefully annotated with interpretive notes, localities, and citations of repositories for the type specimens of 3 brachiopods, over 100 mollusks, 1 insect, 13 fish, 2 reptiles, 4 birds, and 1 mammal that he discovered. The bibliography contains all of Cooper's works, those of his father, William Cooper, a naturalist in his own right, together with literature cited by Coan in the text. This book gives a most interesting view of life over 100 years ago in the United States, besides providing what is essentially an obligatory reference for those investigating the natural history of this country.

Joseph Rosewater
Division of Mollusks
National Museum of Natural History
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Volume 1 of *The American Malacological Bulletin* will be available in early 1983. This journal, formerly *The Bulletin of the American Malacological Union*, will continue to serve as the official publication of the American Malacological Union. In addition, *The Bulletin* will also act as a new outlet for publication of original malacological research and review papers not necessarily presented at the annual AMU meeting.

Volume 1 will contain a wide array of papers of malacological interest ranging from genetics of polygyrid pulmonates and naiad ecological surveys to microstructural studies of oyster shell valves and the life history of a tropical wentletrap. The policy of the journal is to publish high quality manuscripts concerning any aspect of molluscan life.

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It is becoming increasingly important for future research purposes that an identified sampling of species mentioned in publications be deposited in a permanent, accessible museum specializing in mollusks. This is particularly true of mollusks used in physiological, medical, parasitological, ecological, and experimental projects.

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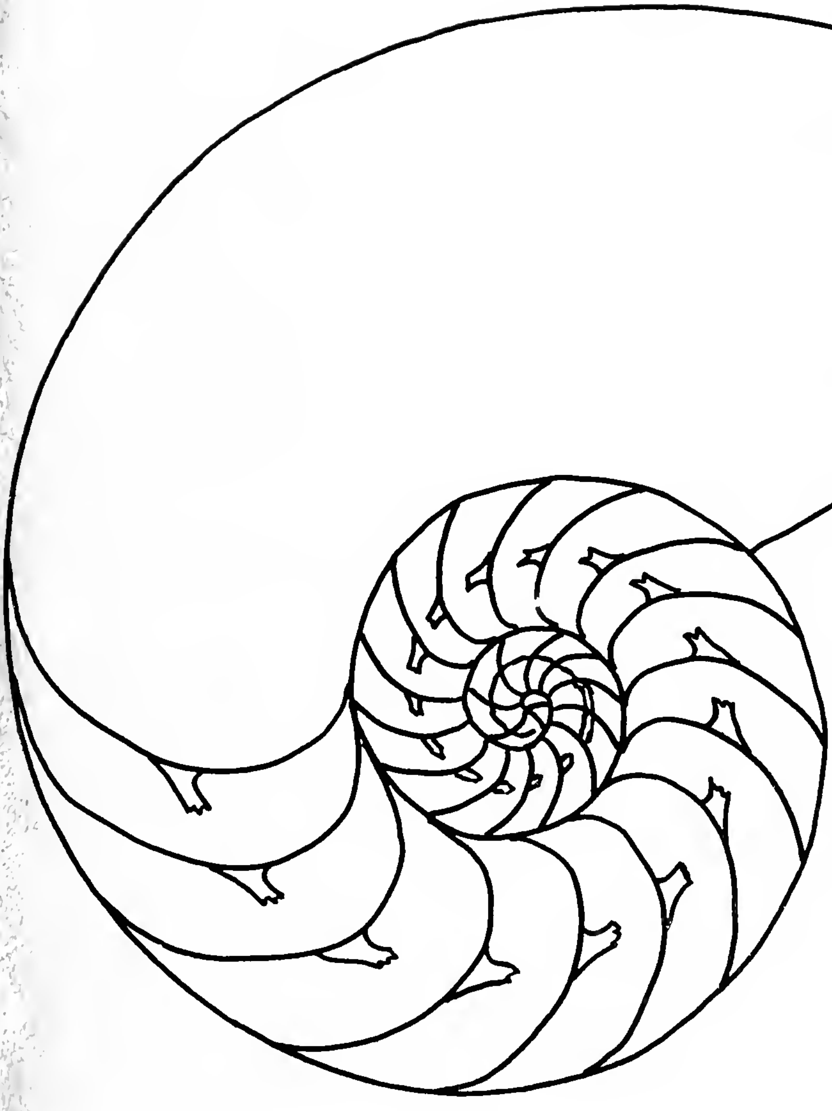

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(signed) R. Tucker Abbott, Editor

DISTRIBUTION OF PYRAMIDELLID GASTROPODS IN LATE PLEISTOCENE NEARSHORE SEDIMENTARY ENVIRONMENTS, DARE COUNTY, NORTH CAROLINA

William Miller, III
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ABSTRACT

Examination of fossiliferous sediments at the Stetson borrow pit indicates that the late Pleistocene molluscan fauna of Dare County, North Carolina, included seven species of ectoparasitic pyramidellid snails that were distributed in recurrent taxonomic associations within three major nearshore environments: 1) back-barrier estuarine (characterized by Odostomia impressa *(Say) and* Turbonilla powhatani *Henderson and Bartsch; also containing* Odostomia virginica *Henderson and Bartsch), 2) transitional (with only* O. impressa*), and 3) inner shelf marine (characterized by* Turbonilla interrupta *(Totten); with rare* Sayella chesapeakea *Morrison,* Odostomia conoidea acutidens *Dall,* Odostomia dux *Dall and Bartsch,* O. impressa, *and* O. virginica).

The Pyramidellidae comprises a large, taxonomically confused group of minute opisthobranch snails that have been studied largely by conchologists. The shells of the organisms are commonly found in Cenozoic fossil deposits of marine and estuarine origin, indicating that pyramidellids were just as important as components of nearshore benthic communities in the past as they are in modern benthic communities (see Bartsch, 1955; Wells, 1961).

The traditional approach to the study of the Pyramidellidae by both conchologists and paleoconchologists has involved extensive, regional taxonomic studies of shells that include general notes on biogeographic and bathymetric distributions (e.g., Bartsch, 1909, 1955; Dall and Bartsch, 1909). A number of significant studies of anatomy, feeding habits, and reproductive behavior has appeared in the past few decades greatly extending knowledge of the biological properties of the most common species of modern Pyramidellidae (e.g., Robertson, 1978; Scheltema, 1965; Wells, 1959; Allen, 1958; Fretter and Graham, 1949). However, the phylogenetic relationships, paleocommunity contexts, and paleoenvironmental distributions of pyramidellid gastropods remain as essentially unexplored areas of research in molluscan paleontology.

The purpose of my paper is to describe the pyramidellid associations (i.e., groups of pyramidellid species derived from a particular kind of community; these are "taxonomic associations" of Kauffman and Scott, 1976, p. 21) preserved in upper Pleistocene estuarine and marine deposits in Dare County, and to reconstruct the paleoenvironmental distributions of these associations in order to test pyramidellids as possible indicators of ancient nearshore environments. In addition, several species previously known only from recent material are described for the first time as fossils.

Because the stratigraphic framework of Late Cenozoic deposits beneath the Atlantic Coastal Plain is being slowly unravelled mainly through the use of various methods of subsurface sampling (see Oaks and DuBar, 1974), it is clearly advantageous to be able to recognize fossil taxa that are both small enough to be recovered more or less undamaged by drilling and that are useful in delimiting, together with stratigraphic and sedimentologic data, ancient sedimentary environments. Benthic foraminiferids, ostracodes, and fragments of larger mollusks have been used in this capacity traditionally. I propose that pyramidellids could be employed as paleoenvironmental "guides" with considerable ease because: 1) no special techniques other than screening sediment are required to isolate specimens, 2) entire shells can be recovered from auger stems or split-spoon cores, and 3) most species can be determined (at least tentatively) using a 10X handlens. It remains to be demonstrated that pyramidellids have recognizable distributional patterns, recurrent in space and time, which allow them to be used in this role.

Locality, Stratigraphy, and Methods

Specimens used in this study were collected from three-dimensional exposures of backbarrier deposits in the walls of the Stetson borrow pit, and from a single power-auger boring in marine deposits below the floor of the pit. The borrow pit is located in northcentral peninsular Dare County, North Carolina, 15 km west of Croatan Sound and 10.5 km east of Alligator River, on the north side of U. S. Highway 64 (Fig. 1).

The Stetson pit is an important Pleistocene fossil locality in northeastern North Carolina, because the low, flat, featureless topography of the Outer Coastal Plain precludes natural surface exposure of the underlying Late Cenozoic formations, and because in 1978 the borrow pit was the only artificial exposure of fossiliferous Pleistocene on the Dare County peninsula. The walls of the pit contain a 4-meter vertical exposure of shelly, sandy lagoonal sediments overlain by about 2 meters of unfossiliferous, muddy sand of river-estuarine origin. A careful study of the sedimentary structures, stratigraphic relationships, and fossil shells in the lagoonal deposits indicates that these beds were deposited in a patchwork of backbarrier sedimentary environments including shallow subtidal muddy-bottom areas that surrounded shallow subtidal to intertidal sand shoals, oyster banks, tidal channels, and lagoon-margin bays and beaches (see Miller, 1978, for a detailed environmental reconstruction). A power-auger boring in the floor of the pit revealed an additional 2 meters of backbarrier muddy sand underlain by about 1 meter of muddy sand containing a mixture of marine and estuarine shells. This transitional unit grades downward into a thick sequence (10 meters +) of marine deposits. The marine sediments show signs of having been deposited in subtidal, inner shelf sedimentary environments that probably included lower shoreface, sand shoal, and intershoal trough areas (Miller, 1978). A generalized stratigraphic column of the borrow pit is shown in Fig. 2.

Fifteen bulk samples, ranging from 0.5 to 4 liters, were collected from surface exposures and the bore hole. Over 26,000 fossil shells were separated from the samples by wet screening, then were dried and identified to species if possible. A total of 350 pyramidellids, or 1.3% of the fossil shells recovered, were later separated from the collection and re-examined with a bino-

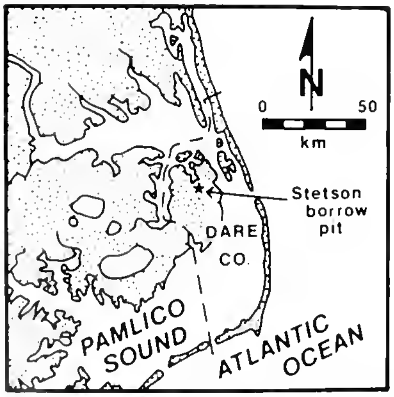


FIG. 1. *Index map showing location of Stetson borrow pit in northern mainland Dare County, North Carolina.*

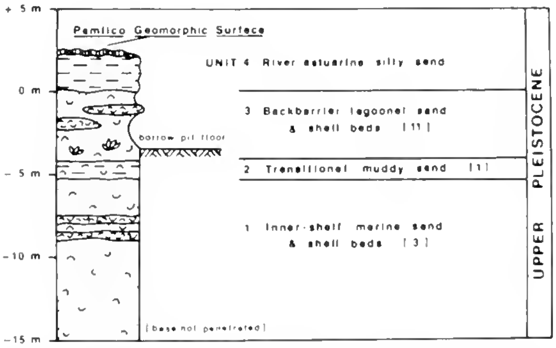
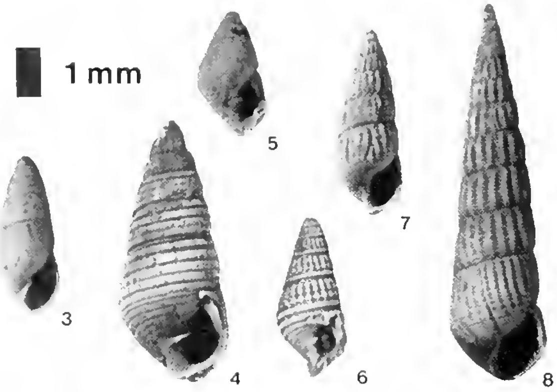


FIG. 2. *Stratigraphic column of upper Pleistocene deposits at the Stetson borrow pit. (Numbers in brackets indicate number of samples collected.)*

cular microscope to double-check determinations and to note the range of morphologic variability of each species. A total of seven species was identified (Table 1; Figs. 3 through 9).

On the Use of Pyramidellid Names in Paleontology

Anyone beginning a study involving the Pyramidellidae is at once faced with the enormous taxonomic difficulties that characterize this group. Even the compilation of simple species lists from a series of samples is hampered by the many look-alike "species" which appear to have been named by authors who applied a strictly typological, rather than a biological species concept in establishing new taxa. Either the myriad of pyramidellid species is the result of unprecedented oversplitting, or rampant adaptive radiation in the Late Cenozoic, partly obscured by morphologic convergence, has visited near-unmanagable diversity upon the taxonomist of pyramidellid mollusks. A combination of these two extreme interpretations is probably nearer the truth. Yet there may be new hope of unscrambling the systematics of this group in the form of taxonomic studies that utilize soft part anatomy and reproductive behavior (e.g., Robertson, 1978). After this approach has been more widely employed, many pyramidellid "species" will probably be recognized as morphotypes and the list of true species will be considerably shortened (Abbott, 1974). (I have found that it is actually possible to identify a great deal of polymorphic variation within certain species using only conchological characteristics (see Fig. 10). This method can be used by paleontologists to control the number of species included in lists that are generated from collec-



FIGS. 3–8. *Fossil pyramidellid snails from the Stetson pit:* **3**, Sayella chesapeakea *Morrison, 1939;* **4**, Odostomia impressa *(Say, 1821);* **5**, Odostomia conoidea acutidens *Dall, 1884;* **6**, Odostomia dux *Dall and Bartsch, 1906;* **7**, Turbonilla powhatani *Henderson and Bartsch, 1914;* **8**, Turbonilla interrupta *(Totten, 1835).*

TABLE 1. *Associations of fossil pyramidellid snails.*

Paleoenvironment	Species	% of samples containing each species	Abundance (average no. of specimens/ liter of sample)
Backbarrier estuarine (11 samples)	Odostomia impressa	81.8%	20.5 (abundant)
	Odostomia virginica	36.4	4.3 (rare)
	Turbonilla powhatani	45.6	7.5 (common)
Transitional (1 sample)	Odostomia impressa	100.0%	34.0 (abundant)
Inner shelf marine (3 samples)	Odostomia impressa	66.7%	2.0 (rare)
	Odostomia dux	33.3	2.0 (rare)
	Odostomia conoidea acutidens	33.3	2.0 (rare)
	Odostomia virginica	33.3	2.0 (rare)
	Sayella chesapeakea	33.3	4.0 (rare)
	Turbonilla interrupta	100.0	44.0 (abundant)

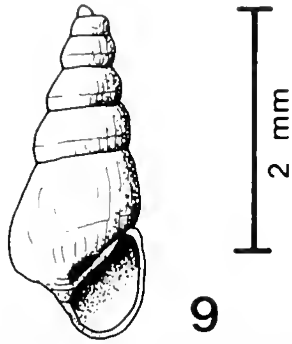


FIG. 9. Odostomia virginica *Henderson and Bartsch, 1914.*

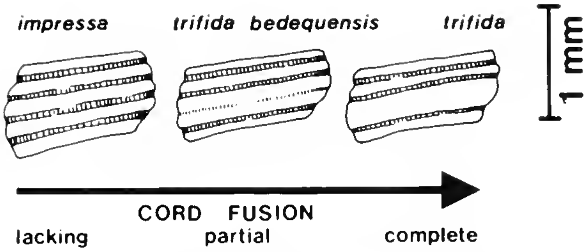


FIG. 10. *Variation in spiral ornamentation on whorl surface above the aperture of* Odostomia impressa *(Say). Variation was observed in every sample containing the species. (From a biological point of view, the variation could be the expression in shell morphology of an underlying developmental polymorphism, possibly expressed functionally in the soft parts of living* O. impressa *(see Gilbert, 1980). Developmental polymorphism in certain species of Pyramidellidae may have resulted in morphotypes that have been regarded previously as distinct species. For comparison, three of Bartsch's (1909) species and subspecies categories, applied to apparent morphotypes of* O. impressa, *are shown along the top of the drawing next to approximately equivalent morphs).*

tions of fossil shells and to approximate the biological species concept when using fossil material.) Unfortunately for the paleontologist, spermatophore morphology, location of the female pore, and reproductive behavior patterns have no chance of being preserved with the dead shells of pyramidellids, and the conchological literature remains as the indispensible source of taxonomic information for the identification of fossil specimens. Published descriptions and illustrations of species consulted in this study include: Abbott, 1974; Morris, 1973; Wells and Wells, 1961; Bartsch, 1955, 1909; and Morrison, 1939.

Pyramidellid Associations

Three recurrent taxonomic associations of pyramidellid snails were found in the Stetson borrow pit samples: 1) backbarrier estuarine associations, 2) a transitional association, and 3) inner shelf marine associations (Table 1). These associations were components of high-dominance, "physically accomodated" benthic communities in which organism-environment interactions were generally more significant than biological interactions, and in which community organization was rather loosely structured (Johnson, 1972). Although pyramidellid distribution was no doubt partly controlled by the occurrence of preferred hosts and other organisms that could be easily parasitized, environmental distribution outlined below was probably also controlled by ambient salinity ranges (Larsen, 1976; Orth, 1976; Wells, 1961, p. 256). Together, trophic resource availability and salinity appear to be the most important parameters controlling the successful post-larval establishment of local pyramidellid populations in temperate nearshore waters.

Communities living in the physico-chemical mosaic of backbarrier environments contained three species of pyramidellids, two of which have not been previously reported as fossils (Tables 1, 2): *Odostomia impressa* (Fig. 4), *Odostomia virginica* (Fig. 9), and *Turbonilla powhatani* (Fig. 7). *O. impressa*, the numerically dominant species, is a biologically well-known ectoparasite of oysters and sometimes other mollusks (Robertson, 1978; Wells, 1959; Allen, 1958). It is no coincidence that samples containing *O. impressa* also contained large numbers of the valves of *Crassostrea virginica* (Gmelin) (see Wells, 1961). *O. virginica* is biologically unknown. *T. powhatani* occurs in moderate numbers in samples and appears to have been restricted to backbarrier deposits. The possibility that this species is an ecophenotype of *Turbonilla interrupta* cannot be excluded. Host preferences of both *O. virginica* and *T. powhatani* are, to my knowledge, undetermined. Co-occurring with the backbarrier estuarine associations are the following species of mollusks, in addition to oysters: *Gemma gemma* (Totten), *Mya arenaria* Linné, *Ensis directus*

TABLE 2. *Fossil occurrences of pyramidellid species.*

Previously reported as fossils (and oldest documented occurrence*)	Not previously reported from fossil material
Odostomia impressa (Pliocene)	*Odostomia dux*
Odostomia concoidea (Miocene)	*Odostomia virginica*
Turbonilla interrupta (Miocene)	*Sayella chesapeakea*
	Turbonilla powhatani

*Clark, 1906; Richards, 1962; Shimer and Shrock, 1965; DuBar, Solliday, and Howard, 1974; DuBar, Johnson, Thom, and Hatchell, 1974; Bailey, 1977.

Conrad, *Petricola pholadiformis* (Lamarck), *Mulinia lateralis* (Say), *Macoma balthica* (Linné), *Anadara transversa* (Say), *Mitrella lunata* (Say), *Nassarius obsoletus* (Say), *Crepidula convexa* Say, and *Lunatia heros* (Say).

In deposits beneath the backbarrier beds at the Stetson pit, a mixed assemblage of estuarine and marine mollusks also contains abundant shells of *O. impressa.* These transitional deposits record the partitioning of a coastal compartment in the Dare County area in late Pleistocene time, possibly by an accreting barrier shoal or island, and the local initiation of estuarine conditions (see Miller, 1978). The eurytopic nature of *O. impressa* is shown by the occurrence of this species in a sedimentary environment that apparently was too rigorous for other pyramidellids. It even has a limited occurrence in the subjacent marine deposits (Table 1). Could polymorphism in *O. impressa* be related to its apparent eurytopic character (see Fig. 10)?

The most species-rich associations in samples came from marine beds below the transitional deposits, and contained the following species: *O. impressa, O. virginica, Odostomia dux* (Fig. 6), *Odostomia conoidea acutidens* (Fig. 5), *Sayella chesapeakea* (Fig. 3), and *Turbonilla interrupta* (Fig. 8). *O. dux* and *S. chesapeakea* are described for the first time as fossils (Table 2). In this association, *T. interrupta* is by far the most abundant species (Table 1). It is a well-known, shallow water species that parasitizes a variety of bivalve mollusks (Morton, 1967, p. 185; Abbott, 1974). The presence of rare *O. impressa* and *O. virginica* indicates that small populations of these species apparently were able to live in marine areas as well as adjacent estuarine environments. *O. c. acutidens* is unknown biologically. *O. dux* may have fed upon tubicolous polychaetes, such as *Sabellaria,* and probably preferred near-normal marine salinities (Wells and Wells, 1961). *S. chesapeakea* may be another eurytopic pyramidellid that occasionally ranged into open marine waters from its normal mud-

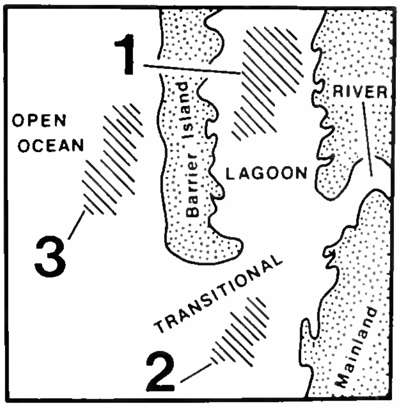


FIG. 11. *Schematic representation of the distribution of pyramidellid associations in neorshore environments: 1-backbarrier estuarine associations; 2-transitional association; 3-inner shelf marine associations.*

flat habitat (see Morrison, 1939). Co-occurring with the inner shelf marine associations were the following mollusk species: *Mulinia lateralis*, *Pleuromeris tridentata* (Say), *Crassinella lunulata* (Conrad), *Mercenaria mercenaria* (Linné), *Donax variabilis* Say, *Spisula solidissima* (Dillwyn), *Retusa canaliculata* (Say), *Terebra dislocata* (Say), *Polinices duplicatus* (Say), *Mitrella lunata*, *Nassarius acutus* (Say), and *Olivella mutica* (Say).

The distribution of pyramidellid associations in late Pleistocene nearshore environments of the northern Dare County area is summarized in Fig. 11.

Conclusions

The stratigraphy and paleontology of the Stetson borrow pit section show that the late Pleistocene history of the Dare County area included an important change in the configuration of coastal environments involving a shift from marine to estuarine conditions. This replacement of environments is reflected in the vertical succession of pryamidellid associations at the borrow pit from a species-rich, inner shelf association, to a transitional zone containing a single species, and finally to a moderately species-rich backbarrier association. The change is also reflected in a shift through time in the relative abundance and rank of eurytopic species (e.g., *O. impressa*), and in the appearance and disappearance of apparently stenotopic species, such as *T. powhatani* (an estuarine species) and *O. dux* (a marine species) in the stratigraphic column.

In conclusion, pyramidellid gastropods appear to be useful as indicators of nearshore sedimentary environments when considered in their paleosynecological and stratigraphic contexts. Although taxonomic complexities have made the Pyramidellidae a less than popular group of mollusks with paleontologists, I believe this family of gastropods holds great promise as a source of raw material for studies of polymorphism and its role in macroevolution, in paleoecological studies of deployment and function of morphotypes of variable species in ancient benthic communities, and in evolutionary studies of the adaptive radiation of parasites that have a good fossil record.

Acknowledgments

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LEAPING AND SWIMMING AS PREDATOR ESCAPE RESPONSES IN THE JACKKNIFE CLAM, *ENSIS MINOR* DALL (BIVALVIA: PHARELLIDAE)

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ABSTRACT

Two distinct behaviors, "leaping" and "swimming", were observed to follow dislodgement from the substratum in the Western Atlantic jackknife clam, Ensis minor *Dall, from the Laguna Madre, Texas. Leaping involves extension of the tip of the foot into the substratum followed by an anteriorly directed thrust of the foot from the pedal gape. During swimming the foot remains flacid and maximally extended from the pedal gape while rapidly repeated shell valve adduction draws water into the mantle cavity ventrally and forces it as a jet of water from the anterior pedal gape propelling the clam posteriorly. Both behaviors are immediately succeeded by burrowing and are presumed to be highly adaptive predator escape responses in this species.*

Swimming behavior is best known and described in the superfamily Pectinacea whose members swim perpendicularly to the hinge axis with the commissure plane approximately 45° of horizontal and in the family Limidae which swim with the commissure plane oriented vertically

(Morton, 1964; Stanley, 1970). Also reported to swim occassionally are some species of the families Solemyacidae (*Solemya velum* Say) (Morse, 1913), and the Cardiidae (*Laevicardium laevigatum* (Linné)) (Stanley, 1970). In the superfamily Solenacea (Razor-shells) swimming has been observed in the families Solenidae (*Solen marginatus* Pulteney) (Poli, 1791–1795, Deshayes 1844–1848) and Pharellidae (*Ensis directus* Conrad) (Drew, 1906; Stanley, 1970). This paper discusses both "leaping" and "swimming" behavior as predator escape responses in a second species of the family Pharellidae, the jackknife clam, *Ensis minor* Dall, that were observed in individuals collected on March 21, 1981, in 5–15 cm of water on a sandy shore of low slope on Bird Island Beach, Padre Island National Seashore, on the Laguna Madre, Texas.

In this area the *E. minor* population is very dense (300–500 individuals/m^2). Individuals were dislodged from their burrows by gently fanning water over the sediment surface to remove the sand covering them. *Ensis minor* with a maximum shell length of 76 mm (Andrews, 1977) is a much smaller bivalve than the Western Atlantic species, *Ensis directus*, which can reach a length of 20 cm (Stanley, 1970; Abbott, 1974). Specimens of *E. minor* collected at Bird Island Beach had a mean shell length of 28.9 mm (s.d. = ±2.66, s.e. = ±0.30, range = 22.3-42.4, n = 79) and a mean shell height of 4.1 mm (s.d. = ±0.36, s.e. = ±0.041, range = 3.4-5.9, n = 79).

Many specimens of *E. minor* dislodged from the substratum showed one or the other of two distinct escape behaviors. The first involved a "leaping" response in which individuals moved rapidly across the sand surface before initiating burrowing behavior. The second involved a distinct "swimming" response in which individuals left the sand surface and moved both vertically and horizontally through the water column before settling and re-entering the substratum. Both leaping and swimming were carefully observed in the field and in specimens removed from the field into 3.8 liter glass vessels.

Leaping in *E. minor* is initiated by an individual lying on its right or left valve by extending the tip of the foot into the substratum followed by an anteriorly directed thrust of the foot, extending for a distance nearly that of the shell length, from the anterior pedal gape which forces the clam to move posteriorly across the sediment surface. Up to five to ten consecutive foot thrusts may occur within a few seconds, moving the clam distances of up to 10–15 cm from the site of dislodgement. Leaping behavior is then immediately followed by burrowing into the substratum as described for *Ensis* by Trueman (1967).

Leaping behavior has also been described for the large Western Atlantic species *E. directus* but instead of anteriorly directed thrusts as occurs with *E. minor* it involves extending the foot and bending it dorsally beneath the shell, followed by a sudden straightening of the foot to the anterior projecting the clam posteriorly. These leaping movements are repeated several times (Drew, 1906). Less commonly, *E. directus* may leap as does *E. minor* by repeated thrusts of the foot anteriorly (Drew, 1906).

Specimens of *E. minor* also displayed a unique swimming behavior when dislodged from the sediment which involved entering the water column for extended periods of time and traveling over relatively large horizontal distances. Swimming was accomplished by extending the foot to its maximal length (nearly equivalent to shell length) from the anterior pedal gape. In this extended condition the foot is somewhat flacid and its diameter appears to be less than that of the pedal gape at the anterior margins of the shell. Foot extension greatly increases the volume of water in the pallial cavity and apparently allows water to be drawn diffusely into the cavity between the unfused portion of the ventral mantle edges as the shell valves open. Thereafter, the valves are rapidly adducted. During adduction the free mantle edges appear to seal the ventral margin of the pallial cavity, forcing a jet of water to be expelled from the relatively constricted anterior padal gape around the extended foot, driving the individual quickly through the water in a posterior direction with the extended foot trailing behind. During swimming, valve adduction occurs at least several times per second propelling the individual rapidly from the sediment surface and away from the site of dislodgement. This swimming behavior was maintained in some individuals for at least 15 to 20 seconds, permitting horizontal movements of well over a meter from the dislodgement site. On cessation of swimming, individuals initiate burrowing immediately on settling to the sediment surface.

Swimming has been previously described for adult specimens of *E. directus* in which it is associated with a repeated rapid extension of the foot from the anterior pedal opening, the shell valves being adducted each time the foot is retracted into the pallial cavity. Simultaneous foot retraction and shell adduction forces a jet of water out the anterior pedal opening propelling the individual posteriorly across the sediment surface without entry into the water column (Drew, 1906). This description is very similar to that reported for the related but smaller species *Solen marginatus* (Deshayes, 1844–1848). This swimming behavior of these two larger species, *E. directus* and *S. marginatus*, is quite different from that of the smaller *E. minor*, (which is accomplished by a rapid valve adduction alone) and appears to be a variant of "leaping" activity in which movement is accomplished by a succession of rapid anteriorly directed extensions of the foot, a behavior not much modified from that associated with burrowing. In contrast, swimming behavior in *E. minor* seems to be distinctly different from that associated with either leaping or burrowing.

Stanley (1970) also described swimming in *E. directus* as "an anterior swimming movement accomplished as in *Solemya* by retracting the extended, plug-like foot and adducting the valves to expel a jet of water posteriorly". This sort of swimming behavior was never observed in *E. minor* and in light of Drew's (1906) report of posteriorly directed swimming in *E. directus* and of the anatomy of the genus, *Ensis* (Trueman, 1967), it is probable that such "anterior swimming movement" does not occur in this genus.

Drew (1906) speculated that leaping and swimming behavior in *E. directus* was not primarily for escape, as this large bivalve is one of the fastest and strongest of burrowing species (Trueman, 1967; Stanley, 1970), apparently much better able to avoid predators by burrowing deeply. Instead, swimming in *E. directus* was hypothesized to be a method for rapidly changing position after settlement while leaping was presumed to allow dislodgement of individuals from highly confining or otherwise unsuitable substrata and possibly for escape if a specimen was somehow dislodged from the substratum (Drew, 1906).

Ensis minor (SL<76 mm) is of a much smaller adult size than either *E. directus* or *S. marginatus.* Because of its short siphons individuals must lie close to the sediment surface where they could be easily dislodged by predators as brachyuran decapods and shore birds that probe the substratum for their prey. Once dislodged, specimens of *E. minor* with their thin fragile shells and open pedal and siphonal gapes would be readily subject to predation. Therefore, leaping and swimming behavior after dislodgement would be of the greatest adaptive advantage to *E. minor* allowing dislodged specimens to move rapidly away from the point of attack before reentering the substratum. If burrowing behavior was initiated immediately after dislodgement a predator could easily relocate and attack a dislodged individual within the 20–100 seconds it requires for *Ensis* to completely re-enter the substratum (Drew, 1906; Trueman, 1967; Stanley, 1970). However, if burrowing is preceeded by leaping or particularly by swimming away from the point of original dislodgement an individual may gain enough time to completely reenter the substratum before it is once again detected by the predator. It now seems probable that small species or juvenile specimens of *Ensis* are capable of a much more efficient and prolonged swimming behavior than has previously been suspected (perhaps being generally of the type described herein specifically for *E. minor*) as small specimens of *E. directus* has been taken in tow nets at the sea surface (Drew, 1906). Such efficient swimming behavior may be lost in the adults of large species as *E. directus* and *S. marginatus* that primarily depend on efficient burrowing to avoid predators but appears to be retained in adults of small species as *E. minor* which are far more susceptible to dislodgement from the substratum by predators than are larger species.

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NOTES ON RARE AND ENDANGERED OR THREATENED PLEUROCERID SNAILS FROM THE CUMBERLAND RIVER, KENTUCKY

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ABSTRACT

Data for Lithasia armigera, L. geniculata *and* Pleurocera alveare, *three species listed as Rare and Endangered or of Special Concern in Kentucky and elsewhere, from the Cumberland River are presented. Ancillary records for* Helisoma anceps, Physa integra, *and* Ferrissia rivularis *are included.*

Recently, a task force (Branson et al. 1981) was assigned the job of generating a list of rare and endangered plants and animals of Kentucky. Included in that list are 65 molluscan species, 49 unionid clams and 16 snails, 12 of which are aquatic. During the writing process, it became obvious that we were hampered by a paucity of published information on the aquatic gastropod fauna or by the lack of recent surveys of the fauna. This stimulated a flurry of activities (Branson and Batch 1981, 1982a, b, c) in attempt to fill in some of the voids in distributional knowledge and to ascertain the status of the species considered rare and endangered.

Thus, the first co-author has been conducting some extensive surveys and biological investigations of the unionid clams of western Kentucky, particularly in the Cumberland River drainage above and below the Lake Barkley Dam. Coincidentally, he and his assistants made collections of some important pleurocerid snails at various sites below the dam, one of the few stretches of the Lower Cumberland River still flowing free-

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[2] Soil Systems, Inc., 525 Webb Industrial Drive, Marietta, Georgia 30062

ly. Because this section of that river was formerly rich in pleurocerid snails it was feared that the giant impoundment and the cold water released below the dam had either extirpated or greatly decimated the operculates. However, this shallow-water reservoir has little temperature stratification, so temperature problems have not developed. The daily water fluctuations and consequent water-quality changes are of more importance with respect to the molluscan populations.

One of those species is *Lithasia armigera* (Say) 1821. This species is listed as Rare and Endangered in Kentucky (Branson et al. 1981) and elsewhere (Federal Register 1980 – candidate for listing). The species is truly Rare and Endangered throughout much of its range, particularly in the Upper Cumberland River (Branson and Batch 1982c) where it is heavily impacted by strip-mining pollutants. However, from the results of Sickel's observations in the Cumberland River below the dam there appears to be a thriving and healthy population in that stretch of the river, i.e., from the dam to the mouth.

Sickel's collecting sites were: Cumberland River, River Mile 16, at Pinkneyville, Livingston County, Kentucky, 8 November 1981, 31 specimens (EKU 11939); River Mile 17.3, Crittenden County, 20 September 1981, 30 specimens (EKU 11942); River Mile 26.9, Lyon County, 7 October 1981, 40 specimens (EKU 11941); River Mile 27.1, Lyon County, 8 October 1981, 21 specimens (EKU 11940). In addition, Bauer secured 11 specimens (EKU 11937) from a massive population in the Cumberland River at Dycusburg on the Livingston-Crittenden county line, River Mile 20, 5 October 1981. All immature shells (12 mm or smaller) are banded, and 65% of the adult shells bear 1 to 5 bands within the aperture.

The presence of an abundance of young shells indicates that the population below Barkley Dam is self-sustaining. Notwithstanding any additional environmental changes in the lower stretches of the Cumberland River, these sites may be considered as a refugium for this and the next species below.

Lithasia geniculata Haldeman 1840 is listed as Endangered in Kentucky (Branson et al. 1981) and is currently being considered for federal listing (Federal Register 1980). It is truly rare throughout its range, thus Sickel's discovery of a small population at Cumberland River Mile 17.3, Crittenden County, Kentucky, 20 September 1981, is of considerable interest. He secured three specimens only, all banded (EKU 11943). No immature shells were collected, and we have no indication of the population's size, although some estimates may be forthcoming after SCUBA-gear observations.

Pleurocera alveare (Conrad) 1834 is considered as of Special Concern in Kentucky (Branson et al. 1981) since Cumberland River specimens have not been reported in many years. Goodrich (1934) found the species abundantly in the Cumberland River above Burnside, a site now inundated by the impounded waters of Lake Cumberland, and recent collecting (Branson and Batch 1982c) in stretches of the river above the lake and elsewhere failed to disclose specimens. Thus, Bauer's discovery of a good-sized population in the Poor Fork of the Cumberland at Gatum, Harlan County, Kentucky, 30 September 1981 (12 specimens: EKU 11938), is noteworthy. He also made collections from the Martins Fork below Martins Fork Dam, Harlan County, without securing specimens of this species, although he did find a thriving community of *Helisoma anceps* (Menke) 1830 (EKU 11935) and *Physa integra* Haldeman 1841 (EKU 11936). The environmental conditions below the dam are vastly changed, including the presence of silt and lowered temperatures.

Ferrissia rivularis (Say) 1817. Because of the very few published records from Kentucky waters, the single specimen removed from a *Lithasia* shell taken from Cumberland River Mile 17.1 by Sickel is herewith reported (EKU 11944).

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EXTRAORDINARILY RAPID POSTLARVAL GROWTH OF A TROPICAL WENTLETRAP *(EPITONIUM ALBIDUM)*

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ABSTRACT

Observations and experiments were conducted on the West Indian wentletrap Epitonium albidum *(Orbigny, 1842) to see how it grows, how fast it grows, and to determine whether one varix is grown per 24 hours. Combining aquarium with field data, and data on both sexes (epitoniids are protandric), growth data were obtained from 23 specimens. The best data set comes from 8 Barbados males that grew for longer than 5 days, in which the mean daily teleoconch length increment was 0.15 ± 0.04 mm, and the mean number of ribs added per day was 1.2 ± 0.5. Three females grew 0.33 to 0.50 mm/day in teleoconch length. The data show that* E. albidum *can grow extremely fast, but that there is no consistency about 1.0 rib being grown per day. Even thick-shelled tropical wentletraps may be among the fastest-growing gastropods.*

Observations are reported on the way Epitonium *teleoconchs grow, and an explanation is given on why the shells are rarely seen with the outer lip between varices. Further observations show that hunger can cause* Epitonium *ribs to become abnormally closely spaced, yet rib-spacings (counts) are considered to be major taxonomic characters in epitoniids.*

According to Bosch (1965), the Hawaiian wentletrap *Epitonium ulu* Pilsbry, 1921, begins to lay egg masses within the remarkably short time of three weeks after the planktotrophic veliger settles and metamorphoses near or on its scleractinian coral host *Fungia scutaria* Lamarck, 1801 (Robertson, 1970: 45-46). According to Guinther (1970) "sexual maturity" can even be attained in "perhaps [a] little more than two weeks," but he may have been referring to male maturity (epitoniids are probably all protandric: Robertson, 1981b). Taylor (1977:258, Fig. 7) has published data on the early postlarval growth rate of *E. ulu* (she did not try to count varices): when with the actiniarian sea anemone *Aiptasia* sp., not its normal host, shell length (of one specimen only?) increased from 0.6 mm to 3.5 mm in 15 days (0.19 mm/day). "Field growth experiments" conducted by Guinther (1970) on "*E. ulu* indicate that [the] growth rate is greatest as the juvenile snail approaches sexual maturity, after which [the] growth rate decreases nearly geometrically." Bosch (1965) reported a maximum shell length in *E. ulu* of 16.5 mm.

Epitonium ulu is an unusual wentletrap in having a fairly thin shell with only traces of varices. The Hawaiian holotype (Acad. Nat. Sci. Philadelphia [ANSP] no. 127818) is 14.2 mm long and has a total of about 135 faint varices on the 9.7 remaining whorls of its teleoconch (about 21 varices on the last whorl). These shell features and the fast early postlarval growth rate caused me to wonder whether wentletrap varices are grown one per 24 hours (possibly each night).

Such an occurrence is not without precedent among gastropods: Berry (1962, 1963) reported that Malayan *Opisthostoma* spp. and *Diplommatina* spp. (operculate land snails of the family Diplommatinidae) grow one interspace and one thin axial rib per day under optimal conditions (ribs are grown somewhat more rapidly in continuous darkness, and irregularly when the snails are too dry). According to Berry (1963), the same things are true of Malayan *Oophana* sp. and *Sinoennea* sp. (Pulmonata: Streptaxidae), even though they are not closely related to diplommatinids. Tillier (1981:182) stated that in diplommatinids sexual maturity coincides with definitive peristome growth (i.e. growth is determinate). Tillier suggested that the New Caledonian diplommatinid *Palaina mareana* Tillier, 1981, begins to grow its peristome and matures in as few as 80 days after hatching, i.e. after about 80 thin axial ribs are grown.

Epitoniids do not cease growing after becoming female (i.e. their growth is indeterminate), but if one varix is grown per day the implication would be that large species such as *Epitonium scalare* (Linn., 1758) (up to about 63 mm long) with big, widely spaced varices (8–15 on the last whorl) are short-lived, the postlarvae growing for only about 78 days (count of the total number of varices on the largest nearly intact specimen at ANSP), and that *E. millecostatum* (Pease, 1860–1861), a much smaller species (up to 9.7 mm long) with many very closely-spaced varices (Robertson, 1981a: 4, Fig. 2) – as many as about 100 on the last whorl only – is relatively long-lived.

Ankel (1936:149) published a statement bearing on the growth and life cycle of epitoniids: he claimed that the sex of the European species *Epitonium clathrus* (Linn., 1758) [as *Scala clathrus*] changes with each breeding season. Multiple sex change seems unlikely (Robertson, 1981b), and Ankel (1936) published no data to show that there is a discrete breeding season. In his paper on the longevity of mollusks, Comfort (1957) had no information about epitoniids.

The main objects of this study were to obtain some growth rate data on a shallow water, tropical *Epitonium* of average size and shell thickness, and with varices of average size and spacing, and to ascertain whether one varix is grown per 24 hours.

Materials and Methods

The species studied was *Epitonium albidum* (Orbigny, 1842) (Figs. 1-3), which in the Bahama Islands (Robertson, 1963), at Virgin Gorda (British Virgin Islands) and at Barbados lives with and feeds on the shallowly subtidal actiniarian sea anemone *Stoichactis*[1] *helianthus* (Ellis, 1768). See Robertson (1983).

Epitonium albidum attains a shell length of 25+ mm (ANSP no. 299697, a sub-fossil shell from Nassau, New Providence, Bahama Islands; R. Robertson, leg. 1954). The second largest specimen collected by me (the largest live-collected) is 15.9 mm long (Figs. 1-3: Virgin Gorda). The largest Barbados specimen (growth completed in aquarium) was 14 mm long. The largest Barbados specimen that I collected in 1982 (growth also completed in aquarium) was only 12.0 mm long. Males turn into females between lengths of 5 and 8 mm (Robertson, 1981b).

Specimens were studied from January to March 1972 at Virgin Gorda, and from March to April 1980 and from January to February 1982 at the Bellairs Research Institute of McGill University, St. James, Barbados. Specimens were breeding at these times, but whether they breed year-round is unknown.

Soon after capture of a specimen, the flared or thickened outer lip was marked with a graphite pencil. If the outer lip was broken, the two preceding varices were marked instead. In this way a replacement rib could be distinguished from a

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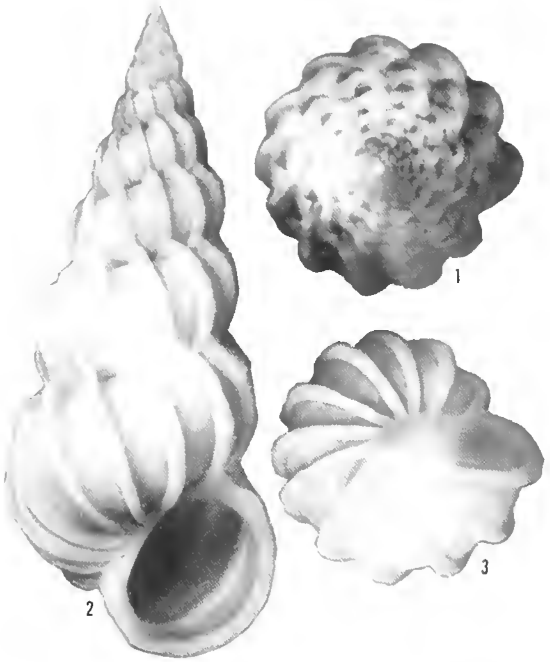
[1] Since going to press, I have learned that the genus should be *Stichodactyla* (see Dunn, 1981:78-82).



FIGS. 1–3. *Shell of* Epitonium albidum *15.9 mm long and 6.6 mm wide (the largest specimen collected during this study). Virgin Gorda, British Virgin Islands. Animal in the female phase. Growth can be extremely fast: varices are usually grown faster than 1.0 per day.* **1,** *Apical view.* **2,** *Apertural view.* **3,** *Basal view.*

completely new rib. Once marked, specimens were 1) kept away from *Stoichactis* in plastic petri dishes about half full of sea water changed daily, or 2) were put with *Stoichactis* in an aquarium with running sea water (temperature about 26° C.), or 3) were returned to a *Stoichactis* in the field and retrieved (if possible) about two weeks later. Both in aquaria and in the field, the wentletraps tend to wander from one anemone to another. Thus in the field individuals are difficult to retrieve.

Stoichactis remained apparently healthy for up to 12 days in the aquaria, although pedal disc movement and detachment were frequent. The fast-growing 7.6–11.5 mm-long female listed in Table 1 was seen twice (three days apart) to feed on single *Stoichactis* tentacles (it may have fed more frequently than this).

On February 4, 1972, near the southern end of Copper Mine Bay, on the southeastern coast of Virgin Gorda, a small group of marked wentletraps was released next to an easily recognized anemone on a near vertical rock face (not one of the anemones with which the individuals were originally found). One of these marked animals was retrieved from the same anemone on February 19, 1972, 14.8 days later.

A more extensive mark and recapture experiment was conducted at the Bellairs Research Institute, just north of Holetown, western Barbados, off which there is an enormous *Stoichactis helianthus* colony. On January 28, 1982, all 12 wentletraps from one anemone, and all 39 from another, were marked, measured, and replaced the same day with the same individual host anemones. The first of these was approx. 25 cm from the perimeter of the colony where the anemones were edge to edge. The second was approx. 15 cm from the first, and approx. 35 cm from the edge of the massed colony. Each of these anemones had sand around the base (the wentletraps prefer anemones with sand, in which they hide and with which they agglutinate their egg capsules). The numbers of *Epitonium albidum* per *Stoichactis* were the maxima observed in the three study areas, and it was hoped that the sand and peripheral position of the anemones would minimize wentletrap wandering. On February 11, 1982, 13.8 days later, an attempt was made to retrieve as many as possible of the 51 marked wentletraps from the two anemones. Of the 16 wentletraps collected, 5 had been marked. On February 13, 1982, 15.8 days later, a sixth marked specimen was found with a *Stoichactis* about 1 m away. Judging by their initial and final shell lengths (between 2.2 and 6.1 mm), all the retrieved specimens were either immature or male (Robertson, 1981b).

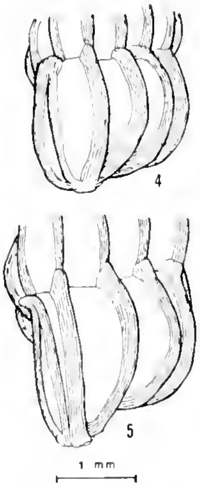
Observations

Observations were made on the way *Epitonium* teleoconchs grow. A new intervarix (the space between two varices) and varix grow simultaneously, thinly at first, then both subsequently thicken. Thus the intervarix and new rib either are thin and easily broken back to the preceding rib, or they both are thick and the outer lip coincides with the last rib. Some individuals had a thin intervarix and a thin outer lip rib, while others, collected and marked at the same time of day, had already thickened these shell parts. Three out of four specimens found with one *Stoichactis* at Virgin Gorda had abnormally thickened penultimate axial ribs.

Specimens found with *Stoichactis* but kept separate from the anemone host usually ceased shell growth in the laboratory, although a thin outer lip was usually thickened or a replacement rib was sometimes grown if the lip needed repair. If new (but not replaced) shell was grown, the intervarix was usually narrowed relative to the immediately adjacent intervarices and grew within a day or so (Fig. 4). On one occasion two new ribs were grown, the second also with a narrow intervarix (Fig. 5). These new ribs were noteworthy in being slanted relative to the preceding rib.

Experimental Results

Growth rate data from the specimens in aquaria are given in Table 1; field data are in Table 2. Twenty-three specimens were studied in all, 14 of them in the immature or male phase, and 9 of them in the female phase (field data on females and laboratory data on large females – 13–25 mm long – unfortunately are lacking).



FIGS. 4 *and* 5. **4,** *Lateral view of the anterior end of an* Epitonium albidum *shell showing normally spaced varices, a narrow intervarix and a new outer lip rib grown the first night in the laboratory (kept away from* Stichodactyla*).* **5,** *Same, showing two new narrow intervarices and two new outer lip ribs grown during two successive nights in the laboratory (kept away from* Stichodactyla*).*

The data are difficult to interpret because days elapsed between measurements are not the same, because there are few individuals in each size class, and because data are not normally distributed when some size classes and days elapsed between measurements are standardized. Additionally, females must be considered separately from males.

Several points are nevertheless clear: 1. Non-normally distributed data and unacceptably high variance result when animals were measured less than 5 days apart. 2. Three egg-laying females gave anomalously high measurements: mean teleoconch length increments of 0.33 to 0.50 mm per day. 3. One class of measurements yields sufficient data to make a clearcut and reliable statement about growth, i.e. males maintained for 7 or more days ($N=8$) grew 0.15 ± 0.04 mm in mean teleoconch length per day (Barbados animals only). The sizes of the animals do not appear to affect this rate over a range of 2.2 to 6.2 mm in initial shell length. 4. The same eight specimens grew a mean number of 1.2 ± 0.5 ribs per day.

Discussion and Conclusions

The observations on teleoconch growth explain why *Epitonium* shells are rarely seen with the outer lip between varices (only when it has been partially broken back). Similar conclusions were reached by Linsley and Javidpour (1980) on much larger, distantly related varix-bearing prosobranchs such as *Cassis* and *Murex*.

The observation that not all individuals were at the same stage of growth at the same time of day does not favor the 24-hour cycle hypothesis. The observation that three specimens collected with one *Stoichactis* at Virgin Gorda all had abnormally thickened penultimate axial ribs does suggest, however, that some extrinsic factor was causative.

When *Epitonium albidum* is parted from its host and if growth does not cease promptly, the spacing between the one or two newly grown ribs usually narrows (Figs. 4–5). It is noteworthy that such changes in spacing should so readily occur, the number of ribs on the last whorl being such a sacrosanct taxonomic char-

TABLE 1. *Data on shell growth in* Epitonium albidum, *based on Barbados specimens maintained in aquaria in which* Stichodactyla helianthus *and sand were available (early February).*

Sex	*Initial shell length (mm)*	*Days elapsed*	*Final shell length (mm)*	*Mean shell length increments/ day (mm)*	*New ribs grown*	*Mean ribs/ day*
♂	4.1	4.1	4.5	0.10	3	0.7
♂	5.0	4.1	5.1	0.02	1	0.2
♂	5.5	4.1	5.6	0.02	0	0
♂	5.7	4.1	5.9	0.05	2	0.5
♂	6.0	4.1	6.4	0.10	2	0.5
♂	6.2	7.3	6.9	0.10	4	0.5
♂	6.2	7.3	7.1	0.12	4	0.5
♀	7.0	4.1	7.3	0.07	2	0.5
♀	7.5	4.1	7.9	0.10	2	0.5
♀	8.5	2.0	8.6	0.05	2	1.0
♀	8.9	4.0	8.9[1]	0	0	0
♀	8.7	4.0	9.4	0.18	3	0.8
♀	7.6	12.0	11.5	0.33	17	1.4
♀	9.7	2.0	10.7	0.50	4	2.0
♀	10.8	2.0	11.6	0.40	4	2.0
♀	11.6	3.7	12.0	0.11	2	0.5

[1] Specimen unable to right itself, and thus did not feed.

TABLE 2. *Mark and recapture data on shell growth in* Epitonium albidum *during 13.8 - 15.8 day periods in the field with* Stichodactyla helianthus *at Virgin Gorda and Barbados. All observations were made in late January and February. Sex: all immature or male.*

Virgin Gorda (VG) or Barbados (B)	*Estimated initial shell length (mm)*	*Days elapsed*	*Final shell length (mm)*	*Mean shell length increments/ day (mm)*	*No. ribs grown*		*Mean ribs/ day*
					Replacement	*New*	
VG	2.8	14.8	3.3	0.03	0	6	0.4
B	2.2	13.8	4.2	0.14	1	23	1.7
B	2.8	13.8	5.7[1]	0.21	0	23	1.7
B	3.3	13.8	5.5	0.16	0	21	1.5
B	3.3	13.8	5.5	0.16	0	19	1.4
B	3.5	15.8	5.5[2]	0.13	1	16	1.1
B	3.4	13.8	6.1	0.20	0	24	1.7

[1] Shell empty. [2] Moved 1 m.

acter in epitoniids. The ribs usually are lined up and joined together from one whorl to the next (Figs. 4–5), and thus the normal spacing is established early in postlarval life. Even so, would the spacing (and "species") change if a wentletrap moved from a preferred host to a less "desirable" host?

The data available do not enable me to determine a growth curve for *Epitonium albidum*. Nor do they make possible statistical comparisons between the laboratory and field data, or between individuals in the male and female phases (do females grow faster than males?).

How well do the data accord with a sigmoid curve? It is not possible to establish the sizes at which the first lag phase ends and the second begins, or the point on the curve where sex change occurs (is there a deflection?). The best data set analyzed in the Experimental Results section (from the 8 Barbados males) may have come from animals still in the initial lag phase when the first measurements were made and from animals probably in the log phase when the final measurements were made. In other words, data from these specimens probably do not indicate the greatest mean rate of growth that can be attained in the log phase. This may help to explain part of the increased rate of growth of the three small- to medium-sized females, but does not explain the inordinately high rates and why the data are so erratic. Presumably they were at the middle or high end of the log phase. This raises questions: Under what conditions does *Epitonium albidum* grow large enough to reach the final lag phase? Is the upper end of the growth curve usually truncated? What causes death?

According to Guinther (1970), growth of *Epitonium ulu* slows soon after "maturity" is reached, but this study of *E. albidum* indicates that the second lag phase begins well after the beginning of female maturity.

It is puzzling to me why the data from fewer than 5 days growth are so erratic. Two of the three fastest-growing *Epitonium albidum* females grew for only 2.0 days, but the one that grew 0.33 mm/day did so for a more sustained time – 12.0 days (Table 1). In five instances the growth rate data for *E. albidum* exceed the rate recorded in young postlarval *E. ulu* (>0.19 mm/day) (Taylor, 1977) (Tables 1–2). The percent daily shell length increase of one male was as high as 7.5 (2.8 to 5.7 mm in 13.8 days; Table 2).

Other isolated data sets also indicate fast growth in *Epitonium albidum*, specifically those relating to rib growth. In three out of seven instances in the field, 23 or 24 ribs were grown in 13.8 days (1.7/day) (Table 2). There are between 10 and 13 ribs on the last whorl of mature *E. albidum* (mean of 42 counts: 11.5), so about two whole new whorls were grown during this time. In two instances in aquaria, females grew 2.0 ribs/day, but only for 2.0 days (Table 1).

Episodic growth in the much larger prosobranchs such as *Cassis* and *Murex* discussed by Linsley and Javidpour (1980) must involve tremendously fast spurts of growth. After each spurt, after each outer lip is thickened, there is a long period of quiescence insofar as shell growth is concerned. Although *Epitonium* has growth spurts, these are much smaller in scale. Periods of quiescence involve only hours or a day or so at most, not months.

What could account for the rhythmic growth of *Epitonium* varices? A 24-hour cycle? A tidal cycle? Rhythmic feeding? An endogenous rhythm? As for the first and second possibilities: there is no one-to-one relationship between rib growth and either of these physical factors. However, the situation may be more complicated. The day-night and tidal rhythms were obscured in the laboratory. Considering only the Barbados field data (Table 2), the mean number of ribs grown per day is 1.2±0.5. It seems unlikely that a 24-hour cycle would result in more than 1.0 rib per day. However, the tidal cycle at Barbados is semidiurnal (1.9 high or low tides per day). Allowing for some lag and behavioral variance, *E. albidum* growth spurts possibly are affected or regulated by the tides. The data are, however, so variable that the latter hypothesis requires rigorous testing. As for the third and fourth possibilities: no data are available.

The data do show that *Epitonium albidum* definitely does not consistently grow 1.0 rib per day, and thus shells cannot be aged simply by counting total numbers of varices.

Breyer's (unpublished) data show that the California species *Epitonium tinctum* (Carpenter, 1864) has an annual life cycle; growth is slow. Relative to its size and shell thickness, *E. albidum* must be one of the fastest-growing gastropods. The data reported here suggest that it has a short sub-annual life cycle.

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DISTRIBUTION OF *CORBICULA FLUMINEA* THE ASIATIC CLAM, IN MISSISSIPPI[1]

Paul D. Hartfield and **Charles M. Cooper**

ABSTRACT

Corbicula fluminea *(Müller, 1774) is recorded from 10 of the 12 major drainage basins of Mississippi. The absence of this clam is associated with shallow, sandy rivers and short coastal drainages influenced by tides.*

In Mississippi, the Asiatic Clam was first discovered in the Yazoo River in 1963 (Hubricht, 1963). It has since been found in the Pearl, Leaf, and Coldwater Rivers (Heard, 1965); the Pascagoula and Chickasawhay Rivers, and the Tennessee River tributaries in northeastern Mississippi (Grantham, 1967); the Tombigbee River (Grantham, 1969); the Tangipahoa and Amite Rivers (Stern, 1976); the Yalobusha River and Grenada Lake (Cooper and Johnson, 1980); and the Big Black River (Hartfield and Rummel, 1981).

Mississippi (Fig. 1) is divided into 12 major drainage basins. We made 51 collections of Asiatic Clams in ten of these systems with the following observations:

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[1] Contribution of the Mississippi Museum of Natural Science, Jackson, MS, 39202 and the Sedimentation Laboratory, ARS, U.S. Department of Agriculture, Oxford, MS 38655.

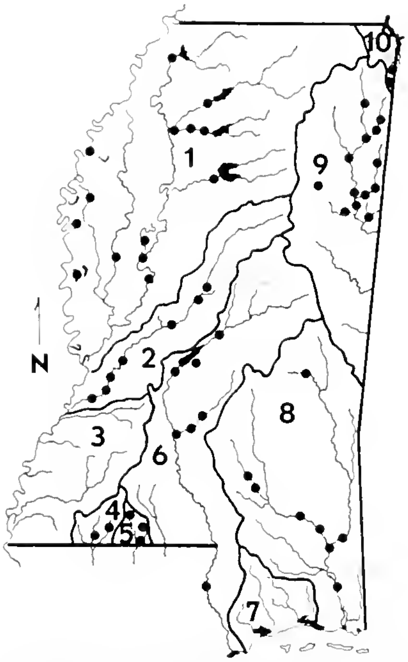

FIG. 1. *Drainage systems in Mississippi (After Cook, 1959). Black dots (•) indicate collections by the authors.*

1. Yazoo-Sunflower Basin. Dispersed throughout Bear Creek, the Sunflower, Yazoo, Tallahatchie, Yocona, Yalobusha and Coldwater rivers, and in Lakes Bolivar, Ferguson and Washington.

2. Big Black River. Locally abundant in the lower half of the Big Black River and is occasionally found north of Madison County.

3. Southwest Mississippi. Absent from Bayou Pierre and the Homochitto and Buffalo Rivers.

4. Amite River. Common, but we have not found any dense populations.

5. Tangipahoa River. Locally common.

6. Pearl River. Abundant throughout the drainage including the Yockanookanay and Strong Rivers, and Ross Barnett Reservoir.

7. Coastal Terrace. Absent.

8. Leaf River. Locally abundant throughout the drainage including Okatoma Creek. Dense populations are found in the lower part of the river between Hattiesburg and the mouth.

9. Chickasawhay River. Locally abundant including Chunky River.

10. Pascagoula River. Abundant above tidal influence but not found in the Black and Red Creeks.

11. Tombigbee River. Locally abundant populations throughout the drainage including the Buttahatchee River and the Tibbee, Luxapalila and Bull Mountain Creeks.

12. Tennessee River. Very abundant in Bear Creek. Animal middens on the creek bank are almost exclusively *Corbicula*.

There are two general regions of Mississippi where Asiatic Clams have not been collected. The first consists of the tributaries which drain into the Mississippi River below Vicksburg, Mississippi and includes Bayou Pierre, Homochitto River and Buffalo River. The absence of *Corbicula* from these streams does not appear to be due to inaccessibility, since the clam is well-established to the north in the Big Black River, to the east in the Pearl River, to the south in the Amite River and to the west in the Mississippi River. Other bivalves are also quite rare in these three streams. Only five species of unionids were found in Bayou Pierre: *Potamilus purpuratus*, *Lampsilis ovata ventricosa*, *L. straminea claibornensis*, *Leptodea fragilis*, and *Tritogonia verrucosa*. Only two species, *Lampsilis radiata luteola* and *Villosa lienosa* have been collected in the main channel of the Homochitto River, but four additonal species (*Toxolasma texasensis*, *Fusconaia flava*, *Uniomerus declivus*, *Anodonta imbecillis*) have been found in a small tributary. No bivalves were collected from the Buffalo River.

Physical characteristics shared by the three streams explain their limited bivalve fauna. Substrates are primarily sand or gravel mixed with sand. Quicksand varying from 15 to 60 cm deep is found throughout the drainages. In general the sand can be considered a very unstable and shifting substrate on which few bivalve species, including *Corbicula*, can survive. The streams have a low flow channel which meanders within wide, sandy flood channels. In the Homochitto River the flood channel may be 400 m wide while the low flow channel is less than 30 m. The low flow channel also meanders extensively as a result of seasonal flooding. One collecting site in the main channel of the Homochitto in 1981 was dry sand and over 25 m from the low flow channel in 1982. In the headwaters where the ratio of the flood channel is much less, long stretches of sand and gravel are exposed during low flow. These sand and gravel bars act as solar collectors during the summer months and water temperatures reach or exceed 35°C. It appears likely that shifting sandy substrates and high summer water temperatures are limiting factors to all bivalve fauna including *Corbicula* in this drainage.

The second region where *Corbicula* could not be found consists of the streams that drain into the Mississippi Sound between the Pearl and Pascagoula Rivers, i.e. the Jordan, Wolf, Biloxi, and Tchoutachabouffa Rivers. All of these streams have comparatively short and narrow drainages, are bayou-like at their mouths with tidal influences extending upstream for several km. Their headwaters above tidal influence are shallow and often have sandy substrates, characteristics common with the streams in the lower Mississippi drainage. Naiad molluscs are also rare in these coastal drainages. Grantham (1969) reported three species from the Wolf River *(L. claibornensis, Villosa vibex, Rangia cuneata)*, two from the Jordan *(Villosa lienosa lienosa, Rangia cuneata)*, four from the Biloxi *(Lampsilis claibornesis, V. lienosa, V. vibex, R. cuneata)* and one from the Tchoutachabouffa *(R. cuneata)*. During our survey, we also found *Fusconaia cerina* and *Villosa lienosa* in the Wolf River, but were unable to add to the faunal lists of the other streams.

Acknowledgments

We wish to thank M. Pierson, C. A. Schultz, R. Rummel, and D. Heins for providing additional collections of *Corbicula*, and Dr. Dave Stansbery for assistance in identifying naiads. Specimens and locality data from this study are on file in the Mollusca Collection of the Mississippi Museum of Natural Science, Jackson, MS.

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THE PLANORBID SNAIL *MICROMENETUS DILATATUS AVUS* (PILSBRY) IN THE WEST INDIES AND CENTRAL AMERICA

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During recent years I collected several samples of a minute planorbid snail in Haiti and Jamaica. The specimens are indistinguishable from a form described as a Pliocene fossil from Florida. This is also the same as a form described from Panama. The snail is properly classified as follows: Walter (1970, Ann Rept. Amer. Malac. Union: 47-51) establishes the use of the generic name *Micromenetus*.

Micromenetus dilatatus avus (Pilsbry)

Planorbis alabamensis avus Pilsbry, 1905; *The Nautilus* **19**:34. (Type locality: Pliocene, Caloosahatchee Formation, near Clewiston, Florida).

Promenetus (Micromenetus) alabamensis avus (Pilsbry), Baker, 1945; Molluscan Family Planorbidae, Univ. Illinois Press: 190; pl. 121, figs. 40, 41; pl. 123, fig. 1; pl. 140, fig. 25.

Promenetus minutus Taylor, 1954; *Revista Soc. Malac. "Carlos de La Torre"* **9**:37–38. (Type locality: Allee Creek, Barro Colorado Island, Panama).

M. d. avus is generally distributed throughout the Florida peninsula and intergrades with *M. d. dilatatus* (Gould) in northern Florida. It is figured and discussed in greater detail in a forthcoming manual on Florida freshwater gastropods. *M. alabamensis* is a different species. West Indian records for *M. d. avus* are: HAITI: Dept. du Sud, creek 14 km N, Cavaillon, 350 m. alt. (UF 32419), irrigation ditch, Les Cayes (UF 34995). JAMAICA: St. Elizabeth Parrish, marshy stream 1.6 mi. SE Snipe (UF 34995). Undoubtedly the species is more widely distributed in the Greater Antilles. It is seldom collected because of its small size (less than 2 mm) and its secretive habit of living under stones and vegetative debris.

A NEW *HUMBOLDTIANA* (PULMONATA: HELMINTHOGLYPTIDAE) FROM NORTHWESTERN COAHUILA, MEXICO

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ABSTRACT

A new species of helminthoglyptid land snail, Humboldtiana malenae, *is described from mountains of northwestern Coahuila, Mexico. Its relationships with other members of the genus in the area are discussed.*

Southward from the eastern side of Big Bend National Park, in Texas, extends a complex but generally linear series of mountain ranges into Coahuila, Mexico. These include, north to south, the Sierra del Carmen, the Sierra Jardin and the Sierra Maderas del Carmen. Between this latter range and the Sierra de la Encantada, which extends on to the south and southeast is the lower Mesa de los Fresnos. At the southern end of this mesa is a pass across the mountains called La Cuesta de Malena or La Cuesta de Plomo. Standing at the pass, one can observe the arid basins and ranges of the Chihuahuan Desert to the west and, to the east, the more mesic mesquite-grassland of Coahuila, where copious rains had fallen in the days before a visit made here in May 1981. The rains had drenched the area of the pass as well and stimulated activity in the *Humboldtiana* reported here. Vegetation comprised grasses and a shrubby matorral. Snails were associated with accumulations of igneous rocks.

I am grateful to Mr. David H. Riskind and Mr. Robert Burleson, who organized and conducted the field excursion during which we visited La Cuesta de Malena, and especially to Mr. Burleson, who provided transportation. Mr. William Murray helped in making collections.

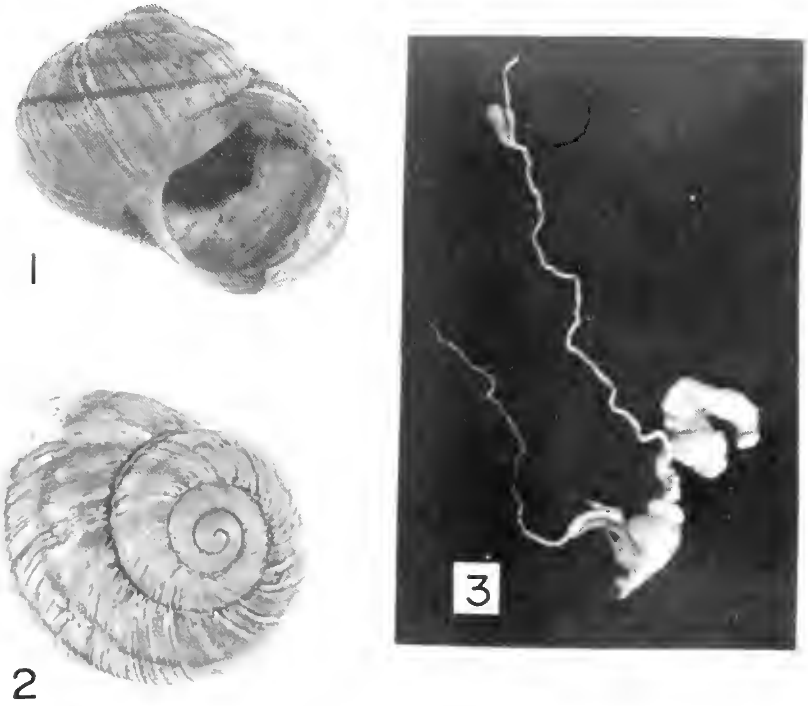
Humboldtiana malenae **new species**

Figs. 1-4

Diagnosis: A relatively small *Humboldtiana* with narrow brown bands on shell, the lowermost band poorly developed; younger whorls granulose; most of surface of the first whorl smooth; and with mucus gland ring situated closely above the dart sacs.

Description of Holotype: Shell subglobose, 24.9 mm in diameter and 21.1 mm high; spire rising steeply, forming angle of 105°; 4.2 whorls, with body whorl rounded peripherally and descending; aperture sub-rounded, 13.8 mm wide and 15.0 mm high, inclined at angle of 25° to vertical; columellar peristome reflected and covering most of umbilicus, leaving only a slit; outer lip thin; most of first whorl smooth but with low, fine, slightly sinuous growth lines appearing at 0.9 whorl, these bearing minute granules, widely separated; both growth lines and granules gradually becoming stronger on younger whorls, the former developing into light yellow growth ridges that alternate irregularly with lower, brownish areas and with granules becoming larger, light yellow in color, and more elongate on dorsal surface, occurring both on and between ridges; granules less developed ventrally; two pale brown bands arise at 1.6–1.8 whorls, one centrally and one peripherally located on the upper surface of the whorl, these becoming darker in color and better defined on younger whorls with both located above the periphery of the body whorl; in some places traces of a third brown band below the periphery of the body whorl are barely discernible. There are several irregularities on the shell surface caused by injury and shell regeneration.

Variation in shells of paratypes: The subperipheral brown band, which is almost indiscernible on the shell of the holotype, is moderately well developed on some paratypes. The relationship of width to height of shell is vari-



FIGS. 1–3. 1 *and* 2, *Apertural and dorsal views of holotype of* Humboldtiana malenae *new species (24.9 mm diameter).* 3, *Genitalia of a paratype of* H. malenae *(dimensions listed first, of four, in text under heading "Genitalia").*

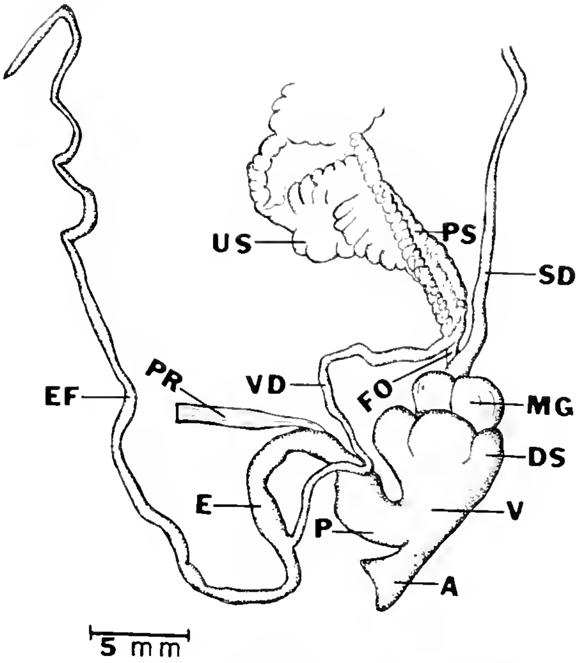


FIG. 4. *Lower region of genitalia of same specimen of* Humboldtiana malenae *new species as in Fig. 3. A-atrium, DS-dart sac, E-epiphallus, EF-epiphallic flagellum, FO-free oviduct, MG-mucus gland ring, P-penis, PR-penial retractor muscle, PS-prostatic part of spermoviduct, SD-spermathecal duct, US-uterine part of spermoviduct, V-unaltered part of vagina, VD-vas deferens.*

able. Thus, the ratio diameter/height for 10 paratypes ranges from 0.99 to 1.19 with mean of 1.08 and standard deviation of 0.059. For these paratypes, the following dimensions (in mm) and counts were obtained (mean is before, range within, and standard deviation after parenthesis): shell diameter, 23.9 (21.5–27.5) 1.81; shell height, 22.3 (20.1–24.1) 1.3; apertural width, 13.8 (12.5–15.8) 1.04; apertural height, 15.5 (14.0–16.7) 0.81; number of whorls, 4.21 (3.8–4.45) 0.19.

Genitalia: (See Figs. 3 and 4). The penis is relatively short for the genus (Solem, 1974: Table 1). Internally, a verge occupies 0.4 to 0.65 of the length of the penis in four specimens dissected. Internally, the verge is much like that reported by Solem (1974:361) for *Humboldtiana fullingtoni* Cheatum, 1972, with an accessory, inner membrane, covering four pilasters that continue downward from the epiphallus. These pilasters are deeply corrugated transversely and continue to the lower end of the verge where they terminate in four finger-like projections. As in *H. fullingtoni* also, a circular pilaster surrounds the lower part of the verge on the inner wall of the penis in two specimens. Below this circular pilaster arise 5 or 6 longitudinal pilasters, which extend on to the atrium. The epiphallus bears a well developed flagellum. The lowermost, unaltered vagina is short. The mucus gland ring is very close to the dart sacs and both are large features. In some specimens (as in Fig. 4) there is no externally discernible separation between mucus glands and dart sacs, while in others a separation not exceeding 0.5 mm is observed. The free oviduct above the mucus glands is short. The spermathecal duct bears a relatively long appendix shortly below its terminal bulb. Measurements (in mm) of genitalia for four specimens dissected (from shells with diameters, respectively, of 26.3, 23.8, 22.5 and 22.5 mm) are: length of penis from penial retractor insertion to atrium, 6.5, 7.0, 5.5, 7.9; length of vas deferens, 19.0, 18.5, 11.5, 16.3; length of epiphallic flagellum, 49.3, 53.7, 42.4, 48.4; length of unaltered vagina below dart sacs, 2.2, 2.2, 1.4, 2.4; height of largest dart sac, 3.0, 2.8, 2.2, 2.4; height of smallest dart sac, 2.3, 2.1, 1.4, 1.5; height of mucus glands, 2.7, 2.1, 2.0, 2.1; length of spermathecal duct plus terminal bulb, 63.5, 59.8, 47.5, 68.6; length of spermathecal appendix, 9.8, 9.7, 7.9, 8.6; length of free oviduct, 2.7, 3.5, 1.3, 3.2. Clearly the relationship between shell size and size of genitalia is not always closely correlated. Thus, the two shells with diameter of 22.5 mm vary considerably in dimensions of the genitalia.

Types: Holotype: National Museum of Natural History, USNM 784,768. Paratypes: USNM 784,769; Dallas Museum of Natural History 5,366; University of Arizona 19,045; University of Texas at El Paso 4647 and 8786.

Type and only known locality: MEXICO, Coahuila; 28°43′55″N, 102°30′39″W; in boundary area between municipios of Ocampo and Muzquiz; on Coahuila state highway 53, 6.2 km slightly N of E from Tres Caminos (village); above head of north branch of Canada la Virgen (draining west); at summit of pass (about 1,625 m in elevation) variously termed La Cuesta, La Cuesta de Malena and La Cuesta de Plomo, where unimproved road diverges northerly from Highway 53 towards the Mesa de los Fresnos and 0.2 km NW of junction with road leading to mining area to south. The above based on the CETENAL 1:50,000 topographic quadrangle for Sierra la Encantada, which, however, shows La Cuesta de Malena 2.5 km east of the type locality. Holotype and paratypes were collected by the author on 7 May 1981 and additional paratypes by David H. Riskind on 25 May 1975.

Etymology: (*malenae* = of Malena) The place name Malena used in the area derives from the given name (contraction of Maria Elena) of a restaurateuse, who formerly maintained a cafe in the area (David H. Riskind, pers. comm.).

Comparisons: Geographically, *Humboldtiana malenae* occurs between the ranges of *Humboldtiana taylori* Drake, 1951, to the north in the Sierra Maderas del Carmen, and of *Humboldtiana plana* Metcalf and Riskind, 1976, to the southeast in the Sierra Santa Rosa (Metcalf and Riskind, 1976, 1979). Shells of all 3 species are granulose but those of *H. malenae* are less so than in the other 2 species. The subglobose, elevated shells of *H. malenae* differ trenchantly from the low, depressed shells of *H. plana*. The internal anatomy of *H. plana* is not known. Mature shells of *H. taylori* reach well over 30 mm in both diameter and height, whereas specimens of *H. malenae* observed do not reach 30 mm in either dimension. Although variable, the shells of *H. taylori* are consistently much darker than those of *H. malenae*. Distinct, close-set, minute granules occur already on whorls 0.5–1.5 in *H. taylori*. In *H. malenae*, fine growth lines (which bear only widely separated tiny granules) first appear at about 0.9 whorl.

A distinctive difference between *H. taylori* and *H. malenae* involves the female genitalia, with the mucus gland ring and dart sacs of the latter being exceptionally widely separated, for the genus. In *H. malenae*, on the other hand, these structures are barely separated. In this respect, the situation with *H. malenae* is like that in the "first" group of Burch and Thompson (1957:2) or the group of *Humboldtiana buffoniana* (Pfeiffer, 1845).

In Big Bend National Park 3 species of *Humboldtiana* have been reported (Pratt, 1971:433, 434). A similar diversity of species probably prevails in the complex of mountains south of the park, which are dealt with here. In addition to *H. taylori* and *H. malenae*, shells of small Humboldtianas, possibly allied with *H. malenae*, have been collected from 2 localities in or north of the Sierra Jardin. Shells from one locality are similar to those of *H. malenae*. A single shell from a second locality is distinctive in lacking any indication of brown bands.

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LIVING *PROMENETUS EXACUOSUS* (PULMONATA: PLANORBIDAE) FROM NORTH CENTRAL TEXAS

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ABSTRACT

Living Promenetus exacuosus *(Say) occur in Tarrant County, Texas, slightly south of latitude 33°N. The previous southern limit in the mid-continental region, a disjunct station, was from approximately 36°N. The Texas population is believed to be a naturally occurring Pleistocene relict.*

The small planorbid snail, *Promenetus exacuosus* (Say, 1821), has been reported as far south as latitude 32°N in the great plains region (Callahan County, Texas, Cheatum et al., 1972), but all such southern records have been either from river drift, or directly from Pleistocene sediments. D. W. Taylor (in Hibbard and Taylor, 1960) surveyed American collections for live-collected material and found that *P. exacuosus* had been collected as far south as Valencia County, New Mexico, in the Colorado Plateau, but in the great plains did not occur alive south of latitude 39°N, with a disjunct station in a spring in Meade County, Kansas. Branson (1961) reported the collection of living specimens in Adair County, Oklahoma, at latitude 36°N in the Ozark region, "in a boggy area near the creek."

It is, therefore, of some interest to find the species alive slightly south of latitude 33°N, in Tarrant County, Texas. The specimens were collected in the course of an ecological study during the spring of 1969 on the Fort Worth Nature Center and Refuge, in the valley of the West Fork Trinity River, on the west side of Lake Worth reservoir, at its north end. *P. exacuosus* was collected in a seasonal pond in bottomland hardwood forest, occurring as a corridor along the Trinity River, which at this point has cut a deep valley in the limestones of the lower Cretaceous comanchean series. The uplands support tall grass prairie, presently much altered by grazing. The pond in which *P. exacuosus* was collected is refilled annually by winter and spring overflow of a small adjacent stream, and dries completely during the summer and fall. Other species with disjunct stations in the area include *Punctum minutissimum* (Lea, 1841) (Pratt, 1971) and several plants *(Quercus muehlenbergii* Engelm., *Hexalectris spicata* (Walt.) Barnh., and *Botrychium virginianum* (L.) Swartz). The occurrence of all is related to a local microclimate which is more mesic, and probably cooler, than the regional average.

The seasonal pond is deeply shaded, its bottom covered by a layer of fallen leaves. The substrate is arenaceous clay (14% sand, 7% silt, 79% clays), with a 16% organic content. It has developed in place on sandy Pleistocene terrace deposits with little organic content. Water pH was 7.3 on 5 January and 7.1 on 13 April. Total hardness was 150 ppm and 290 ppm on the same dates. At the time of the second sample the stream was high with clear, brown-colored water and connected with the pond by a single channel about 20 cm deep. In the January collection, *P. exacuosus* occurred at a density of 13.5 per m², and all were adults. On 13 April the density had increased to 139 per m², all juvenile except for a single large adult. I conclude that at this locality *P. exacuosus* is probably semelparous, breeding in the early spring. Associated species were *Fossaria (Bakerilymnaea) techella* (Haldeman, 1867), *Fossaria (Bakerilymnaea) dalli* (Baker, 1907), *Physella (Costatella) virgata* (Gould, 1855), and *Sphaerium (Musculium) lacustre* (Müller, 1774).

It seems probable that the population represents a relict of a more extensive distribution during the Wisconsin Pleistocene, but it does not seem to have been found in the Pleistocene deposits of the region, as yet. Cheatum and Allen (1965) did not report it in their summary paper of the region, although *Promenetus umbilicatellus* (Cockerell, 1887) was common in several deposits. Branson (1961), who included all river drift records, reported only a single additional record for Oklahoma, collected by Wallen and Dunlap (1953) in Texas County, Oklahoma. (The precise locality and the nature of the material were not specified in the original report). Apparently the only Pleistocene locality in the great plains south of Kansas is Singley's (1893) record of material from a Pleistocene deposit in Tule Canyon, Swisher County, Texas. The alternative possibility is aerial dispersal on flying aquatic animals, which has been repeatedly documented for various bassomatophoran snails. It seems, however, that if *P. exacuosus* is presently dispersing by this means in the southern mid-continental region, it should be much more common than it is. The few, widely scattered stations from which it is known are separated by considerably more than an average single flight distance, with numerous suitable resting habitats between. The station reported here is not a good waterbird habitat, is not visible from the air, and is within a kilometer of several hundred hectares of open marshland. While the population probably was established by aerial dispersal, it seems probable that the dispersal occurred during the Pleistocene, at a time when populations of *P. exacuosus*, although scattered, were much more closely spaced in the region.

The specimens have been catalogued in the author's collection, as numbers 2691 (January Collection) and 2707 (April Collection).

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THE FRESHWATER SNAIL, *MENETUS DILATATUS*, (PLANORBIDAE) IN NOVA SCOTIA

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ABSTRACT

The small planorbid snail, Menetus dilatatus *(Gould), is established as part of the Canadian molluscan fauna through rediscovery of the species in Nova Scotia.*

Since 1970 the Nova Scotia Museum has undertaken collecting programs that have considerably increased both the holdings of its scientific collections and knowledge of the natural history of Nova Scotia. Studies of land and freshwater Mollusca have been included in this work. A synopsis of the land and freshwater mollusca of Nova Scotia is in preparation. The family Planorbidae in Nova Scotia includes *Gyraulus circumstriatus* (Tryon), *Gyraulus deflectus* (Say), *Gyraulus parvus* (Say), *Helisoma anceps* (Menke), *Helisoma campanulatum* (Say), *Helisoma trivolvis* (Say), *Planorbula armigera* (Say), *Menetus exacuosus* (Say) and the recently rediscovered *Menetus dilatatus* (Gould).

Menetus dilatatus was first recorded from "Dartmouth lakes", in Nova Scotia as "*Planorbis dilatata*", and reported in 1863 by Robert Willis (Ganong, 1890). In a catalogue of the recent Mollusca of Canada prepared by LaRocque (1954) this record was either overlooked or discounted as a misidentification. Up to the present time the species has not been considered as part of the Canadian freshwater molluscan fauna (Clarke, 1981) although an occurrence within 70 km of the Canadian border in the Niagara Frontier region indicates that it could be expected (Robertson and Blakeslee, 1948).

In Nova Scotia, *M. dilatatus* was rediscovered by the author in Gold River at New Ross, Lunenburg County, in 1968, when a single living specimen was taken.

Twenty-six other specimens were obtained from a pond at Waternish in the St. Mary's River Valley, Guysborough County, in 1973 and from Lake Fletcher, Lake Thomas, Lake William and Grand Lake, in Halifax County, in 1973 and 1975. The Halifax County localities correspond roughly with the original Dartmouth Lakes locality given by Willis. These localities are shown on the map (Fig. 1). The species was not found at about 100 other freshwater localities sampled. The habitats where *M. dilatatus* has been found are ponds, lakes and quiet sections of rivers. In all cases aquatic vegetation was present and the snails were attached either to the plants or to stones. These habitats generally correspond with the "quiet pools and ponds" given as the habitat for this species in New England (Emerson and Jacobson, 1970). Some Nova Scotia specimens may attain a larger size than the 2.00 mm diameter usually given for this species. For example, the specimen illustrated in Fig. 2, which was collected at Lake Thomas in August 1975, is 3.5 mm in diameter.

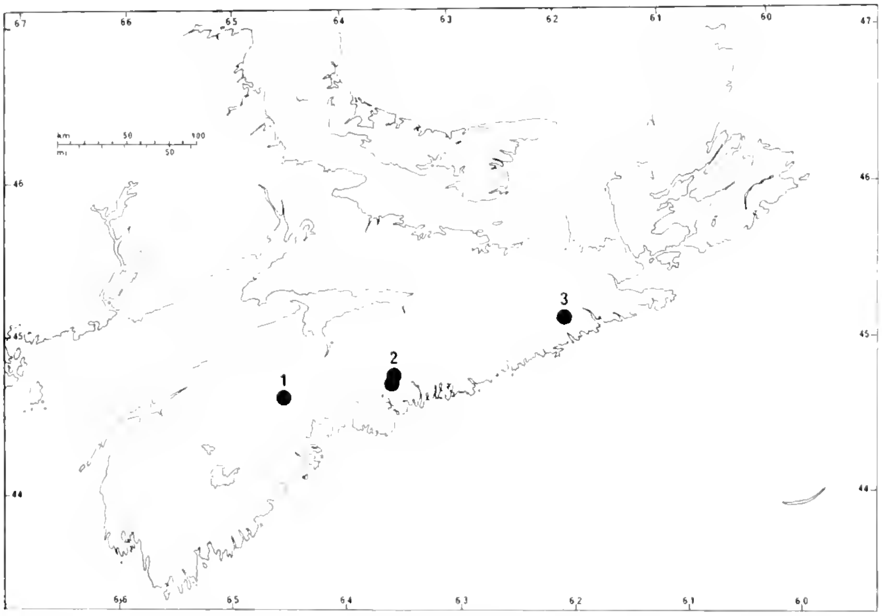

FIG. 1. *Localities for* Menetus dilatatus *(Gould) in Nova Scotia. 1. Gold River, New Ross, Lunenburg Co. 2. Dartmouth Lakes, Halifax Co., and 3. Waternish, Guysborough Co.*

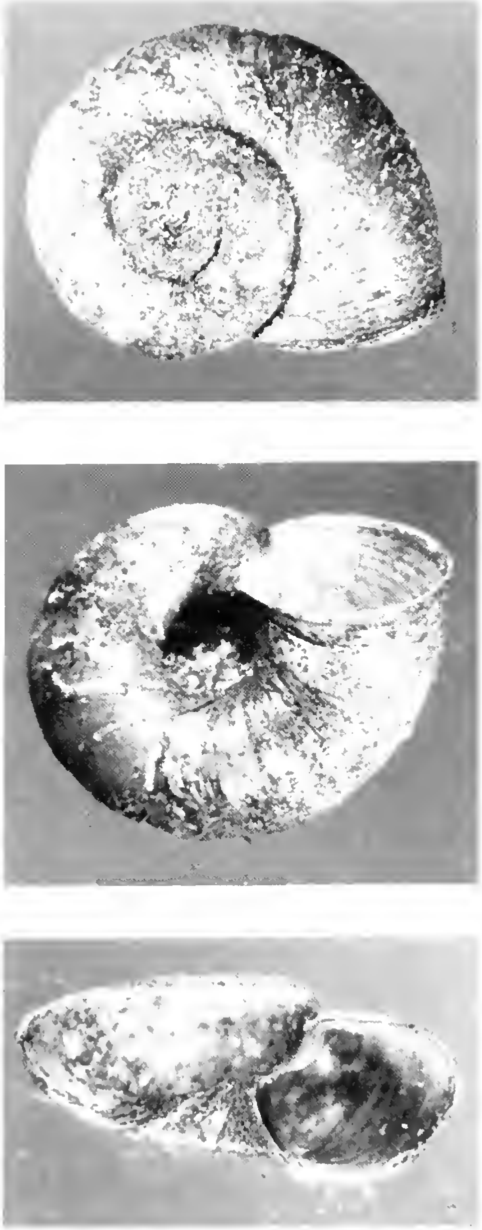

FIG. 2. Menetus dilatatus *(Gould). A large specimen collected from the outlet of Lake Thomas, Halifax Co., Nova Scotia, 6 Aug. 1975. Diameter 3.5 mm. Nova Scotia Museum cat. no. 1975Z.250.4. Photo by A. Wilson.*

The occurrence of *M. dilatatus* in Nova Scotia is of some interest. It is apparently a disjunct species, being separated by several hundred kilometers from the population in New England. However, there are not yet sufficient records to clearly indicate a pattern of distribution. The Gold River and St. Mary's River watersheds drain directly to the Atlantic coast, perhaps indicating an association with a coastal plain glacial refugium that contributed the New England element to the flora of southwestern Nova Scotia (Roland and Smith, 1969). The lakes north of Dartmouth however, drain into the Bay of Fundy by way of the Shubenacadie watershed. *Menetus dilatatus* may have been introduced into these lakes from lakes draining to the Atlantic coast, following construction of a canal during the middle part of the last century. The possibility that the species was introduced into Nova Scotia from New England was also considered, as it has become locally established in Britain following introduction about 1861. (Ellis, 1951, Kerney, 1976). A similar introduction into Dartmouth Lakes, which are close to the Halifax-Dartmouth urban area of Nova Scotia, is conceivable, but the occurrence in the Gold River and St. Mary's River watersheds could not be explained in this way.

At the present time it is sufficient to establish that *M. dilatatus* is part of the molluscan fauna of Nova Scotia and of Canada. A study of nonmarine mollusca in Nova Scotia, based upon a 10 km^2 grid system, as successfully used in Britain (Kerney, 1976), is being contemplated. This will eventually provide a clearer picture of the distribution of *M. dilatatus* and other poorly known species in the province.

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VARIABILITY IN NORTH AMERICAN *LYMNAEA STAGNALIS* L. (GASTROPODA: LYMNAEIDAE)

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ABSTRACT

The nomenclatural history of the pond snail, Lymnaea stagnalis L., *in North America is briefly reviewed. An examination of a population of coexisting* L. s. appressa (=jugularis) *and* L. s. sanctaemariae *shows continuous variation suggesting that these two forms are ecophenotypes.*

The pond snail, *Lymnaea stagnalis* L., is widely distributed in the northern hemisphere, occurring in North America, Europe, parts of North Africa and much of Asia (Hubendick, 1951). Its wide tolerance ranges for many water chemistry parameters (e.g. Pip, 1978) and its apparently effective dispersal have contributed towards its extremely numerous populations. The ecological success of *L. stagnalis*, combined with the isolation of individual populations characteristic of many freshwater organisms, has been accompanied by a great variety of shell form. The often striking morphological differences between various populations may be regarded in large part as a product of environmental conditions acting on the fixed genetic resources of a population which frequently results from interbreeding among the descendants of a small number of colonizers. Any additional variation in such populations must be introduced through mutation or immigration of new genotypes.

The variability of *L. stagnalis* has been responsible for a long history of nomenclatural excesses. During the latter part of the 19th century a great number of European named varieties were distinguished (e.g. Baker, 1898), many of which were shown by Vignal (1911) to be obtainable from average populations by altering environmental conditions. Subsequent workers (e.g. Zhadin, 1952; Frömming, 1956) suggested that environmental quality and availability and type of food were important factors in influencing variability in this species. Zhadin (1952) and Germain (1969) declined to assign any names to subspecific rank in their treatments on the basis that continuous variation appeared to exist between different forms.

In North America, the great variability of *L. stagnalis* was recognized by Walker (1892-3), who figured several extreme forms. Baker (1898) initially assigned the bulk of the North American forms to *L. s. appressa* Say 1818 (=*L. s. jugularis* Say 1817), noting the substantial variation in spire length. Subsequently (1911) he recognized six forms that were differentiated on the basis of relative spire length, and degree of shouldering and lip expansion. Hubendick (1951) suggested that the forms cited by Baker (1911) have overlapping ranges of variation and therefore represent ecophenotypes. The former worker pointed out that the full range of variation may be found in every geographical region where this species occurs. La Rocque (1968) presented a similar viewpoint and also noted that Pleistocene examples of this species in North America are primarily referable to *L. s. jugularis*.

Clarke (1973) compared a number of population samples from the Canadian Interior Basin and found that the major characters distinguishing some of the forms were not valid because of the extent of variation that could be encountered within the same population. He did retain *L. s. sanctaemariae* Walker 1892 since the ratio of the aperture length to total shell length in population samples of this form (>0.65) appeared to show some discontinuity with the ratios for *L. s. appressa* samples (<0.60). The former variant also appeared to show some geographical unity, occurring in the Winnipeg River, Lake Superior, Lake Huron and Wisconsin River systems, where it is present as local populations interspersed with populations of *L. s. appressa*. However some single populations on the periphery of the range of *L. s. sanctaemariae* were reported by Clarke (1973) to consist of morphological intergrades between the two forms.

A large population which contains both the two forms and their intergrades (Fig. 1) is present in Pike Lake, Cass Co., Minnesota (47°18′N, 94°37′W), approximately 200 km south of the present known boundary range of *L. s. sanctaemariae*. The aperture length to shell length ratios measured for a sample from this population (Fig. 2) indicate that the generally accepted ratios for distinguishing between the two forms are not valid for this population, which apparently shows continuous variation.

Shortness of the spire in *L. s. sanctaemariae* is generally regarded as a result of selection pressures in turbulent habitats (Baker, 1928; Clarke, 1973). The coexistence of both forms and their intergrades in the same habitat suggests that such a population contains an unusually diverse range of genotypes, perhaps the result of multiple immigrations from different sources and/or endogenous origin of some forms. The origin of the short-spired form in Pike Lake is perplexing as a search of lakes in the same and adjacent counties yielded only the long-spired form.

That the morphological diversity of *L. stagnalis* in North America is an ecophenotypic one is supported by observations that anatomical differences between the forms are minor (Baker, 1928) or doubtful (Clarke, 1973). However Alaskan forms of this species may constitute a separate race (Baker, 1928; Hubendick, 1951).

FIG. 1. *Specimens of* L. stagnalis *from a single population in Pike Lake, Cass Co., Minnesota. First shell is 30 mm. Others to same scale.*

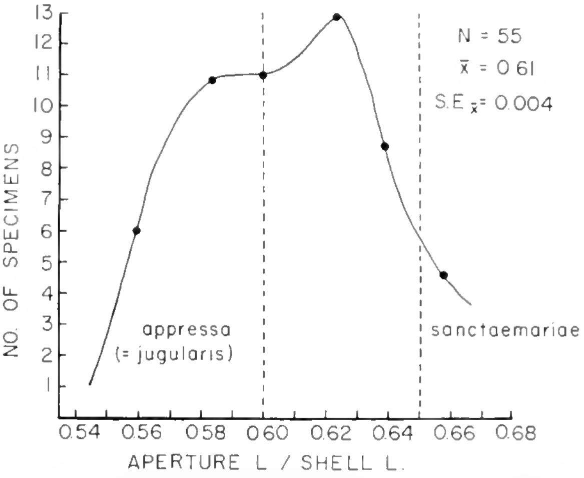

FIG. 2. *Distribution of aperture/ shell length ratios rounded off to nearest even number from a Pike Lake sample of* L. stagnalis.

It is interesting that Baker (1928) noted that some populations of the short-spired form exhibit a high proportion of scalariform-like abnormalities characterized by a forward slippage of the affected whorls along the shell axis. In long-spired forms this anomaly is very rare. In the Pike Lake sample approximately 10% of the individuals exhibited this anomaly (Fig. 1).

Voucher specimens from this sample have been deposited in the National Museum of Canada (NMC 77376).

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UNEXPLAINED OCCURRENCE OF THE MACTRID BIVALVE, *RANGIA CUNEATA*, FROM THE ARROWHEAD FARMS INDIAN SITE NEAR LOUISVILLE, KENTUCKY

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ABSTRACT

Over three thousand valves of the Atlantic Coast brackish water clam Rangia cuneata *(Gray) were unearthed from the Arrowhead Farm archaeological site near Louisville, Kentucky. These clams were brought to this site by Lake Woodland or Archaic inhabitants of the Ohio River Valley for unknown reasons. This represents only the second mid-continent occurrence of these shells in an archaeologieal site. The reasons that the Indians had for bringing them to the Arrowhead Farm Site are obscure.*

Marine mollusk shells in archaeological sites far from the ocean no longer are startling discoveries because of the rather large numbers of them found associated with human living areas (Parmalee 1958). These mollusks, however, mainly share the common denomination of being beautiful, unique or useful (Biggs, 1970).

It was thus with great interest that several thousands of valves of the exceedingly common estuarine clam, *Rangia cuneata* (Gray 1831), were discovered at Arrowhead Farm, a multi-component Late Archaic through Lake Woodland archaeological site in Jefferson County, Kentucky (USGS Lanesville, Indiana-Kentucky quadrangle 38° 10′ 15′ ′N 85° 53′ 48′ ′W). A report of the archaeological investigation at the Arrowhead Site is in print (Mocas 1976). Identification of the shells as *Rangia cuneata* (Gray), the Common Rangia, was verified by Dr. Henry vander Schalie of the University of Michigan after an original determination by the author. Also, Dr. Dee Dundee of Louisiana State University was kind enough to send several recently collected shells of this clam for comparative purposes.

Rangia cuneata is an old species, first appearing in the Miocene of North America (Dall 1898). During the Pleistocene it occurred on the East Coast from New Jersey to northern South America (Richards 1938, 1939, 1962; Moore 1969). Until 20 years ago *R. cuneata* was restricted to the Gulf of Mexico coast of the United States and Mexico. However, since the late 1950's it has re-invaded its former range, occurring presently along the East Coast from Florida to Maryland (Hopkins and Andrews 1970).

Hopkins et al. (1973) describe *R. cuneata* as the most widely distributed and by far the most abundant species of brackish water clam in its habitat. Hopkins (1970) notes that the optimum salinity for this clam is from 1 to 15 parts per thousand. *R. cuneata* cannot maintain populations outside this salinity range, thus it would not survive in an entirely riverine habitat.

Population densities are high in many places where this clam exists. Pfitzenmeyer (1970) recorded a maximum density of 10,000 individuals per square meter, however, this is an exceedingly high figure reflecting an extreme of the tremendous reproductive potential of the species. Normal densities are in the range of 4 to 30 clams per square meter (Hopkins et al. 1973). However, since the dead shells accumulate over the years in a productive area, the high reproductive rate and large populations produce huge piles of easily accessible dead shells. Shells are presently so abundant they are mined with bulldozers, etc. for use in place of gravel in road building as well as various industrial and water purification processes (Hopkins et al. 1973).

Living shells certainly are not known for their beauty. Adult *R. cuneata* are small, less than 4 cm long. The periostracum is fairly smooth and grayish brown while the interior of the shell is glossy white with a tinge of blue-gray.

Results and Discussion

During the excavation of the Arrowhead Site, Mr. Steve Mocas (personal communication) estimated that over 10,000 shells of *Rangia* littered the surface at the site. However, 3,298 shell fragments of which 1,629 were nearly complete, were available for this report (Table 1). This latter group was also complete enough to recognize the specific characteristics (Abbott 1954) used to identify them (Fig. 1). The 1,669 unsided fragments could only tentatively be assigned to *R. cuneata*. No other mussel species was identified with these shells, a condition not unlike that in the natural habitat of the Common Rangia (Hopkins et al. 1973). Only one shell fragment was unique enough to suggest the presence of a second marine species. None of the shells was modified by humans in any recognizable manner, thus presumably precluding their collection for the purpose of artifact manufacture.

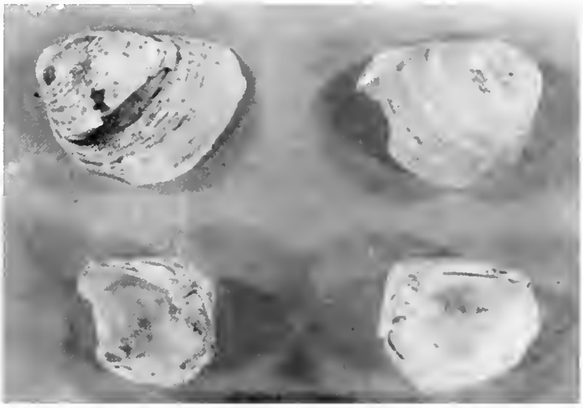

FIG. 1. Rangia cuneata *valves from the Arrowhead Farms site, Louisville, Kentucky. Upper valves are about 4 cm in size.*

TABLE 1. *Animal remains from the Arrowhead Site, Kentucky.*

Rangia cuneata valves 767 left, 362 right, 1669 fragments.

1 Indeterminable marine mussel 1 shell fragment.
1 Indeterminable freshwater mussel 1 shell fragment.

cf. *Odocoileus virginianus*, whitetail deer - 1 tooth fragment.
Sus scrofa, domestic pig - 1 tooth fragment.
Canis familiaris, domestic dog - 1 right upper carnassial.
Sylvilagus floridanus, cottontail - 1 left tibiofibula adult.

Since nearly all of the shells were badly eroded and quite chalky, length measurements were not made. Comparisons of the shells with those sent by Dr. Dundee show the Arrowhead Farms specimens to be within the maximum of 2½ inches (6 cm) total length suggested for this species by Abbott (1954). In fact, the largest appears to have been no longer than 4 cm. Most look to be no larger than about 2.5 cm.

A limited number of other species was found as remains associated with these shells. These are reported in Mocas' (1976) report. A small number of additional species are listed here in Table 1. All of the other faunal remains are from forms which clearly existed in the Louisville Area throughout the time of occupation of this site. The pig and dog remains are modern intrusives found on the surface.

The cultural affiliation of the shells is unfortunately not possible to determine since none of them was found in a culturally definible feature (Mocas 1976). However, they appear to have been introduced by a Middle Woodland or later group (Mocas 1976).

Many of the shells were present in the undisturbed sub-plowzone. Mocas (1976) indicates that the shells must have been deposited in shallow pits, most of which were subsequently destroyed by plowing. These latter shells were scattered across the surface of the Arrowhead Farms site.

The only other archaeological site in which the Common Rangia appears in the Midwest is Cahokia. Baker (1941), Parmalee (1958) and Chmurny (1973) report its presence. However, these authors report only a small number of unmodified shells and offer no insight in unraveling the mystery of the Arrowhead Farms cache.

The origin of the shells is clearly somewhere along the Atlantic or Gulf Coast. The possibility exists that these shells were part of a collection brought from the East Coast as trade items. Why they ended up concentrated in the Arrowhead Farms site still remains a mystery.

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AUTO-DRILLING IN THE OYSTER DRILL *THAIS HAEMASTOMA* (MURICIDAE)

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ABSTRACT

Abnormal drilling behavior is reported in the muricid gastropod Thais haemastoma canaliculata *(Gray). A single starved oyster drill was observed boring into its own operculum from the pedal side. This misplaced drilling may be a response to stimuli received within a mixed faunal aquarium.*

The oyster drill, *Thais haemastoma* (Linnaeus, 1758), is a well-known, predatory, boring gastropod found throughout the Caribbean and in the Gulf of Mexico. This gastropod may devour up to 50% of a given oyster population in a year's time (St. Amant, 1938) and, in higher salinities, up to 85% (May and Bland, 1969). The muricid's primary food is obtained by drilling a small hole in the prey's calcareous valves using corrosive secretions of the accessory boring organ and mechanical raspings of the radula. Gunter (1968) suggests that large *T. haemastoma* bore through the shell in order to release a paralytic substance. Once the hole is drilled in the oyster, for instance, the snail releases a paralytic agent through the aperture and this causes relaxation of the bivalve's adductor muscles. The predator then consumes the soft parts through the gaping valves. The exact nature of predation by this species is still in dispute (Breithaupt and Dugas, 1979). Nevertheless, the extensible proboscis is used to ingest the meat.

During mid-March 1982, a single specimen of *Thais haemastoma* [subspecies *canaliculata* (Gray, 1839) (Synonym: *haysae* Clench, 1927)] from northwest Florida, 64 mm-long, initiated an unusual type of drilling behavior. The snail, while located alone on the wall of an aquarium, bored a hole through its own operculum.

The snail had been placed in an artificial sea water (26.6 ppt, 21°C), 20 gallon aquarium with five other similarly sized snails and was fed oysters (*Crassostrea virginica*) at irregular intervals not exceeding four weeks between feedings. In nature *Thais haemastoma* feed heavily about every three weeks (Demoran and Gunter, 1956).

After being in the tank for a period of 21 weeks and with the previous four weeks under starvation conditions, the snail extended its proboscis along the midventral region of its foot and rasped at a small portion of the operculum (Fig. 1). The proboscis was partially obscured along the anterior region because of infolding of pedal musculature. Along the posterior half of the foot, however, the proboscis was clearly evident and the radula was seen, through the extended, translucent proboscis wall, rasping at the operculum. Gunter (1968) reported that in *T. haemastoma*, during an attack on an oyster, "The foot is folded around the proboscis and the latter is never seen."

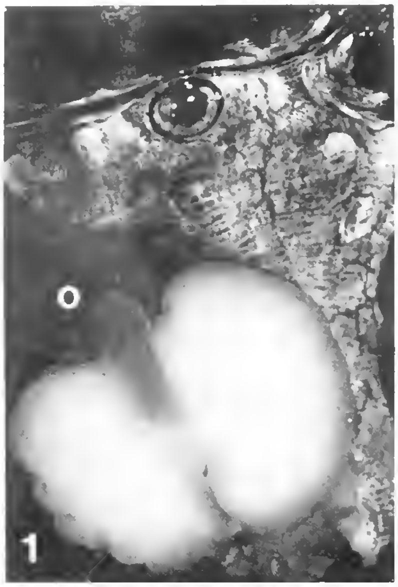

FIG. 1. *Proboscis of* Thais haemastoma canaliculata *extended between folds of foot upward to pedal side of operculum. Operculum (O) shows as dark semilunar plate at tip of proboscis. Horizontal field width = 4.5 cm.*

After about four and one-half hours, activity ceased and a borehole was evident in the operculum. This hole was located 8.9 mm from the anterior edge of the operculum, 8.4 mm from the posterior edge, 3.5 mm from the right edge and 5.7 mm from the left opercular edge (Fig. 2). The hole itself has a diameter of 0.75 mm. During these observations the snail did not apply the accessory boring organ (ABO) to the drilled region.

Within five months after the event, the hole had been transferred to the very edge of the operculum as natural opercular growth displaced it. At this date (eight months later), the snail still feeds and shows no further aberrant behavior nor any obvious indication of physiological distress.

Carriker et al. (1978) and Carriker and Williams (1978) suspect that secretions from the accessory boring organ, of at least *Urosalpinx cinerea*, are involved in the breakdown of calcified shell and organic matrix in molluscan prey. Jensen (1951) reports that some naticid gastropods can bore into skate egg cases. Thus, the

FIG. 2. *Diagram of the operculum of* Thais haemastoma canaliculata *showing site and size of auto-drilled hole. Horizontal field width = 9.5 mm.*

ABO is likely responsible for at least partial penetration of partly and fully organic substrates. Drilling of a poorly calcified, proteinaceous operculum without use of the ABO is likely to be relatively "easy" for a large oyster drill. The well-developed radula, used consistently, penetrated the thin horny operculum within five hours. Carriker (Pers. Comm.) has supportive evidence for the use of only the radula in some events of drilling. This support is based on observations of raspings by *U. cinerea* on the periostracum of *Mytilus edulis*. The relatively thin, noncalcified operculum of *T. haemastoma* may offer little resistance to purely mechanical boring.

The significance of this anomolous activity is uncertain. No other snails starved for the same duration showed any signs of aberrant drilling. In one instance, another snail did extend its proboscis partly within a fold of its foot but did not attempt to rasp or drill the operculum. It is possible that starved drills may periodically extend their proboscises in response to chemical stimuli. Gunter (1968) reports that hungry *T. haemastoma* will evert their proboscis in response to oyster flesh stimulus. Carriker and Yochelson (1968) and Hancock (1959) report that in laboratory populations of drills (both *Urosalpinx* and *Eupleura*) kept in tanks with both dead (empty valves) and live oysters, the snails would occasionally drill into an unoccupied shell. It has been suggested that the snail could not distinguish live from dead because of high concentrations of dispersed chemoattractants in the tank (Carriker and Yochelson, 1968). The possibility exists that a chemical stimulus within the aquarium was detected by our specimen. The aquarium at the time was also occupied by several hermit crabs [*Clibanarius vittatus* (Bosc, 1801)] and one large Dolly Vardin crab [*Hepatus epheliticus* (Linnaeus, 1763)]. The proboscis of the drill may have extended in response to some metabolite released by one of these organisms or perhaps by another snail. The tip of the probing proboscis may have encountered the operculum and "mistaken" this for the shell of potential prey. Recent and fossil boreholes of *Thais haemastoma floridana* (Conrad, 1837) reported by Carriker and Yochelson (1968) from calcified oyster valves had diameters greater than 1.4 mm, twice that found in the operculum. In the former cases the borehole reflects the size and shape of the ABO. The small size of the hole drilled in the operculum may be a result of the animal becoming "aware" of the fact that it was not drilling into food, and thus terminating the purely radulate drilling.

It is unlikely that the exact cause of this behavior will be uncovered; however, it is important to note that aberrant proboscidal activity and drill behavior may be a result of keeping thaids in laboratory conditions in mixed faunal aquaria.

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RECENT DEATH

Wendel Phillips Woodring, paleontologist, died January 29, 1983, in Santa Barbara, California, at age 92. Born in Reading, PA, June 13, 1891, he obtained his Ph.D. at Johns Hopkins University in 1916. He did extensive field work in the West Indies and Central America while employed by the U. S. Geological Survey. His first outstanding publication was on "The Miocene Mollusks from Bowden, Jamaica," but throughout his 67 productive years of research he became the leading authority on the taxonomy and stratigraphy of the Tertiary mollusks of the tropical New World. He was a past-President of the Paleontological Society of America and the Geological Society of America, as well as receiving many honors and medals for his work. He is survived by his wife, Merle Crisher (Foshay). Additional information in *American Malacologists*, first edition, 1973, p. 487 and *Who's Who*.

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KATHERINE V. W. PALMER – AN OBITUARY
1895 - 1982

On September 12, 1982 death brought to an end the distinguished career of Dr. Katherine V. W. Palmer, one of America's foremost paleontologists. Katherine Evangeline Hilton Van Winkle was born February 4, 1895, in Oakville, Washington, the daughter of Dr. Jacob Outwater Van Winkle and Edith Hilton Van Winkle. After high school she enrolled in the University of Washington where she came under the influence of Dr. Charles E. Weaver who urged her to work in paleontology. An excellent student, she published her first scientific paper before graduation. Having completed requirements for graduation at the University of Washington, she spent the last two quarters of her senior year as Assistant in Geology at the University of Oregon. After receiving her B. S. in 1918 she went to study under Professor Gilbert D. Harris at Cornell where she was Goldwin Smith Fellow in Geology for 1918-19 and 1919-20. Her plans to return to Washington to work with Dr. Weaver changed after she married Dr. Ephraim Laurence Palmer on December 24, 1921. Dr. Palmer, a professor at Cornell who later became an eminent naturalist, encouraged his wife in her studies. She received her Ph.D. from Cornell in 1925.

Marriage and the subsequent birth of two sons did not stop Dr. Katherine Palmer's paleontological research. She continued to work with Professor Harris who had his own printing press. He and his students set type, made plates, ran the press and folded signatures. From this modest beginning came the Paleontological Research Institution, with Katherine Palmer as one of the Founding Members in 1932. After the death of Professor Harris in 1951 she became Director of the Paleontological Research Institution and served in that position until her retirement in 1978. The story of this unique and important institution is told in her last publication which details the organization and functions of the P.R.I. during its first fifty years.

Katherine Palmer was active and admired in many circles. In 1917 she was Chapter President (and Charter President) of Alpha Delta Pi, an undergraduate social sorority. The lead in its publication, *The Adelphian*, of April, 1920, a two-page article plus a fetching photograph, described her as "all-around", "wonderfully good-natured", with a sense of humor and "a droll way that every one loves." This assessment of her disposition and wit remained valid throughout her life. Her popularity with one and all is reflected in many newspaper articles, one in particular referring to the Palmers as one of only two couples of whom both were listed in *Who's Who;* "The other couple was Charles and Anne Morrow Lindbergh. Quite an honor for the Lindberghs, wasn't it?"

She was also a member of Sigma Xi; Phi Kappa Phi; a co-founder of Sigma Delta Epsilon, a women's graduate scientific organization of which she was later National President; a Charter Member and President of the Cornell

Chapter of the women's geological organization, Chi Upsilon.

Katherine Palmer was a member, either active or honorary, of many scientific organizations. Among these were the American Malacological Union, of which she was a Life Member and President in 1959-60; she was a Fellow of the Geological Society of America; a Fellow of the American Association for the Advancement of Science; a member of the Society of Systematic Zoology; the American Association of Petroleum Geologists; the Society of Economic Paleontologists and Mineralogists; a Life Member of both the Geological Society of France and the Société Linnéenne du Lyon; and a Fellow of the Paleontological Society of America, which presented her with its prestigious Paleontological Society Medal in 1972.

As the seventh recipient of the Paleontological Society Medal, Katherine Palmer established a number of 'firsts': The first recipient to have worked with mollusks, the first institutional administrator to receive the award, and is still the only woman to have been so honored. On presenting the Medal to her, Dr. Kenneth E. Caster referred to "the Harrisian kind of paleontological instruction . . . where all students were treated as 'zealous companions in research'". Whether inate or acquired, treatment of every interested person as a companion in research was characteristic of Katherine Palmer. Although always engaged in her own research and the affairs of the P.R.I. she gave freely of her time and advice, encouraging amateurs, students and fellow scientists alike. She made all feel that what they were doing was important. She especially enjoyed helping build up their libraries and was always alert for titles needed by various workers.

The excellent library of the P.R.I. and her own impressive library served her well, making it possible to work at home or the Institution. Recognizing the importance of the literature and bibliographic detail she continued reprinting unavailable, old and rare publications by the P.R.I.

Her interests were many and varied. Her work with Tertiary mollusks inevitably led to work with Recent mollusks, and her search for completeness of detail in her taxonomic publications led to additional publications in biography and bibliography. She had a strong interest in systematic nomenclature and attended the Copenhagen Colloquium on Zoological Nomenclature in 1953 and the London Colloquium in 1958. She was an active participant in the deliberations at both of these important conferences.

In 1978 Tulane University conferred upon Katherine Palmer an honorary Doctor of Science degree during a symposium that was held in her honor. The citation for the honorary degree stated in part, ". . . all the praise and recognition she has received could not be enough to match the extent of her contribution to Tertiary paleontology. The brilliance of her work, the precision of her method, the wisdom of her leadership of the Paleontological Research Institution will stand as the greatest monument to Dr. Palmer and as the highest example for future generations of what it means to be a scientist."

In her acceptance of the Paleontological Society Medal, she commented that "our ideas have not come spontaneously, but were stimulated and nurtured by the tomes of the giants before us . . ." Katherine Palmer's name must now be added to this list of giants who have left a legacy of solid scientific research to be utilized and expanded by future generations. She published over 70 books and papers. A complete bibliography appears immediately following her last scientific publication in *Tulane Studies in Geology and Paleontology* (1979, *15*(1–4):74, 94, 104, 128). In May of 1982 she completed what was to be her final paper, a history of the first fifty years of the Paleontological Research Institution which has now been published by that Institution.

Katherine Palmer will continue to be known through her work by future generations of paleontologists and malacologists. To those of us who knew her, she will be remembered not only for those contributions, but also for being the special person she was. Dr. Katherine V. W. Palmer is survived by one son, Richard Robin Palmer.

Richard E. Petit
North Myrtle Beach
South Carolina

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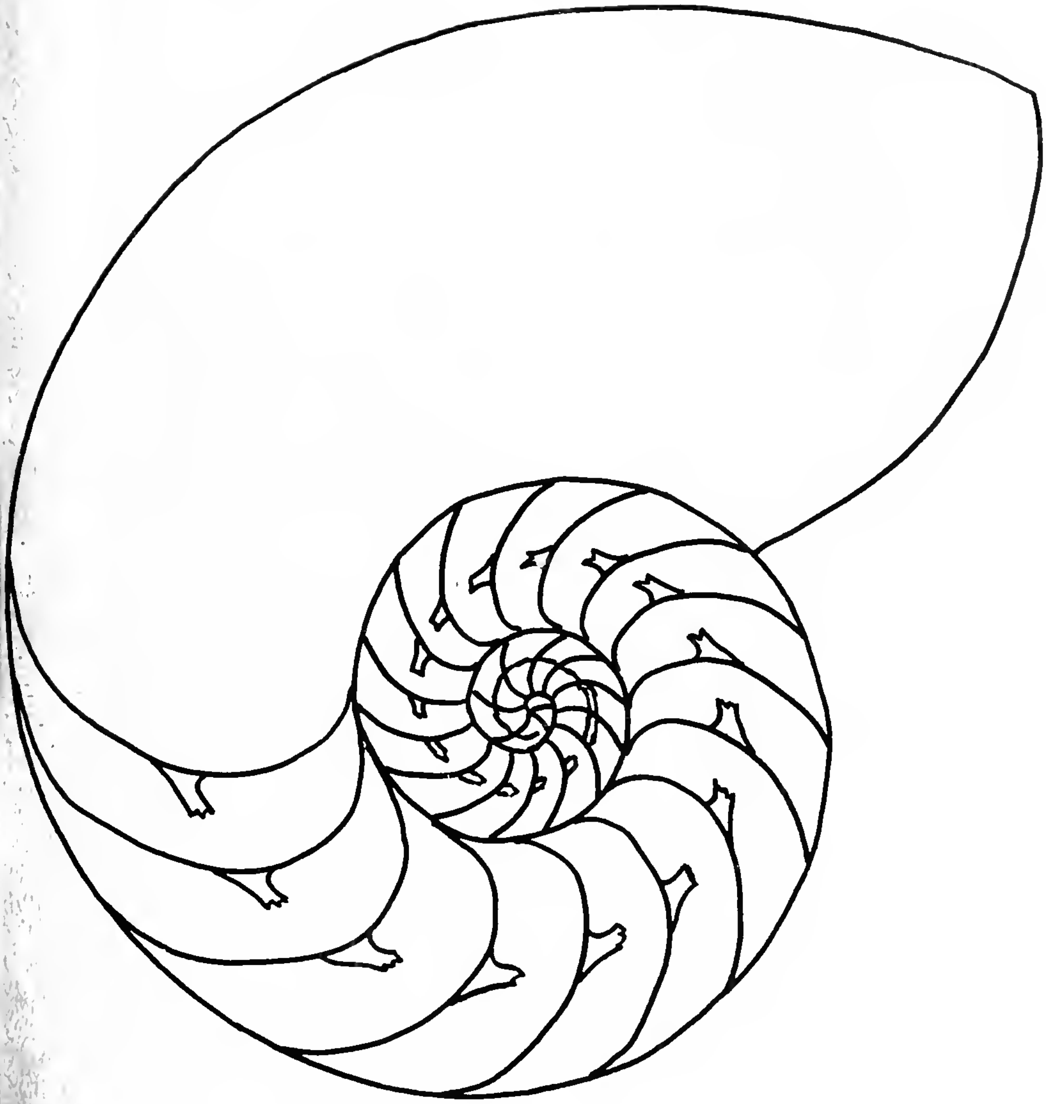

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NEWS

A.M.U. SEATTLE MEETING

American Malacological Union's 49th Annual Meeting, Aug. 7-13, 1983, at the University of Washington in Seattle. Symposia on "Molluscan Nerve Cells," "Molluscan Extinctions" and "Avian Molluscivores." Papers on Cephalopods, Pacific Northwest Molluscs and recent studies. Workshops, field trips. For information write Alan J. Kohn, Dept. of Zoology, Univ. of Washington, Seattle, WA 98195 or Tel. (206) 543-1629. The **Western Society of Malacologists** will have a joint program and auction with the A.M.U.

PUBLICATIONS RECEIVED

Inaba, Akihiko. 1982. *Molluscan Fauna* of the *Inland Sea, Japan.* Hiroshima Shell Club. 180 pp., 4 pls. Paperback. An annotated checklist, containing geographical and habitudinal information on 1005 marine mollusks in the Seto Inland Sea. Illustrations of 72 uncommon species. A useful guide to one of Japan's richest collecting areas between Honshu and Shikoku Islands. Send International Postal Money order for U.S. $13.00 to Hiroshima Kairui Danwakai (Hiroshima Shell Club), c/o Mukaishima Marine Biol. Station, Onomichi P. O., Hiroshima Pref., Japan 722.

JECOLN Annual Reports (Japanese Expert Consultation on Living Nautilus, Kanagawa). 1979-1982. 56 collected reprints on the *Nautilus,* maily by Japanese authors. Covers years 1977-78; 1978-79; 1979-82. ISSN 0396-054X. Yokosuka City Museum, Fukadadai, Yokosuka 238, Japan.

Bogan, Arthur E. and Paul W. Parmalee, 1983. *The Mollusks* in Vol. 2 of *Tennessee's Rare Wildlife.* 123 pp. Spiral bound. Tenn. Wildlife Resources Agency, Nashville, TN 37204. Names, illustrations, maps, descriptions, synonymies, distributions, and natural history information on 33 bivalves and 20 gastropods considered to be rare or endangered.

Garcia - Cubas, Antonio. 1981. *Moluscos de un Sistema Lagunar Tropical en el sur del Golfo de Mexico (Laguna de Terminos, Campeché).* Special Publ. no. 5, Inst. Cienc. del Mar y Limnol. Univ. Nal. Auton. Mexico. 182 pp. 175 species described, illustrated and ecologically discussed.

C.O.A. FLORIDA MEETING

The Conchologists of America will hold their annual meeting in Sarasota, Florida, Sept. 21 through 25. For details see the C.O.A. June Bulletin, or contact Dick Forbush, 1104 Sklar Drive East, Venice, FL 33595.

SHELL SHOWS 1983

Jacksonville (Florida) Shell Show. July 29-31, 1983.

Midwest Regional Shell Show (Indianapolis). Aug. 13-14, 1983.

Philadelphia Shell Show. Oct. 1-2, 1983.

Astronaut Trail Shell Show. (Merritt Id., FL). Nov. 4-6, 1983.

MALACOLOGICAL COLLECTION OF H. P. MERA AT THE UNIVERSITY OF COLORADO MUSEUM

Dr. Harry P. Mera's collection of land and fresh water molluscan shells, which was donated to the University of Colorado Museum in the early 1950's, was rediscovered here in the spring of 1980 by Dr. Dwight W. Taylor, who was visiting the Museum. The University had been without a curator in malacology for 40 years until the arrival of Dr. Shi-Kuei Wu in 1973, and so much work remained to be done that the Mera Collection had not yet been recognized for what it was.

Dr. Mera, a practising physician in Abilene, Kansas, began collecting shells in about 1912 and continued for at least 15 years. According to an obituary and bibliography published in *American Antiquity* (Vol. 17, July 1951), he moved to New Mexico in 1922 and later became widely known as an anthropologist and staff archaeologist at the Laboratory of Anthropology in Santa Fe, where he specialized in the artifacts of southwestern Indians. His bibliography contains no malacological publications.

He supplemented his shell collecting efforts in Kansas and New Mexico with extensive purchases from W. F. Webb and Ward's Natural Science Establishment in Rochester, New York, and from the dealers Sowerby and Fulton in London and Geret in Paris. His collection also contains shells from the collections of Bryant Walker, Junius Henderson and Victor Sterki, who all helped Dr. Mera with identification problems, and from F. C. Ackers, C. M. F. Ancey, Miss Bowman, H. C. Brooks, J. Y. Crans, Lorenzo E. Daniels, Joseph L. Goodell, E. E. Hand, I. B. Hardy, Esther Haskell, Ethel Haynes, Anson A. Hinkley, Yoichiro Hirase, Florence Ives, Julia Ives, P. B. James, Norman W. Lermond, Herbert N. Lowe, F. E. Mera, Mrs. H. P. Mera Sr., Amanda Nixon, Mary Olney, Charles R. Orcutt, G. W. Pepper, J. F. Quadras, H. E. Sargent, E. R. Schowalter, Charles T. Simpson, John H. Thompson, Charles Townsend, R. H. Turver, Robert Walton and Edna Worley.

The collection has now been put into useful order. There are 1380 lots; 947 are land snails and 433 are fresh water mollusks. Numerous paratypes are included. The filing system is both numerical and alphabetical by genus. The land snails have a worldwide distribution and include representatives of over 90 genera. Nearly half the specimens are island forms, and two thirds of those are from islands in the Pacific. The fresh water lots, which include 30 genera, are dominated by *Pisidium*, *Sphaerium* and *Musculium*, many of which came from Bryant Walker. In addition to Dr. Mera's private collection, which is housed separately at the University of Colorado Museum, the Museum collection contains 139 lots of shells which were sent by Dr. Mera to Junius Henderson, the original curator, between 1912 and 1921.

The collection is all dry material in good physical condition and predominantly with complete data. Specimens are sometimes identified only to the genus level. The nomenclature is often years out of date, but it is hoped that this would not be an overwhelming obstacle to an experienced worker.

The author wishes to acknowledge the helpful comments and suggestions of Dr. Dwight W. Taylor and Dr. Shi-Kuei Wu in the preparation of this manuscript.

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RECLASSIFICATION OF SOME AMERICAN SPECIES ASSIGNED TO THE RISSOIDAE (*SENSU LATO*)

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ABSTRACT

*Twenty five species of taxa previously assigned to the Rissoidae (*sensu lato*) are, from examination of their type material, considered to belong to other families.*

During the examination of type material of the Rissoidae in several museums in the U.S.A. it was found that a number of species described as rissoids had been wrongly assigned to the family. As most of these are still included in the Rissoidae (Abbott, 1974; Keen, 1971), a list of the species, together with an assessment of the family to which they properly belong is given below.

Abbreviations – ANSP-Academy of Natural Sciences of Philadelphia; CAS-California Academy of Sciences, San Francisco; MCZ-Museum of Comparative Zoology, Cambridge, Mass.; USNM-National Museum of Natural History, Washington, D.C.

List of Non-rissoid Taxa

apicina Verrill, 1884, *Alvania*. Southeast of Nantucket, 1608 fathoms. Epitoniidae (holotype, USNM) (also noted by Warén (1974)) who says that it is close to, if not identical with *Epitonium frielei* (Dall, 1889).

athymorhyssa Dall, 1892, *Rissoa*. Pliocene, Florida. Hydrobiidae (holotype, USNM).

berryi Baker, Hanna & Strong, 1930, *Rissoina*. Cape San Lucas, Baja California. ?Epitoniidae (holotype, CAS). This species is based on a juvenile specimen with a damaged aperture.

callistrophia Dall, 1892, *Rissoa (Onoba)*. Pliocene, Florida. Hydrobiidae (holotype, USNM).

campta Dall, 1927, *Rissoa (Cingula)*. Off Georgia. Family?, possibly Fossariidae or Epitoniidae. The shell has a paucispiral protoconch, weak axial sculpture and no varices (type, USNM).

conica C. B. Adams, 1850, *Cingula*(?). Jamaica. Cerithiidae (holotype, MCZ). Figured by Clench & Turner (1950) without comment. The holotype is a worn, juvenile *Cerithium* (s.l).

curta Dall, 1927, *Rissoa (Cingulina)*. Off Fernandina, Florida, 294 fathoms. Skeneidae (syntypes, USNM). Preoccupied by *Rissoa curta* Dujardin, 1837.

eulimoides C. B. Adams, 1850, *Rissoa*. Jamaica. Eulimidae, as shown by Lyons (1977).

fernandinae Dall, 1927, *Rissoa (Nodulus)*. Off Fernandina, Florida, 294 fathoms. Family?, possibly Skeneidae (syntypes, USNM).

fragilis Wade, 1926, *Rissoina*. Upper Cretaceous, Tennessee. Eulimidae (holotype, USNM). Sohl (1960) has already pointed out that this species is "melanellid in character".

gallegosi Baker, Hanna & Strong, 1930, *Alvania*. Cape St. Lucas, Baja California. Cerithiidae (holotype, CAS).

infrequens C. B. Adams, 1852, *Rissoa*. Panama. Epitoniidae (holotype, MCZ). Bartsch (1915) placed this species in *Pliciscala* but Keen (1971) rejected this location in favour of *Rissoina*. Examination of the holotype supports the placement of this species in the Epitoniidae.

lacunatus Carpenter, 1865, *Amphithalamus*. California. Family? (holotype, USNM). The type is a broken juvenile and could belong in one of several families. This species should be regarded as a *nomen dubium*. It is certainly not an *Amphithalamus*.

lampra Dall, 1927, *Rissoa*. Off Fernandina, Florida, 294 fathoms. Fossariidae (*Couthouyia* - *Zeradina* group). Preoccupied by *R. lampra* Suter, 1908. *R. lampra* Dall is, however, very similar to *R. sandersoni* Verrill and may be conspecific so a replacement name is not provided.

mayori Dall, 1927, *Rissoina*. Off Georgia & Miami. Epitoniidae (type, USNM).

microcharia Dall, 1892, *Rissoa (Onoba)*. Pliocene, Florida. Pyramidellidae (holotype, USNM).

pompholyx Dall, 1927, *Rissoa*. Off Georgia. Fossariidae (*Couthouyia - Zeradina* group) (type, USNM).

portoricana Dall & Simpson, 1901, *Rissoa*. Mayaguez Harbor, Puerto Rico. Cerithiidae (*Finella (Caloosalaba)*) (holotype, USNM).

sandersoni Verrill, 1884, *Cingula*. Off Cape Hatteras, North Carolina, 142 fathoms. Fossariidae (? syntypes, USNM, one lot ANSP). Warén (1974) states from examination of the lot in the USNM that they are Rissoellidae or, possibly Aclididae. They appear to me to belong to the *Couthouyia - Zeradina* group in the Fossariidae. *R. lampra* Dall is very similar.

solida C. B. Adams, 1850, *Cingula* (?). Jamaica. Trochidae (?=*Halistylus pupoides* (Carpenter, 1864)) (holotype, MCZ). Figured by Clench & Turner (1950) without comment. This is a juvenile shell with a broken aperture that matches specimens of the West Coast *H. pupoides* rather well, indicating that the original locality is probably in error.

stephensae Baker, Hanna & Strong, 1930, *Rissoina*. Cape St. Lucas, Baja California. Cerithiidae (probably *Bittium*) (holotype, CAS).

stewardsoni Vanatta, 1909, *Rissoa (Nodulus)*. Fairyland, near Hamilton, Bermuda. Hydrobiidae (holotype and paratypes, ANSP).

subornata Wade, 1926, *Rissoina*. Upper Cretaceous, Tennessee. Fossariidae (*Couthouyia* - *Zeradina* group) (holotype, USNM).

texana Stanton, 1947, *Rissoa*? Lower Cretaceous, Texas. Family?, possibly Cerithiidae or Trichotropidae (types, USNM).

toroensis Olsson & McGinty, 1958, *Rissoa*. Bocas Island, N.E. Panama. Pyramidellidae (holotype and paratypes, ANSP).

Acknowledgments

I would like to thank Drs. G. M. Davis and R. Robertson (ANSP), Dr. B. Roth (CAS), Prof. R. D. Turner (MCZ) and Drs. R. S. Houbrick and J. Rosewater (USNM) for giving me access to the type collections in their care and the facilities with which to study them.

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REDISCOVERY OF THE PALM SNAIL, *HEMITROCHUS NEMORALINUS INTENSUS* PILSBRY (CEPOLINAE)

James D. Lazell, Jr.
8 Swinburne Street
Conanicut Island, RI 02835

During a biological reconnaissance of Guana Island, just north of Tortola in the British Virgin Islands, a small, arboreal snail was found associated with the palm, *Thrinax morrisii*. The snail appears to be *H. n. intensus* Pilsbry, 1889, described without type-locality and apparently not mentioned in the literature since. In life, the shell has a lightly striped, axial pattern; the shell has shades of brown, from ivory or ochraceous buff to russet. The soft parts are pinkish grey. A dozen specimens were preserved in ethanol and deposited in Florida State Museum, Gainesville (UF 40044).

Although empty shells of *H. n. intensus* were occasionally found at several points on Guana Island in association with scattered *Thrinax* palms, the concentration of both snails and palms is in the moist ravine on the northern side of the island at *ca* 30–100 m (Fig. 2). This was during the dry season, from February to April,

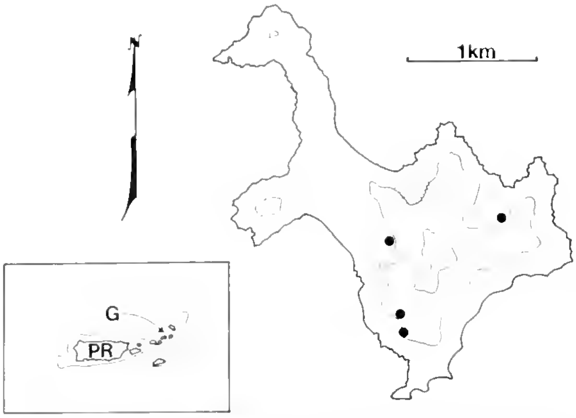

FIG. 2. *Guana Island in the British Virgins. Stippling indicates the zone of palms,* Thrinax morrisii, *in which* H. n. intensus was concentrated in March, 1982. Dots indicate positions of empty shells. Contours are 100 m. Inset shows Puerto Rico (PR) and the Virgin Islands. Arrow indicates the position of Guana Island (G). Fine line is the approximate 100 m submarine contour, probable maximum land edge during Würm glaciation.

FIG. 1. *Guana palm snail,* Hemitrochus nemoralinus intensus *Pilsbry, 1889, from Guana Island in the British Virgins. Photo by Robert Ginsberg.*

when I was present on the island. At this time there were only a few, small, scattered pools of fresh water in the ravine. No other ravine on the island retained any standing fresh water in March, 1982.

The palm itself is described as "unusual" in the Virgin Islands by D'Arcy (1971), although Read (in Howard, 1979) indicates these islands are well-within the general distribution. Although I have done extensive survey work in the British Virgins (Lazell, 1980), I have not found stands of *Thrinax morrisii* elsewhere. It does occur widely as single, isolated individuals, and in small stands on Anegada (D'Arcy, 1971). The ravine stands on Guana form a dense undercover dominated by the plants, *Bursera simaruba, Pisonia subcordata,* and *Hippomane mancinella.* The palm is widely harvested in the Virgin Islands to make brooms and is often called "broom palm" or "broom tyre."

The biological relationship of *H. n. intensus* to nominate *nemoralinus* Petit of Puerto Rico should be investigated. Moisture-dependent vertebrates, such as frogs of the genus *Eleutherodactylus,* fossorial reptiles such as *Amphisbaena* and *Typhlops,* and some terrestrial geckos of the genus *Sphaerodactylus,* show greater tendencies for speciation in the Virgin Islands than do more xeric-adapted forms (Lazell, 1983). This is presumably true because, even during the height of the Würm glacial maximum when the land areas were united, moist areas in the eastern, low portions of the Puerto Rico Bank (now the Virgin Islands) were still isolated by intervening xerophytic regions.

I am indebted to Dr. Fred G. Thompson, Florida State Museum, for identification of the snail, and to Dr. Robert W. Read, U.S. National Museum, for identification of the palm. I was assisted in the field by Gerald Durrell, Dr. Lee Durrell, Robert Ginsberg (who provided Fig. 1), Jan Soderquist, and members of the Jarecki family – owners of Guana Island. I am deeply grateful to the Jareckis, and Mary Randall and Albert Penn, who manage the island, for their help and hospitality.

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SURVEY OF THE PYRAMIDELLID GASTROPODS IN THE WASSAW SOUND AREA, COASTAL GEORGIA

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ABSTRACT

Four taxonomic associations of pyramidellid snails were identified in the Wilmington River-Wassaw Sound estuary and on the adjacent continental shelf, including: 1) an estuarine margin association, consisting mostly of Odostomia impressa *(Say) occurring in and around intertidal oyster banks; 2) an offshore estuarine association, with sparse* Turbonilla interrupta *(Totten) occurring in subtidal areas with abundant* Mulinia lateralis *(Say); 3) an open marine association, characterized by a few* T. incisa incisa *Bush also associated the valves of* M. lateralis; *and 4) a mixture of odostomes, turbonills, and pyrams derived from several stratigraphic horizons and original environments, and associated with a species-rich assemblage of fossil mollusks occurring for the most part within tidal channels.*

The purpose of this paper is to report the composition of the pyramidellid snail fauna of the Wilmington River-Wassaw Sound estuary and adjacent shelf, and to document the distribution of the fauna in the estuarine and nearshore marine environments of the area. An unexpectedly taxonomically rich fauna was discovered, particularly where fossil and recent shells had been mixed within tidal channels; high abundance of individuals, however, was attained only by one species. Members of the Pyramidellidae inhabiting the environmental mosaic of the Wassaw Sound area could be readily segregated into four taxonomic associations (terminology of Kauffman and Scott, 1976), and the distributional and paleontologic aspects of pyramidellid species will be discussed in terms of these recurrent groups of taxa.

Methods

During the summer of 1981, fifteen bulk samples of shelly sediments were collected from a variety of coastal environments, wet-sieved to separate shells from matrix, and carefully examined for pyramidellid shells. The sample stations are shown in Fig. 1. Samples labelled with KJ were collected in deeper subtidal locations using a Reineck box corer deployed from the deck of the R/V *Kit Jones*. Samples labelled with W and H-1 through H-4 were collected at low tide from intertidal locations, and H-8 was collected in shallow water with a bottom grab-sampler deployed from a small whaler. Six major types of estuarine and nearshore marine en-

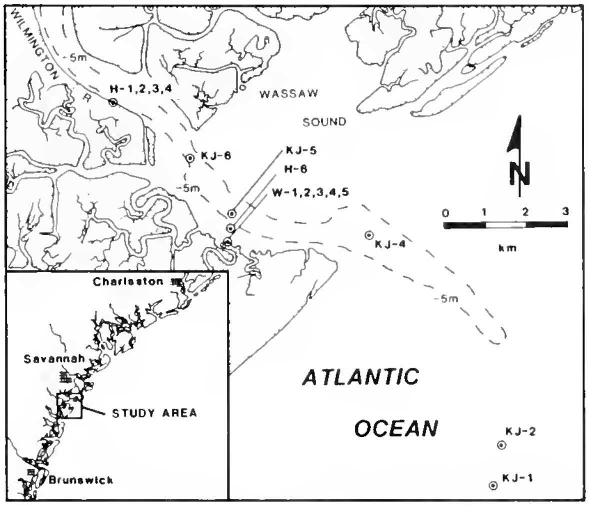

FIG. 1. *Index map showing location of study area in northern coastal Georgia (inset) and map of the Wassaw Sound area showing location of sample stations.*

vironments were sampled, including: 1) seaward flank of the ebb tidal shoal located at the mouth of the sound; 2) surface of the ebb tidal shoal; 3) the tidal inlet floor; 4) estuarine channel bottom within the sound; 5) the flank of the estuarine channel; and 6) intertidal oyster banks or reefs along the margins of the sound and lower stretches of the river (Table 1, Fig. 1).

All samples were sieved, dried, and handpicked to remove all pyramidellids larger than about 1 mm in largest dimension. Published descriptions and illustrations were used to identify specimens (Maryland Geological Survey, 1904; Bartsch, 1909; Henderson and Bartsch, 1914; Morris, 1973; Abbott, 1974). All specific determinations were made using a dissecting microscope and all identifications were double-checked at least once. Other mollusks co-occurring with the pyramidellids in large numbers were also identified.

TABLE 1. *Environmental setting, water depth, and volume of samples before processing. Sample numbers are keyed to Fig. 1.*

SAMPLE NUMBER	ENVIRONMENTAL SETTING	BOTTOM DEPTH (meters)	SAMPLE VOLUME (liters)
W-1	intertidal estuarine, rubble flat behind oyster bank		1.00
W-2	intertidal estuarine, slope in front of oyster bank		1.00
W-3	subtidal estuarine, tidal slough near oyster bank	(few cm's)	1.00
W-4	intertidal estuarine, sediment pond within oyster bank		1.00
W-5	intertidal estuarine, sediment pond within oyster bank		0.75
H-1	subtidal estuarine, shelly bar in tidal creek near oyster bank	(few cm's)	1.00
H-2	intertidal estuarine, dead oyster bank	*	0.75
H-3	intertidal estuarine, rubble slope in front of oyster bank	*	0.75
H-4	intertidal estuarine, shell-armored levee		1.00
H-8	subtidal estuarine, offshore tidal channel flank	-4	2.00
KI-1	subtidal marine, ebb tidal shoal flank	-5	3.10
KI-2	subtidal marine, ebb tidal shoal surface	-3	3.20
KI-[illegible]	subtidal estuarine, inlet floor	-9	1.00
KI-5	subtidal estuarine channel bottom	-9	[illegible].60
KI-6	subtidal estuarine channel bottom	-9	1.20

* collected at above mean low tide level

Taxonomic Practice

A total of 1859 specimens was recovered, representing at least fourteen species belonging to three genera (Table 2). Taxonomic conservatism was practiced wherever possible. For example, samples from tidal channel areas contained small turbonills that resembled very closely *Turbonilla puncta* (C. B. Adams, 1850), but graded toward larger shell sizes into definite *T. interrupta* (Totten, 1835). Although to my knowledge *T. puncta* and *T. interrupta* have not as yet been shown to be the same species, I identified all of these specimens as *T. interrupta*. However, within the same series of samples, a number of different species of *Turbonilla* definitely co-occur, and some of these seem to be best assigned to the species-groups erected by Henderson and Bartsch (1914) for Virginia turbonills, which were evidently based upon very small collections. Taxonomic conservatism has its natural limitations in the study of the pyramidellids because there really is an extraordinary richness to the family (*cf.* Odé, 1981), probably owing to the mode of evolution within the group.

Habitat heterogeneity, very limited contact between populations of adult individuals, small populations isolated on resource islands (host organisms), and ability to self-fertilize may have promoted a kind of accelerated parapatric speciation among some pyramidellids, with the result that every geographic segment or compartment of the coast might actually contain its own recently evolved set of species. Other pyramidellids have evolved to exploit exceedingly widespread prey, and through the Late Cenozoic have "tracked" their abundant hosts in space and time to become very widespread and abundant themselves (*e.g.*, *Odostomia impressa* (Say) with *Crassostrea virginica* (Gmelin)). Both rarer species like *O. gibbosa* (Bush), and the abundant and variable forms like *O. impressa* have with time become distributed interprovincially. Nevertheless, if we remember that most pyramidellids are parasites, it should not surprise us to find small numbers of narrowly distributed species or subspecies, which are actually or potentially reproductively isolated from other

TABLE 2. *Pyramidellid snails from the Wassaw Sound area, coastal Georgia. Sample numbers are keyed to sample stations shown in Fig. 1.*

TAXA	SAMPLES W-1	W-2	W-3	W-4	W-5	H-1	H-2	H-3	H-4	H-8	KJ-1	KJ-2*	KJ-4*	KJ-5	KJ-6*
Odostomia impressa (Say, 1821)	722	2	6	80	553	22	13	217	92	-	-	1	5	-	6
O. conoidea (Brocchi, 1814)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
O. laevigata (d'Orbigny, 1842)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
O. gibbosa Bush, 1909	1	-	-	-	-	-	-	-	-	-	-	1	4	-	-
O. seminuda (C. B. Adams, 1837)	1	-	-	-	-	-	-	-	-	-	-	2	6	-	1
O. engonia Bush, 1885	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-
O. dux Dall and Bartsch, 1906	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
O. pocahontasae Henderson and Bartsch, 1914	-	-	-	-	-	-	-	-	-	-	-	-	4	-	2
Odostomia sp. indet.	2	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Turbonilla interrupta (Totten, 1835)	-	-	-	-	-	-	-	-	-	5	-	3	23	10	18
T. conradi Bush, 1899	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
T. incisa incisa Bush, 1899	-	-	-	-	-	-	-	-	-	-	2	2	3	-	3
T. powhatani Henderson and Bartsch, 1914	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
T. toyatani Henderson and Bartsch, 1914	-	-	-	-	-	-	-	-	-	-	-	-	6	-	4
Turbonilla sp. indet.	1	-	-	-	1	-	-	1	-	-	-	1	6	1	5
Pyramidella sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2

*Samples composed wholly or partially of reworked Pleistocene shells.

morphologically similar forms, co-occurring with the more widespread and abundant taxa. *We should expect* to find abundant, widely distributed taxa with long stratigraphic durations; together with rare, widespread taxa also having long stratigraphic ranges; as well as the rare, very poorly known endemic species or subspecies with short or unknown evolutionary histories. The more infrequent case of abundance and widespread geographic distribution *versus* the apparently more common case of rarity among the Pyramidellidae is probably related to degree of host specificity (see Price, 1980); breadth of distribution is probably a function of host deployment patterns and the age of pyramidellid lineages. Therefore, the taxonomic philosophies of the liberal and the conservative label-users, excluding of course the methodologic blunders which have multiplied synonyms to the point of absurdity, should both contain an element of natural reality: there are both species that have been overnamed (*e.g.*, *T. interrupta*) and species that have been unjustifiably ignored (*e.g.*, *T. toyatani* Henderson and Bartsch).

A biologically meaningful taxonomy of pyramidellids must be developed from an understanding of how the family has evolved, and not merely from a less extravagant nomenclatural practice. In the words of Price (1980, p. 43), "For such small, short-lived, precisely adapted organisms as parasites, evolution will operate in minature – in short times, in small spaces, but with impressive results."

Survey Results

Four taxonomic associations of pyramidellid species were readily delineated in the samples: 1) an intertidal to very shallow subtidal estuarine margin association with abundant shells and fragments of *Odostomia impressa;* 2) a deeper subtidal estuarine association with few

TABLE 3. *Taxonomic composition of pyramidellid associations, Wassaw Sound area, Georgia.*

MAJOR COMPONENTS	MINOR COMPONENTS
ESTUARINE MARGIN	
Odostomia impressa	*O. conoidea*
	O. laevigata
	O. gibbosa
	*O. seminuda**
	*O. engonia**
OFFSHORE ESTUARINE	
Turbonilla interrupta	*O. engonia*
OPEN MARINE	
T. incisa incisa	
T. conradi	
ENVIRONMENTALLY AND TEMPORALLY MIXED ASSEMBLAGES	
O. impressa	*O. gibbosa*
O. seminuda	*O. pocahontasae*
T. interrupta	*O. dux*
T. toyatani	*O. conoidea*
	T. incisa incisa
	T. powhatani
	Pyramidella sp

*allochthonous, probably washed in from deeper water

Turbonilla interrupta; 3) a subtidal open marine association with few *T. incisa incisa* Bush; and 4) a temporally and environmentally mixed assemblage of fossil and modern odostomes, turbonills, and pyrams, confined to tidal channels and the ebb tidal shoal surface (see Table 3). Distribution of the modern associations of pyramidellid species not only coincides with the distribution of host organisms, but also appears to closely coincide with environmental gradients (a predictable result of membership in physically-accomodated nearshore benthic communities in which environment-organism interactions generally determine community structure; see Johnson, 1972).

Estuarine Margin Association – *Odostomia impressa* is a well-known ectoparasite of oysters (Allen, 1958; Wells, 1959, 1961; Robertson, 1978). Its shells are found in great numbers in modern shell deposits surrounding beds and isolated clumps of *Crassostrea virginica* along the edges of the lower Wilmington River and Wassaw Sound. Nearly all of the shells of *O. impressa* showed evidence of attack and peeling by crabs, both as repaired and unrepaired shell damage. Although some of the broken shells and small fragments of *O. impressa* are the results of physical destruction by waves, in all likelihood most of the fragments are the by-products of crab predation. Crab predation on intertidal populations of *O. impressa* may be an important cause of mortality among these snails, and appears to be unreported in the literature. In addition to signs of predation, nearly all shells and fragments were at least slightly damaged due to dissolution of calcium carbonate. (A detailed report on the ecologic significance of the condition of *O. impressa* shells from the estuarine margin association is in preparation). Other rare pyramidellids occurring in samples from the estuarine margin are listed in Table 3. Mollusks commonly co-occurring with *O. impressa* included: *C. virginica*, *Mulinia lateralis* (Say), *Brachidontes exustus* (Linné), *Geukensia demissa* (Dillwyn), and *Ilyanassa obsoleta* (Say).

Offshore Estuarine Association – Samples recovered from Wassaw Sound, which did not contain a mixture of fossil and recent mollusks, were characterized by a few shells of *Turbonilla interrupta*, the second most abundant pyramidellid collected in the survey (Table 2). *T. interrupta* is a common ectoparasite of shallow-water bivalves in areas of near-normal marine salinities (Morton, 1967). In addition to about half of all shells of *T. interrupta* showing signs of peeling and breakage by crabs, one-third of all shells had been bored by predatory gastropods. Mollusk species commonly co-occurring with *T. interrupta* included: *Mulinia lateralis*, *Tellina agilis* Stimpson, *Abra lioica* (Dall), and *Acteocina canaliculata* (Say).

Open Marine Association – Only sample KJ-1 contained modern shells of *Turbonilla incisa incisa* and *T. conradi* Bush. The discovery of these two snails in a modern shell deposit off the Georgia coast represents a northern extension of geographic ranges for both species, which normally inhabit waters south of Georgia (Abbott, 1974). To my knowledge, both species are biologically unknown. The single specimen of *T.*

conradi showed signs of repaired crab damage. Mollusks co-occurring with these two species included *Mulinia lateralis* and *Tellina agilis*.

Mixed Assemblages – The most species-rich collections of pyramidellids came from samples taken in the estuary channel, inlet, and from the ebb tidal shoal surface (Fig. 1, Table 2). Most of the shells were broken and abraded, and many were chalky or stained with iron oxide. The most common pyramidellid in these samples was *Turbonilla interrupta*, mostly derived through reworking of the older shelly Pleistocene deposits that underlie the area (Frey *et al.*, 1975). Other fossil pyramidellids found in the samples were the distinctive shells of *Odostomia seminuda* (C. B. Adams) and *O. dux* (Dall and Bartsch) (which were absent from the open marine and offshore estuarine associations), and a variety of turbonills referrable to *T. incisa incisa*, *T. toyatani*, and *T. pouhatani* (Henderson and Bartsch) (Table 3). These samples also contained the only specimens of *Pyramidella* encountered in this survey. Associated with the pyramidellids were large numbers of the following mollusk species, most of which showed signs of being derived from Pleistocene deposits: *Mulinia lateralis*, *Crassostrea virginica*, *Tellina agilis*, *Spisula solidissima* (Dillwyn), *Anadara transversa* (Say), *Anadara ovalis* (Bruguière), *Anadara brasiliana* (Lamarck), *Donax variabilis* Say, *Abra aequalis* (Say), *Crassinella lunulata* Conrad, *Corbula contracta* Say, *Nucula proxima* Say, *Acteocina canaliculata*, and *Mitrella lunata* (Say).

This bewildering assemblage of broken, chalky, stained shells is of especial interest to paleontologists, as it represents a mixed fossil assemblage "in the making." Not only have several stratigraphic horizons contributed shells to the assemblage, but a variety of estuarine and marine benthic communities are represented. If entombed at the base of a regressive sequence of estuarine sediments, the mixed pyramidellid assemblage would be easy to recognize (even if individuals cannot be identified to species) because of the condition of shells, association with an environmental mixture of other molluscan taxa, and envelopment within a coarse-grained matrix of channel sand. This assemblage would grade upward in the sequence into the offshore estuarine association contained in a finer-textured matrix of muddy sand containing *M. lateralis* shells, which in turn could be overlain by an oyster biostrome containing the estuarine margin association. A transgressive sequence would, on the other hand, consist of either a tidal channel deposit containing a mixed assemblage of shells, the offshore estuarine association, or oyster bank deposits containing abundant *O. impressa*, grading upward into either the open marine association or the ebb tidal shoal sediments also containing a mixed assemblage of pyramidellids.

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The use of research vessels and laboratory space at the Marine Extension Service of the University of Georgia, at Skidaway Island, Georgia, is gratefully acknowledged. My stay at Skidaway Island was supported by a grant from the Administrators of the Tulane Educational Fund, expedited by Dr. Emily H. Vokes. Dr. Robert W. Frey assisted with the fieldwork and Dr. R. Tucker Abbott gave valuable advice on the literature of pyramidellids. Mrs. Elizabeth Seale skillfully typed the manuscript.

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OBSERVATIONS ON THE LIFE HISTORY OF THE WENTLETRAP *EPITONIUM ECHINATICOSTUM* IN THE BAHAMAS

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ABSTRACT

The wentletrap Epitonium echinaticostum *(Orbigny, 1842) lives with the actiniarian sea anemone* Bunodeopsis globulifera *(Duchassaing, 1850) at Freeport, Grand Bahama Island. Both were collected in a canal from turtle grass* (Thalassia testudinum *Banks ex König) leaves. The* Epitonium *feeds on portions of the anemone's tentacles. Further observations are reported on* E. echinaticostum's *habitat, host, feeding, sexuality, spermatozeugmata, egg capsules, eggs, planktotrophic veligers, protoconchs and purple dye. As expected, there is protandry, but, puzzlingly, squashes of 27 whole animals of all representative sizes failed to reveal any oocytes or eggs—although some of the individuals had just laid egg capsules in the laboratory. Comparisons are made with the larger, Caribbean species* E. albidum *(Orbigny, 1842) and the Western Pacific* E. millecostatum *(Pease, 1860-1861), the only other tropical wentletraps on which similar life history data have been published.*

Wentletraps (Gastropoda: Epitoniidae) are now well-known to live with or to crawl in search of coelenterates, on which they all apparently feed (Robertson, 1981a:13). However, the only tropical western Atlantic species whose host has so far been reported is *Epitonium albidum* (Orbigny, 1842), which feeds on *Stichodactyla helianthus* (Ellis, 1768) (Robertson, 1963, 1983a and 1983b). It was therefore with much interest that I learned from Jack Worsfold (an avid naturalist and shell collector) that he had found *E. echinaticostum* (Orbigny, 1842) associated with a sea anemone at Freeport, Grand Bahama Island, northern Bahamas. In early and mid-September 1982 I was at Freeport to study the association myself.

Methods

Salinity was determined with an American Optical Hand Refractometer. The gamete determinations in Figs. 3B and 3C (and the observations on a dearth of females) are based on squashes of whole live animals (unstained and

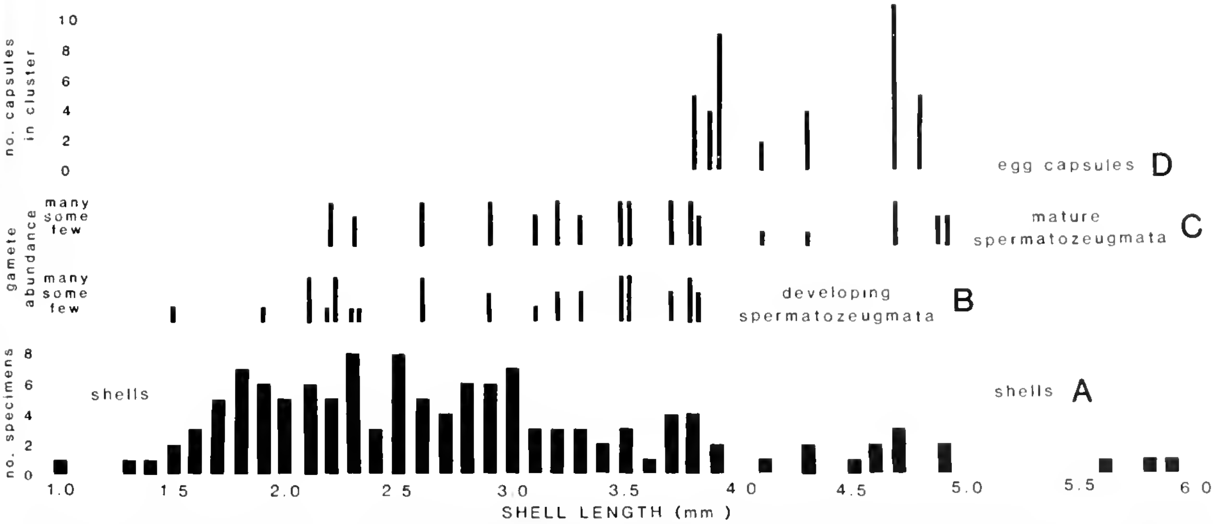

FIG. 3. Epitonium echinaticostum: A. *Shell length frequency distribution of a randomly collected sample obtained at Freeport, Grand Bahama Is. in early- and mid-September 1982.* B. *Lengths of the freshly collected animals containing developing spermatozeugmata and their frequencies in mid-September.* C. *Same, but mature spermatozeugmata. No developing or mature spermatozeugmata were found in specimens 1.4, 5.8 and 5.9 mm long.* D. *Lengths of specimens that laid eggs in the laboratory in early- and mid-September 1982, and the numbers of capsules in each cluster. The data clearly show protandry.*

uncleared) that were studied with a compound microscope.

Voucher Specimens

Epitonium echinaticostum: Acad. Nat. Sci. Philadelphia A9513 (portion of sample in alcohol); 355872 (dry shell [Fig. 2]). *Bunodeopsis globulifera* (Duchassaing, 1850): California Acad. Sci. 031663.

Locality and Habitat

Worsfold showed me the best locality that he had found for *Epitonium echinaticostum* which is near the southwest end of the about 20-year-old canal between Oceanhill Boulevard and Bamboo Cay (Street), southwest Freeport (0.4 km E.S.E. of Xanadu Beach Hotel and Marina: 26°30′N.; 78°43′W.), Grand Bahama Island, Bahamas. The host anemone lives on many of the hard substrates in the habitat but is most readily collected from the distal halves of turtle grass leaves (*Thalassia testudinum* Banks ex König), the plants of which grow patchily on the canal's soft substrates at a depth at low tide of about 0.5 to 2 m. The bottom salinity was tested once and was approximately 34 ‰.

Also present in the sheltered canal habitat are such conspicuous organisms as the algae *Penicillus, Halimeda, Acetabularia* and *Caulerpa*, the large, benthic scyphozoan *Cassiopea xamachana* Bigelow, 1892, the gastropods *Cerithium litteratum* (Born, 1778), *Modulus modulus* (Linné, 1758), *Strombus gigas* Linné,

FIG. 2. Epitonium echinaticostum: *representative shell. Freeport, Bahamas.*

1758, *Fasciolaria tulipa* (Linné, 1758), and the fishes *Lutjanus apodus* (Walbaum, 1792) and *Eupomacentrus* spp. The bivalve *Isognomon alatus* (Gmelin, 1791) is common on the canal walls. Some of these organisms commonly live on or near mangroves, but no mangroves are present at the Oceanhill Boulevard-Bamboo Cay locality.

The Host

The sea anemone host of *Epitonium echinaticostum* at Freeport is *Bunodeopsis globulifera* (Duchassaing, 1850)[1] (Fig. 1). This species is unusual in having relatively large, conspicuously colored and patterned ovoid vesicles on the column. *B. globulifera* can turn itself outside in so that its tentacles go through the mouth and become hidden in the coelenteron (Duerden, 1902:299 made similar observations); the mouth can also invert. This behavior may afford *Bunodeopsis* some protection against animals that attack its tentacles. When the tentacles are extended, *Bunodeopsis* is able to detach its pedal disc and swim weakly or drift to another substrate. With the tentacles spread radially, *Bunodeopsis globulifera* at Freeport attains a maximum diameter of about 3 cm; the pedal disc diameter is up to about 2 cm.

The tentacles of *Bunodeopsis globulifera* are translucent, faintly tinted with orange-brown. The column and pedal disc are pale orange-brown. The vesicles are cream-colored (sometimes pale-brown or tinted with green) with brown or purple-brown spots or stripes.

Bunodeopsis globulifera has hitherto been recorded only from Bermuda, Florida, Jamaica, Guadeloupe, Barbados and Curaçao (Duchassaing and Michelotti, 1861: 320, as *Viatrix globulifera;* Verrill, 1900; Duerden, 1902; Carlgren, 1949, 1952; Lewis and Hollingworth, 1982).

The Parasite

The shell of *Epitonium echinaticostum* (Fig. 2) has from 6 to 15 wavy axial ribs per whorl (Clench and Turner, 1951:253-255; Robertson, in press). The maximum observed shell length is 9.5 mm (Clench and Turner, 1951). The largest observed at Freeport was 5.9 mm long; the modal length at the time of the observations was about 2.4 mm (Fig. 3A). The shell is refigured here because Clench and Turner's three illustrations (copied by Abbott, 1974:120) all show shells with unusually disjunct whorls (see Rex and Boss, 1976, about "open" coiling of this species). The distinctive shell characters of *E. echinaticostum* led to its becoming the type-species of *Cycloscala* Dall, 1889, ranked as a subgenus of *Epitonium* by Clench and Turner (1951:253).

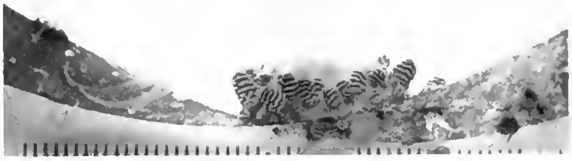
FIG. 1. Bunodeopsis globulifera *on a* Thalassia testudinum *leaf. Note the vesicles on the column and the juveniles on the leaf. Hope Town, Abaco, Bahamas. mm scale.*

In color, the overall aspect of living *Epitonium echinaticostum* is cream-white, with much of the soft body surface finely speckled with pale brick-red and cream. The spire becomes covered with cream-colored detritus. Thus the *Epitonium* is not cryptically colored either with its anemone or on *Thalassia* leaves.

The known geographic range of *Epitonium echincticostum* is from Bermuda, the Bahamas and Florida south through the West Indies to the Caribbean coast of Panama and the state of Espírito Santo, Brazil (Clench and Turner, 1951:255; Olsson and McGinty, 1958:13; Rios, 1975:56, pl. 15, fig. 216). It has been dredged as deep as 200 fathoms [=366 m] (Clench and Turner, 1951), but this record may have been based on an empty shell. Porter (1974:167) records the species from S.E. of Cape Lookout, North Carolina, in 200 m (not live-collected), but

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[1] Probable synonyms: *B. antilliensis* Duerden, 1897; *B. globulifera* Verrill, 1900.

this identification needs to be checked. Abbott (1974:120) remarked that "Dan Steger reports it common in Florida Bays and inlets" – sheltered areas similar to the Freeport canals.

At the Freeport locality it was not feasible in the time available to quantify the abundance of *Epitonium echinaticostum* except to record that an average of about 11.3 specimens was collected per man hour (138 specimens in a total of about 12¼ hours). The *Epitonium* in all cases was found on *Thalassia* leaves near *Bunodeopsis globulifera*. Thus the species is epifaunal, not infaunal as speculated by Rex and Boss (1976:295, the "axial ribs. . . may function to anchor individuals . . . firmly in the substratum adjacent to their hosts.").

Feeding

In the laboratory, *Epitonium echinaticostum* was seen to feed both during the day (five times) and at night (six times), always on *Bunodeopsis* tentacles. Feeding was most readily observed after the wentletraps had been starved for several days. A tentacle was ingested either starting from the tip and extending proximally (once) or by being bitten off somewhere along its length and thence being ingested either towards the tip or the base (7 times). The tentacles are too big to be swallowed whole (they can be 10 mm or more long, and the wentletrap at Freeport was less than 6 mm long). When the acrembolic proboscis of *E. echinaticostum* is fully everted it is about ½ or ⅔ the length of the shell. After a piece of *Bunodeopsis* tentacle of manageable length is nipped off, it can be seen passing proximally in the inverting proboscis. The dishes in which feeding took place became littered with discarded tentacle tips. Two feeding attacks by moderate-sized wentletraps were seen to be thwarted by an anemone pulling away the threatened tentacle in time, after it had been touched by an *Epitonium*. A 1.4 mm long *Epitonium* was seen repeatedly trying to attach the tip of its tiny proboscis onto a much larger diameter anemone tentacle, but without success. There was no indication that *Bunodeopsis* vesicles or columns were ever attacked.

Sexuality

Squashes of whole animals were made of 27 freshly collected specimens of all representative sizes. As expected, *Epitonium echinaticostum* is protandric, with developing spermatozeugmata present in the gonads of individuals 1.5 to 3.8 mm in length (Fig. 3B), and with mature spermatozeugmata in individuals 2.2 to 4.9 mm in length (Fig. 3C). Puzzlingly, not a single oocyte or egg was seen in any of the 27 specimens, although specimens 3.8 to 4.8 mm-long laid eggs in the laboratory (Fig. 3D). Animals that had just laid eggs contained only spermatozeugmata. After initial protandry there is a relatively long stage of simultaneous hermaphroditism during which eggs perhaps are grown and expelled rapidly by a few individuals. (Growth can be very rapid in *Epitonium* – Robertson, 1983a). Conditions possibly are different in seasons other than later summer. There is no evidence yet for an exclusively female stage in *E. echinaticostum*, as there is in *E. albidum* (Robertson, 1981b). The largest specimens squashed (5.8 and 5.9 mm long) contained gametes of neither sex.

Spermatozeugmata

The spermatozeugmata of *Epitonium echinaticostum* are unusual in having two posterolateral projections on each side of the hind part of the lamellar end.

Egg Capsules and Eggs

Egg capsules (Fig. 4) were first observed several days after the wentletraps had fed voraciously. Clusters of from 2 to 11 capsules (mean of 7 counts: 5) were seen to have been laid by animals 3.8 to 4.8 mm long (Fig. 3D). The capsules are connected one to another by an elastic mucous thread, one end of which comes from the median ventral groove in the posterior three-fifths of the foot of the parent (the pedal pore from which the thread is secreted lies in this groove). Thus the parent drags a cluster of egg capsules behind it.

The capsules are elliptical in outline, with several rounded mucoid projections around its periphery. There is no sand agglutination, but

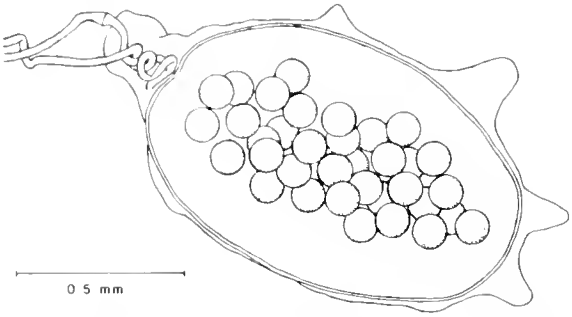

FIG. 4. Epitonium echinaticostum *egg capsule. Freeport, Bahamas.*

detritus may be attached here and there. In lengths the capsules range from 0.9 to 1.2 mm. The number of contained eggs ranged from 28 to 65 (mean of 8 counts: 43). It was not possible to determine whether small capsules are laid by small females and contain fewer eggs than large capsules, as in *Epitonium albidum* (Robertson, 1983b).

The eggs are cream-white, and their uncleaved diameters measured 98 to 106 μm (mean of 10 measurements: 102 μm). The surrounding medium within the capsule initially is albuminous, and causes the eggs to cluster along the capsule's longitudinal axis. Viscosity decreases during development.

In the laboratory, all but three of the capsules became infected interiorly with bacteria and protozoans. Planktotrophic veligers hatched from two of the uninfected capsules but were abnormal. The hatching shell diameter is about 170 μm, i.e. much larger than the egg. The veliger has a coiled shell, a pair of small velar lobes, an operculum, a purplish black pigmented mantle organ, and a pair of eyes but no tentacles.

Protoconch

The protoconch is about 0.3 to 0.4 mm long, i.e. it is much larger than the hatching veliger shell – proof that the larva is planktotrophic and grows substantially while it is in the plankton. Unfortunately, the protoconch could not be studied with a scanning electron microscope, but at ×50 with a dissecting microscope it was seen to have less inflated whorls than *Epitonium albidum.* Microsculpture could not be discerned but may be present.

Purple Dye

No purple was seen to be released when *Epitonium echinaticostum* fed, only when it was molested or dying. I have suggested elsewhere (Robertson, 1983b) that *Epitonium* purple is repugnatorial.

Discussion and Conclusions

Epitonium echinaticostum is a smaller species than *E. millecostatum* or *E. albidum*, the only other tropical wentletraps on which there are similar published life history data (Robertson, 1981a and 1983b). Like many (but not all) wentletraps, each lives with, or crawls in search of, a particular genus or species of coelenterate upon which it feeds.

There is little information on the sexuality of *Epitonium millecostatum.* Although both *E. echinaticostum* and *E. albidum* are protandric, the two species differ considerably in other respects. At least in late summer at Freeport there seems to be no exclusively female stage in *E. echinaticostum;* animals producing eggs are curiously rare, and large individuals seem to be in a post-reproductive stage.

The egg capsules of *Epitonium echinaticostum* are relatively large, being about the same size as those of small-or medium-sized female *E. albidum*, a much bigger animal. Differences between the egg capsules of *E. echinaticostum* and *E. albidum* are that the former are much thinner-walled, have mucoid projections, and have the mucous thread attached terminally instead of laterally. With their mucoid projections, the egg capsules of *E. millecostatum* are more like those of *E. echinaticostum* but those of the former have thicker walls. Sand agglutination occurs in *E. albidum* but not in the other two species, which lack loose sand in their microhabitats.

The uncleaved eggs of *Epitonium echinaticostum*, averaging 102 μm in diameter, are bigger than those of *E. millecostatum* (mean: 73 μm) and *E. albidum* (mean: 68 μm). *E. echinaticostum's* eggs are not so large, however, as to make the species lecithotrophic; it is still planktotrophic. Both in *E. echinaticostum* and *E. albidum*, and possibly also in *E. millecostatum*, the developing larvae appear to subsist in part on the albuminous material initially present inside the capsules. Hatching sizes are larger than egg sizes.

ACKNOWLEDGMENTS

I am most grateful to Jack Worsfold for all his help and kindness at Freeport. Dr. Daphne Fautin Dunn (California Academy of Sciences) identified the *Bunodeopsis* and shared her knowledge of sea anemones. Tracy D. Pedersen drew Fig. 2. The following kindly read and criticized various drafts of the manuscript: Dr. Arthur E. Bogan, Dr. George M. Davis, Dr. D. F. Dunn, Virginia Orr Maes and Dr. Joseph Rosewater. My personal bank account helped to support this research.

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DIET EXPANSION OF *BUSYCON CONTRARIUM* IN THE ABSENCE OF *TRIPLOFUSUS GIGANTEUS* (GASTROPODA: BUCCINACEA)

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Busycon contrarium (Conrad) is a large, melongenid, predatory gastropod occurring along the Atlantic and Gulf coasts of North America (Abbott, 1974). This species feeds almost exclusively on sand-dwelling bivalves (Paine, 1963; Kent, 1982), but Paine (1963) found that *B. contrarium* was not eating two large and apparently poorly defended pen shells (Bivalvia: Pinnidae), *Atrina rigida* (Lightfoot) and *A. serrata* (Sowerby) in northwestern Florida. Of the eight predatory gastropods Paine (1963) studied, only the very large fasciolariid *Triplofusus*[1] *giganteus* (Kiener) (Olsson & Harbison, 1953) preyed on *Atrina*. The absence of *Atrina* from the diet of bivalve-specializing *B. contrarium*, when sympatric with *T. giganteus*, suggests that an interaction may be occurring between these two gastropods. During a study of competitive interactions between busyconine whelks in 1979, I made diet observations on *B. contrarium* in an area near Paine's study site. These observations are useful for testing the hypothesized interaction between *B. contrarium* and *T. giganteus*, since during 1979 *T. giganteus* was virtually absent from intertidal grass flats. Paine (1963) reported a mean density of 3.6 *T. giganteus*/hr. (from Fig. 1 in Paine, 1963); in 1979 only eight *T. giganteus* were observed on grass flats in 11 months of intensive study (Kent, 1983).

In Paine's (1963) study *Atrina* spp. accounted for 20% of the diet of *T. giganteus* (13 of 66 prey); the remainder of the diet consisted entirely of gastropods (13 *Fasciolaria tulipa*, 6 *F. lilium hunteria*, 17 *B. contrarium*, 4 *Busycotypus spiratum*, 12 *Chicoreus dilectus*, and 1 *Polinices duplicatus*). In 1979, six of the eight *T. giganteus* were feeding and one of these six feedings was on *Atrina* (=17% of diet). As in Paine's study, the remainder of the diet was composed of gastropods (1 *F. tulipa*, 2 *B. contrarium*, 1 *C. dilectus*, and 1 *Melongena corona*). Despite the very small sample size for 1979, the diets are surprisingly similar; however the very low densities of *T. giganteus* in 1979 meant that it was not a numerically important predator.

The diet of *B. contrarium* changed markedly when *T. giganteus* was rare. Paine (1963) found that no *Atrina* were eaten in 172 feedings, while in 1979 eight of 63 feedings were on *Atrina* (=13% of diet; Kent, 1983). The change is even more dramatic if only larger (≥120 mn) *B. contrarium* are considered; eight of 32 feedings were on *Atrina* (=25% of diet). This comparison is more suitable than using all *B. contrarium* because; 1) small *B. contrarium* were rare during Paine's study and 2) it compares *B. contrarium* and *T. giganteus* of similar sizes, thus avoiding size-related differences in diet (Kent, 1983).

A second sympatric busyconine whelk, *Busycotypus spiratum* (Lamarck), does not prey on *Atrina* in the absence of *T. giganteus*. Apparently this is due to a strong preference by *B. spiratum* for active bivalves (e.g. - scallops and cockles) rather than passive bivalves such as *Atrina* (Kent, 1983).

While these data suggest that an interaction is occurring between *T. giganteus* and large *B. contrarium*, the exact mechanism of this interaction is unclear. The dietary expansion of *B. contrarium* may simply represent competitive release, although the situation is complicated by *B. contrarium* being an important prey of *T. giganteus* (28% of diet in Paine's study and 33% during 1979). Detailed observations and experimental manipulations are needed both to clarify the mechanism for this interaction and to determine the effects this change has had on the selective pressures acting on *Atrina*.

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[1] Considered a subgenus of *Pleuroploca* by some recent authors—*editor*.

ECOLOGY AND LARVAL DEVELOPMENT OF *CREPIDULA PROTEA* (PROSOBRANCHIA: CREPIDULIDAE) FROM SOUTHERN BRASIL: A NEW TYPE OF EGG CAPSULE FOR THE GENUS

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ABSTRACT

Examination of museum specimens verified the existence of at least three distinct species of the marine gastropod genus Crepidula *off the coast of southern Brasil:* C. protea, C. plana, *and* C. aculeata. *Specimens of* C. protea *were collected alive by dredging. They carried broods of larvae that appeared to be ready to be released in the veliger stage. Unlike other* Crepidula, *the larvae were imbedded in the matrix of the egg capsule material. Other character states distinguishing* C. protea *and* C. plana *are discussed, as well as the population structure of* C. protea. *The distribution of* C. protea *is limited compared with that of* C. plana.

Crepidula protea d'Orbigny, 1841, is a common subtidal gastropod found on shelly substrates off the coast of South America. Because living specimens are obtained most often by dredging, little is known about the species. Even the limits of variation of the shell phenotype are poorly defined. D'Orbigny (1841, 1842) commented that his description could encompass North American specimens, presumably *C. plana* Say, 1822. The original species localities were the Antilles, the coast of Patagonia, and "Maldonado, Brasil" [Uruguay]. Dall (1889) synonymized *C. protea* with *C. unguiformis* Lamarck, although most other workers have maintained it as a separate species (Rios, 1982 ms.; Hoagland, 1977).

In December, 1981, I examined museum records and specimens of *Crepidula protea* in the Museu Oceanografico de Rio Grande do Sul, Brasil. Once assured on the basis of shell characters that *C. protea* is distinct from *C. unguiformis* and *C. plana*, I arranged to dredge off the coast of southern Brasil in an attempt to collect living specimens. This paper describes the specimens obtained, including characteristics of their brooded embryos and their population structure. Confirmed localities for *C. protea* and *C. plana* in South America are compiled from examination of the museum specimens.

Methods

In December, 1981, Prof. E. Rios arranged for me to examine the collection of *Crepidula* at the Museu Oceanográfico, Rio Grande. He also kindly arranged for the use of their oceanographic vessel equipped with bongo nets. The nets were lowered and dragged on the bottom approximately 10 miles off Barra, S.E. of Rio Grande, in the state of Rio Grande do Sul, southern Brasil. Shelly substrates were sampled at 25, 30, and 40 m. *C. protea* was found at 30 m. The shell debris was sorted and specimens of *Crepidula* were returned to the laboratory still attached to their substrates, which were either shell fragments or, more commonly, living specimens of the trochid gastropod *Photinula blakei* (Clench and Aguayo).

The specimens were separated from one another, sexed, and examined for broods of embryos. Shell characters, including size and color, were recorded. All brood capsules were removed from the females, examined in seawater, and their embryos counted using a dissecting microscope. The adult specimens were then frozen for electrophoresis, the results of which are reported elsewhere (Hoagland, 1984). Voucher specimens of *C. protea* are deposited at the Academy of Natural Sciences (ANSP

#355327). The type specimens (shells only) of *Crepidula protea* were examined at the British Museum (Natural History), in order to confirm the identity of the Brasilian material.

Results

There are 16 syntypes of *Crepidula protea* d'Orbigny in the British Museum [BM(NH) reg. no. 1854.12.4]. The locality is given only as Patagonia. One lot of 5 specimens (#573) contains one white and four tan specimens, all arched, with no muscle scar, and with the shelf margin broken. Length of the shells varied from 16 to 32 mm. A second lot of 11 white specimens (#574) contained shells of length 11-29 mm. They agreed in shell phenotype with the first lot. One specimen did have a septal margin intact; it had a notch at the center and at the left corner. The larger specimens were flatter, approaching *C. plana* in appearance.

The shell phenotypes of Brasilian *Crepidula protea* were in agreement with the type material. However, the shell characters that I found to distinguish the Museu Oceanográfico specimens of *C. protea* from those of *C. plana* are few. The internal septum of *C. plana* has a deep notch on the left side near where it joins the shell proper, while *Crepidula protea* has smaller notches located there and at the center of the septum (Fig. 1A). The shell of *C. plana* is thin, white, occasionally with faint orange lines, and flat or slightly convex. The shell of *C. protea* is slightly convex to highly arched, generally smaller but thicker than *C. plana*, and most often tan with reddish-brown lines, although pure white specimens occur (Fig. 1B). Fifteen percent of the 60 live-collected specimens were white.

Table 1 gives the known localities for *Crepidula protea* and *C. plana* based on the Museu Oceanográfico collection. The data support the claim of Rios (personal communication and 1982 ms.) that *C. protea* is found only as far north as Rio de Janeiro, not in the Antilles as thought by Castellanos (1970) and d'Orbigny (1842). The southernmost locality represented in the collection for either species is Miramar, Argentina, although localities to the south are likely.

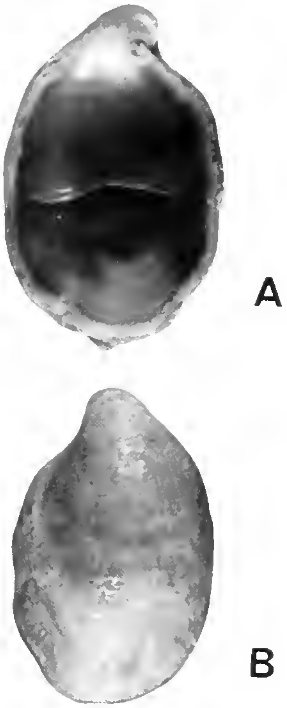

FIG. 1. *The shell of the largest specimen of* Crepidula protea *collected off Rio Grande, Brasil. Shell length = 15.1 mm.* A, *ventral view.* B, *dorsal view.*

One observation distinguishes *Crepidula protea* from all other *Crepidula* I have examined. The egg capsules consisted of an outer membrane containing a sticky matrix in which the embryos were imbedded, making the embryos difficult to remove from the capsules. Other species of *Crepidula*, both species with a planktonic larval stage (e.g. *C. fornicata* (Linnaeus), *C. plana*, *C. onyx* Sowerby) and those which brood through metamorphosis (*C. convexa* Say, *C. aculeata* (Gmelin), *C. adunca* Sowerby), hold the embryos loosely within the thin egg capsule membrane so that the embryos move freely in a watery medium.

Table 2 gives the sex structure of the sample of 60 snails collected off Rio Grande. Most commonly, a male-female pair was found on one piece of substrate, with the male sitting on the right side of the shell of the female in mating position. Specimens of opposite color did form male-female pairs. There were 2 juveniles, 25 males, 2 intermediates undergoing sex change,

TABLE 1. *Localities of specimens of* Crepidula protea *and* C. plana *deposited and cataloged in the Museu Oceanográfico. Localities are arranged approximately north to south.*

Locality	*Species*	*Depth (m)*
BRASIL		
Ile de Itamaracá	*C. plana*	
Cassiporé	*C. plana*	
Sepetiba, R.J.	*C. plana*	
Off Juatinga, R.J.	*C. plana*	40–50
Cabo Iguapé, Sao Paulo	*C. protea*	
Imbituba, S.C.	*C. protea*	
Off Amapá	*C. plana*	45
Off Rio Grande do Sul	*C. protea, C. plana*	20
Farol Conceição, R.G.S.	*C. protea, C. plana*	18
Sul da Barra, R.G.S.	*C. protea, C. plana*	15
Cassino, R.G.S.	*C. protea*	
Farol de Albardão, R.G.S.	*C. protea, C. plana*	25, 35
Chui, R.G.S.	*C. protea*	166
URUGUAY		
Cabo Toloui0	*C. plana*	40
La Coronilla	*C. protea*	
La Paloma	*C. protea*	
Ilha dos Lobos	*C. plana*	
ARGENTINA		
San Antonio	*C. protea, C. plana*	40
370 Parallel	*C. plana*	
Miramar	*C. protea, C. plana*	

TABLE 2. *Sex structure of dredged sample of* Crepidula protea *from a single locality.*

Sex Category	*Number of Specimens*
Juvenile alone	2
Intermediate alone	2
Male alone	5
Male on Female	3 M + 3 F
Male on Female with embryos	17 M + 17 F
Female alone	3 (1 parasitized)
Female alone with embryos	8
	60 total

and 31 females of which 25 (81%) were brooding embryos. The sex ratio of the mature individuals was 45% males. The size range of females was 7.3 to 15.1 mm in length and 4.8 to 9.7 mm in width. Males were 4.6 to 8.0 mm long and 3.8 to 5.7 mm wide. The largest female (Fig. 1) was on a dead shell of *C. protea* that was 20 mm long. The size of each of the other specimens was constrained by the size of the shells used as substrate.

The average number of egg capsules per brood was 31.6 with standard error of 1.1, and with a range of 26 to 48. The largest specimen contained the largest number of egg capsules. One capsule from each of 10 females was counted to determine the average number of embryos per capsule: the mean and standard error were 61 and 8, respectively. The largest specimen contributed greatly to the high variability. It contained capsules of 120 embryos, whereas the range without that specimen was 33-70 embryos per capsule. Electrophoretic study (Hoagland, 1982) confirmed that all specimens belonged to the same species, so one is not justified to remove the larger specimen from the analysis. The average number of embryos per brood was 1,927.

All of the embryos were in the veliger stage or earlier. All embryos in each brood were at a similar developmental stage. Because none of the broods examined were in the egg stage, the diameter of the uncleaved egg of *Crepidula protea* could not be determined. The diameter of a developing embryo was approximately 0.15 mm. The shell diameters of the brooded veligers were not significantly greater than the diameter of earlier development stages, nor did there appear to be less capsule matrix in capsules of more advanced development. The veligers were pinkish in color, unlike the nearly transparent veligers reported for *Crepidula plana* (Hoagland, 1977, p. 390). Facilities for rearing larvae were unavailable, but it appeared that the larvae would be released as veligers. There was no sign of resorption of the velum or enlargement of the foot and shell in any of the 25 broods examined.

Discussion

Crepidula protea as seen in Brasil is the same as d'Orbigny's type material. The dredged specimens were especially like smaller individuals of BM(NH) #574. The species is distinct from *C. plana* primarily on the basis of its egg capsule composition and the shape of the septum. *C. protea* is more variable in shell shape and color than is *C. plana*. Specimens of *C. protea* constrained to a small substrate become highly arched; they reproduce at a small size and have smaller broods than unconstrained specimens. Both the number of egg capsules per brood and the number of embryos per capsule are reduced. In fact, these specimens of *C. protea* are the smallest of the genus that I have seen to produce larvae that are apparently planktotrophic.

An average brood size of nearly 2,000 for *C. protea* can be compared with *C. plana* of New England, about 5,000-8,000 planktonic larvae, and *C. convexa*, about 200 non-planktonic larvae (Hoagland, 1975). Both the number of embryos per capsule and the number of capsules per female *C. protea* were of the order of magnitude expected for a species of *Crepidula* with planktotrophic development. Because one large specimen contained the largest brood, and because the sizes of the dredged specimens were on the low end of the size range seen in museums, I expect that the ~2,000 embryos per brood reported here is at the low end of the range of brood sizes for *C. protea*. The embryo diameter of 0.15 mm is similar to the 0.136 mm reported for eggs of *C. plana* (Conklin, 1897).

The sticky capsule matrix must be investigated chemically to determine if it is a nutritive material that is ingested by veliger-stage or earlier larvae remaining in the capsule. The observation on the broods from southern Brasil do not support the hypothesis, because the capsule matrix did not appear to break down or decrease in volume with the advancement of larval development. Measurement tools available did not detect size increase of embryos within the capsules. However, a full range of larval sizes were not seen, and it is still possible that the matrix is used late in development, or that its composition changes with development.

The size ranges of adult males and females support the notion that, like all other known *Crepidula*, *C. protea* is protandrous. From the scarcity of juveniles present and the large percentage of females brooding embryos, one would expect December to be near the beginning of a breeding season. The presence of several brooding females without males shows that mated pairs are not permanent, although stacking of at least 3 specimens (one a dead specimen) was observed. No obvious growth lines were found on the shells to indicate age of the large stacked specimens, although most of the smaller specimens had a single growth discontinuity near the shell margin.

The distribution of all species of *Crepidula* in the southern Atlantic is limited because of the lack of suitable substrate. Only in mudflats or on scallop or oyster beds (as in Mar del Plata and San Antonio, Argentina) are *Crepidula* abundant and in shallow water. Dredging off Rio Grande demonstrated that specimens of *C. protea* are patchy. No specimens of *C. plana* were collected, so anatomical comparisons of the two could not be done. However, museum records do document the sympatry of the two species off Rio Grande.

Four living specimens of *Crepidula aculeata* were collected together with those of *C. protea*. Body pigment patterns, shell characters, and electrophoretic patterns confirmed that this is the same species as *C. aculeata* from Florida. Brasilian museum records document a nearly continuous distribution of *C. aculeata* from Florida to Mar del Plata, Argentina. No other species of *Crepidula* besides *C. plana* and *C. aculeata* are known to coexist with *C. protea* in southern Brasil; however, at least two species, *C. onyx* and *C. dilatata* Lamarck from the Chilean fauna, overlap at Mar del Plata (Parodiz, 1939).

The factors that limit the north-south distribution of *Crepidula protea* relative to other species of *Crepidula* are unknown, especially in the light of the discovery of a planktonic larval form. One would expect phoresis of adults in addition to larval dispersal, because of the small size and sedentary habits of *C. protea*, and its apparent preference for settling on other living gastropods. However, the relatively greater known range of *C. plana* may be revised downward if some southern populations turn out to be sibling species when they are examined biologically. At this time it must be concluded that *Crepidula protea* is a South American species endemic to southern Brasil, Uruguay, and Argentina.

ACKNOWLEDGMENTS

This work, particularly the dredging of live specimens, would have been impossible without the arrangements made by Prof. E. Rios of the Museu Oceanográfico Rio Grande do Sul. R. Capitoli and G. M. Davis assisted in collecting the specimens. P. Mordan of British Museum (Natural History) made available the types of *Crepidula protea*. The manuscript was read and criticized by G. M. Davis and R. Robertson. Funding was provided in part by a Fleischmann Foundation grant to the Wetlands Institute, Stone Harbor New Jersey. I appreciate the hospitality of S. and R. Capitoli during my stay in Rio Grande.

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THE FRESHWATER NAIAD (MUSSEL) FAUNA OF THE NOLIN RIVER IN THE GREEN RIVER DRAINAGE OF CENTRAL KENTUCKY (MOLLUSCA: BIVALVIA)

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ABSTRACT

A survey of the freshwater mussels (naiads) of Nolin River of the Green River, Kentucky, drainage, produced specimens of twenty-one species of naiads, and the Asian Clam, Corbicula fluminea. *Six of the species reported from the Nolin are considered Endangered or of Special Concern by the Kentucky Academy of Science.* Villosa ortmanni *is considered endangered by most malacologists because it is restricted in distribution to the Green River drainage. At present, however, it is the most commonly found species in the Nolin River.*

Ortmann (1926) recognized the importance of the Green River as a freshwater mussel stream. Individuals were abundant, species were numerous. The typical Ohioan fauna of this stream was identical with the Kentucky River and other Ohio River tributaries to the north, but distinctly different from the Cumberlandian fauna of the Cumberland and Tennessee Rivers just to the south.

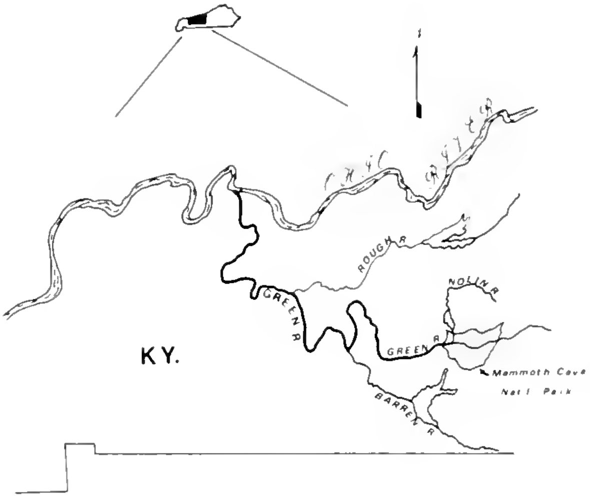
Clench and van der Schalie (1944) did additional work on the mainstem Green River and made extensive collections in several major tributaries, such as the Nolin, Barren and Rough Rivers. Additionally, during the 1950's and 1960's David Stansbery (1965) and others from Ohio State University collected extensively in the Green River. Their work, including that of their predecessors, produced a list of 64 species resident in the Green River drainage and led Stansbery (1965) to state that the mussels in the Green River . . ."comprise the finest representative Ohioan naiad fauna yet in existence."

Within the last twenty-five years adverse effects of damming have come to the unique Green River. At the present time all the major tributary headwaters, including the mainstem, have been dammed. While no studies documenting a concommitant decline in mussel populations have been forthcoming, it must be assumed, based on numerous other studies, that the dams will have deleterious effects.

The dams and the large lakes behind them, which are unsuitable habitat for most stream forms, are formidable barriers and restrict the free flow of host fish species between the mainstem Green River and tributary headwaters. The full long-term effect of such barriers has not yet been documented. Baseline data on the mainstem Green River are readily available through the works of the previously-mentioned authors. There is, however, a dearth of recent information available on some of the major tributaries.

Clench and van der Schalie (1944) collected the Barren River extensively and composed a list of 36 resident species. Their work at two stations on the Rough River netted 22 species, and limited collecting on the Nolin River produced only 8 species. I have been unable to find additional papers on this drainage, and in this paper an attempt is made to fill a gap in the data base. The only previous collections on the Nolin reported in the literature were made nearly forty years ago and prior to impoundment of the river. This paper reports on extensive collecting in the river, above Lake Nolin, during the summer of 1981.

The Nolin River is one of two major tributaries of the Green River which enter from the north. The Nolin originates in the Mississippian Plateau Province of central Kentucky. The origin in Larue Co. is located a few miles south of the Abraham Lincoln Birthplace National Historical Site. The river then flows through Hardin, Grayson and Edmonson Counties to its confluence with the Green River within the confines of Mammoth Cave National Park.



Collecting Stations

1. Nolin River at White Mills, Hardin County, Kentucky, two miles E of State Rt. 84 on County Rd. 1904.

2. Nolin River, four miles due west of village of Flint Hill on State Rd. 720 on Hardin/Grayson Co. line. (This site roughly corresponds to one site reported by Clench and van der Schalie.)

3. Nolin River at Millerstown, at intersection of State Rt. 224 and 479. (Extremely rich area for several hundred meters above and below the bridge.)

Numerous other sites were visited, but these three were by far the most productive. The Millerstown site is to the Nolin River what Munfordville is to the Green River, the site where all conditions seem to be prime for mussel habitation.

Naiad Species Recorded from the Nolin River

1944 = Previously recorded (Clench and van der Schalie, 1944). 1981 = Recently collected (Taylor, 1981).

Strophitus u. undulatus (Say, 1817)	1944; 1981
Alasmidonta viridis (Raf., 1820)	1981

Lasmigona costata (Raf., 1820)	1944; 1981
Tritogonia verrucosa (Raf., 1820)	1981
Quadrula cylindrica (Say, 1817)	1981
Quadrula p. pustulosa (Lea, 1831)	1981
Amblema p. plicata (Say, 1817)	1944; 1981
Fusconaia m. maculata (Raf., 1820)	1981
Fusconaia flava (Raf., 1820)	1944; 1981
Cyclonaias tuberculata (Raf., 1820)	1981
Pleurobema sintoxia (Raf., 1820)	1981
Elliptio dilatata (Raf., 1820)	1944; 1981
Ptychobranchus fascioluris (Raf., 1820)	1981
Actinonaias l. carinata (Barnes, 1823)	1981
Villosa ortmanni (Walker, 1925)	1981
Lampsilis r. luteola (Lam., 1819)	1944; 1981
Lampsilis ventricosa (Barnes, 1823)	1981
Lampsilis fasciola (Raf., 1820)	1981
Epioblasma triquetra (Raf., 1820)	1981
Epioblasma cincinnatiensis (Lea, 1840)	1981
Epioblasma torulosa rangiana (Lea, 1839)	1981
Corbicula fluminea	1944; 1981

Clench and van der Schalie reported *Villosa lienosa* and *L. ovata*, but I did not find them.

Discussion

A total of twenty-one species of naiads plus the exotic Asian Clam is about what could be expected from a stream of this size in this part of the country at the present time. The stream is unique in that it contains a good number of species of concern to contemporary biologists. The State of Kentucky does not have an official Rare and Endangered List, but the Kentucky Academy of Science (Branson et al., 1981) has recently produced a list of Endangered, Threatened and Rare Animals of the State. This list includes the following Endangered species found in the Nolin River: *Quadrula c. cylindrica* (Say, 1817), *Fusconaia m. maculata* (Raf., 1820), *Epioblasma torulosa rangiana* (Lea, 1839), *Villosa ortmanni* (Walker, 1925). *Epioblasma triquetra* (Raf., 1820) is a species which should be monitored, as it may, for a variety of reasons, become endangered.

Quadrula c. cylindrica

Found only in the area of White Mills and only as fresh dead shells. This species may very well be on the way out in the Nolin River. It is absent throughout most of its former range.

Fusconaia m. maculata

Fairly common throughout the study area.

Epioblasma torulosa rangiana

Found at only the Millerstown site, but several dozen freshly dead specimens were taken from a raccoon midden at this locality.

Epioblasma cincinnatiensis

Found only as a badly eroded single valve at the Millerstown site.

Epioblasma triquetra

Represented at two sites by a single specimen each. Apparently very rare in this stream.

Villosa ortmanni

Known only from the Green River drainage and thus deserves the designation of Endangered. It is, however, doing quite nicely within the Nolin River. In total numbers it is by far the most common mussel found in this study and hundreds of specimens were found at each of the stations mentioned above. Stansbery related (pers. comm.) that the nacre of Green River specimens is always orange, but the nacre of all the Nolin River specimens is violet to deep-purple.

All other species in the composite list were found in fairly good numbers at several stations.

I did not find *Lampsilis ovata* which was reported by Clench and van der Schalie. All my specimens were typical *ventricosa*. I did, however, find several specimens of *L. ovata* with the strongly acute posterior ridge characteristic of this species in a single collection from the Green River, approximately ten miles upstream of Munfordville. In the spirit of working with animals that are all under the threat of reduced numbers, no live specimens were taken if a fresh dead one could be collected for a voucher specimen. Voucher specimens have been accessioned to the Marshall University Malacological Collections and the Ohio State University Museum of Zoology.

ACKNOWLEDGMENTS

Many thanks to Dr. David H. Stansbery of the Ohio State University Museum for identification and confirmation of some of my specimens.

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AN ADDITIONAL RECORD OF LIVING *ORYGOCERAS* (HYDROBIIDAE) FROM TEXAS

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ABSTRACT

The uncoiled hydrobiid Orygoceras, *known only from the fossil record until Taylor (1974) discovered a living population in Real County, Texas, was collected in Williamson County, Texas, extending the known range of the living population 230 km northeastward. The nature of its occurrence in Williamson County supports the theory that* Orygoceras *lives interstitially in a hypogean, phreatic environment. The range extension implies that* Orygoceras *is widely distributed across the southern Edwards Plateau, but is seldom encountered due to its specialized habitat.*

The uncoiled shell named *Orygoceras* by Brusina (1882) was known only as fossils from late Tertiary deposits in southeastern Europe and southern Idaho, until Taylor (1974) made the astonishing discovery of several hundred fresh, adult shells and a single living specimen in Roaring Springs, Real County, Texas. In February, 1982 I collected an additional fresh shell in the headwaters of a small reservoir on South Brushy Creek, Williamson County, Texas, extending the known range of the living population 230 km northeastward (Fig. 1).

Taylor (1974) declined to name the Roaring Springs *Orygoceras* based on only one live specimen. However, he described the morphology of the body and shell in detail, and demonstrated that the Texas *Orygoceras* is one of the Hydrobiidae, much like *Horatia*. The Williamson County shell (Fig. 2) closely conforms to Taylor's account of shells from Roaring Springs, and is most likely conspecific.

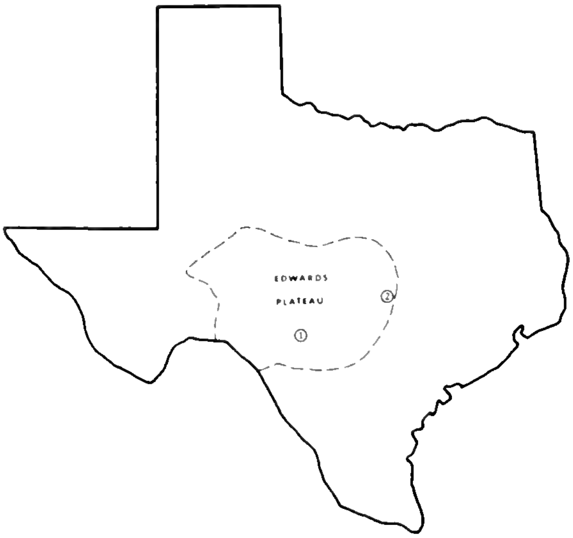

FIG. 1. *Locality records for* Orygoceras *species in Texas.* 1, *Roaring Springs, Real County (Taylor, 1974).* 2, *Avery Lake, Williamson County (this report).*

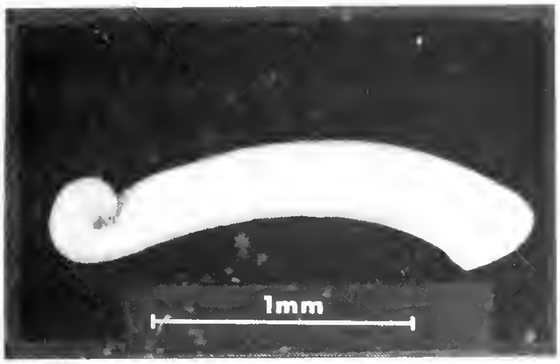

FIG. 2. *Shell of* Orygoceras *species from Avery Lake, Williamson County, Texas.*

Both existing localities are small, limestone stream systems incised deeply enough to intersect the water table, thus supporting perennial flow. The new shell was taken from the headwaters of Avery Lake, a small mainstream impoundment, among much shell debris (including *Physa virgata, Biomphalaria obstructa, Gyraulus parvus, Helisoma anceps, Pyrogophorus coronatus, Gundlachia radiata*, and several terrestrial species), undoubtedly having been washed into the reservoir from an upstream source.

Taylor (1974) proposed that *Orygoceras* exists interstitially in a hypogean, phreatic environment (i.e., in groundwater strata), rather than being crenobiontic (i.e., living in springs), and probably does not exist in the open spaces of cavernous groundwater formations. His theory was based on the fact that Roaring Springs specimens were found only close to the outflow from the water table, occurred interstitially in gravel, totally lacked eyes, and were collected after a period of heavy rainfall which probably flushed them from beneath the ground. Also, the tubular shell appears to be an adaptation to an interstitial existence, enabling a snail of given size to pass through smaller spaces in gravel or coarse sand than it could otherwise. The new record supports Taylor's theory in that there are no major springs in the Avery Lake watershed from which *Orygoceras* could have originated. Thus, it was probably flushed from the interstices of an exposed water-bearing formation. Additionally, no *Orygoceras* have been collected during extensive investigations on the fauna of major springs issuing from the cavernous Edwards Aquifer in southcentral Texas (G. Longley, Edwards Aquifer Data and Research Center, *personal communication*).

The discovery of *Orygoceras* in Williamson County implies that the living population is widely distributed across the southern portion of the Edwards Plateau; numerous physically similar habitats exist throughout the region. The paucity of locality records is probably due to the specialized habitat, in which *Orygoceras* is difficult to detect.

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DEATH

We greatly regret to report the death of Gordon K(utchka) MacMillan, retired malacologist, on November 27, 1981 in Pittsburgh, PA. He was born May 18, 1906 in Mueleim, Germany. He was an Associate Curator of Mollusks at the Carnegie Museum from 1929 to 1951. Gordon served as a water chemist with the Sanitary Authority of Allegheny County for 20 years before his retirement. He was a former President of the Pittsburgh Shell Club, and was best-known for his book on *The Land Snails of West Virginia*. He is survived by his widow, Mary Louise Jeffrey MacMillan. (See American Malacologists, 1973, p. 352.).

THE UNIONIDS (BIVALVIA) OF LOCH RAVEN RESERVOIR, MARYLAND

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ABSTRACT

A six-year study of the unionid populations at Loch Raven Reservoir, Maryland, Baltimore's principal source of drinking water, indicates diversified habitats for living Anodonta cataracta, A. imbecillis *and* Lampsilis radiata.

In 1971, while casually wading near the Fishing Center boat docks at Loch Raven Reservoir, I found two small naiads and, at the same time, began a six-year informal study of fresh water clams in this impoundment which serves as Baltimore's principal source of drinking water.

The Reservoir

Loch Raven is an impoundment of the Gunpowder Falls, a stream which flows from the uplands of Baltimore County into the upper Chesapeake Bay. The course of this stream is interrupted by two spillways, one about thirty feet high and the other over seventy-five feet high. The latter is situated one-half mile upstream from the first and was constructed in the 1940's. City use of fresh water had kept the reservoir within confines, while allowing for a constant flow of water over the upper spillway and into the lower impoundment.

In 1974 the level of the reservoir was temporarily lowered to construct an additional feeder line to the Baltimore water works. As a result, subsequent periods of drought caused water levels in the impoundment to drop far below normal summer pool, altering the shoreline habitat.

Collecting Sites

(1) Deadman's Cove, situated just south of the point where Dulaney Valley Road crosses Loch Raven Reservoir, is a favored fishing spot affording easy access to gently sloping substrate of coarse gravel and sand covered by a thin layer of silt and low mossy vegetation.

(2) The main channel of Gunpowder Falls, south of Dulaney Valley Road bridge, where a steep bank was cut in the flood plain prior to impoundment. The substrate is composed of a dense combination of coarse sand and clay from the normal summer pool shoreline to the steep bank and covered by a thin layer of silt.

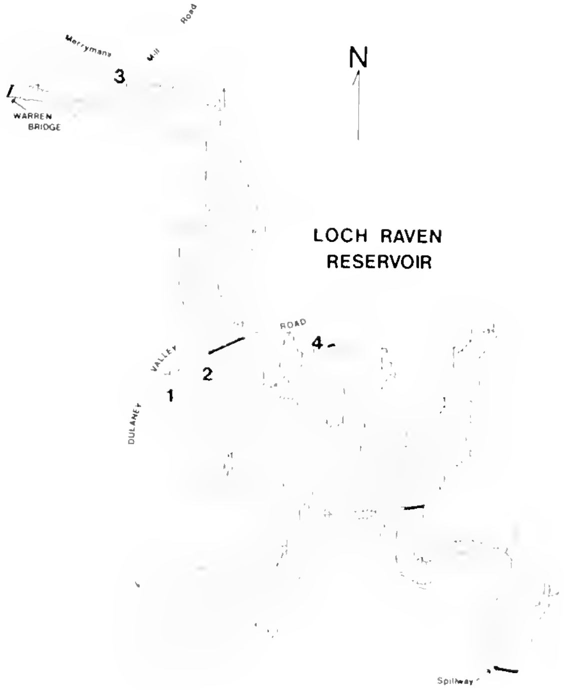

FIG. 1. *Map of Loch Raven Reservoir, Baltimore, Maryland, showing the four collecting sites for unionids.*

(3) East of Warren Bridge is a small cove fed by a series of small streams. The substrate at this site is similar to that in Deadman's Cove but with greater irregularity, including narrow channels, rock formations and a deeper layer of silt.

(4) The Fishing Center is located at a semicircular basin of shallow water and the substrate here is also similar to that at Deadman's Cove.

Unionid Populations

Three species of mussels, an aggregate of over 600 specimens, were collected at these four sites between 1971 and 1977. They are, in order of abundance, *Anodonta cataracta cataracta* Say 1817; *Lampsilis radiata radiata* (Gmelin 1791) and *Anodonta imbecillis*, Say 1829. Ninety percent of the specimens were dead, half of these recently expired due to receding water levels.

Anodonta cataracta cataracta is represented by a full range of shell forms from elongate to short and high forms. Specimens were collected representing numerous stages of growth from semi-transparent juveniles 36 mm in length to mature specimens over 144 mm in length. More than 75% of the shells collected during the study period are of *A. c. cataracta*. They were found in quantity at each site.

Lampsilis radiata radiata specimens were next in abundance. As with *A. c. cataracta*, self-sustaining populations are implied in this collection sample. Mature, sexually dimorphous specimens and juveniles at various stages of growth are included in the sample.

Anodonta imbecillis was found at two sites and in a growth series that would also suggest a viable, self-sustaining population.

Observations

Heaps of dead shells were found in 1972, submerged under at least one-half meter of water in favored hiding places for large fish. No evidence of muskrat or raccoon predation was apparent. This would suggest that these densely populated mussel beds were established as a result of glochidia-laden host fish returning to favored hiding places long enough for mature larvae to drop into the substrate and develop.

The two species of *Anodonta* were very active in the substrate, particularly as water levels were reduced due to drought and increased piping of impounded water to Baltimore filtration plants. When they were found in water more than one-half meter deep, their mobile habits were circuitous and random. When water levels were less than one-half meter deep, the mussels set out in far straighter courses of movement, giving the impression that there was deliberate effort expended to reach deeper water. Perhaps there is some sensory mechanism possessed by these clams that can measure variation in water pressure resulting from water depths. Or perhaps there is a thermal condition which stimulates the clam to seek cooler and thereby deeper water.

When water levels dropped very rapidly in well-established areas of clam population, few specimens were observed to migrate from their burrows. Nearly all the clams closed up to avoid dehydration. Perhaps this behavior is a more radical thermal response. Juvenile specimens of *Anodonta c. cataracta* were as adept as nearly mature specimens of *Anodonta imbecillis* at traversing large areas of deep silt, demonstrating a condition of specific gravity only slightly heavier than water itself. This factor would contribute to the survival of *A. c. cataracta* and *A. imbecillis* in the placid waters of lakes and ponds.

When *A. c. cataracta* specimens were removed from the reservoir and placed upright in pans filled with their native substrate material and water, the incurrent/excurrent function of their siphons caused such a dynamic movement of water that a pronounced undulation of the water surface was created. This phenomenon seemed to demonstrate clearly that these *Anodonta* specimens would be able to survive in very still water because of their own ability to pump enormous amounts of food-laden water through their filtering systems. This circumstance would, then, allow *A. c. cataracta* to prosper in a healthy reservoir environment. A large *A. c. cataracta* specimen (140 mm in length) was placed in a home aquarium fitted with a filter. The specimen was observed for 8 months before it apparently starved to death. During the period of survival in the aquarium, the mussel absorbed virtually all of its body tissue before expiring. One could conclude from this that a mature and healthy *A. c. cataracta* could survive prolonged periods of unfavorable conditions in a natural environment which withheld nutrition but which did not cause suffocation or dehydration.

All *Lampsilis radiata radiata* specimens were found living in substrate normally submerged by deeper water than that in which the bulk of *Anodonta* specimens were found; no less than two meters. Clams living in substrate covered by three or more meters of water were inaccessible. Therefore, no reliable conclusions can be drawn regarding any overlap of *Lampsilis* and *Anodonta* populations. All *Lampsilis* specimens were found at the edge of the swiftest available current in the area. Over sixty percent of the *Lampsilis* specimens were found at the Dulaney Valley Raod bridge site where the original stream bed had been cut to form a steep-banked channel between Dulaney Valley Road bridge and Deadman's Cove. Nowhere is there stronger or more consistent current in the entire impoundment, except at the exit point of the pipelines which supply the Baltimore waterworks.

Sincere personal thanks are due to Dr. David Stansbery who has characteristically offered helpful and unselfish guidance, and identified specimens for this project. Specimens have been deposited in the Museum of Zoology, Ohio State University.

AXIAL SHELL RIB COUNTS AS SYSTEMATIC CHARACTERS IN *EPITONIUM*

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ABSTRACT

Epitonium albidum *is shown to have from 15 to 10 axial shell ribs per whorl, with a clear trend for very small shells to have the most ribs. This is because several ribs commonly are crowded together at the beginning of the teleoconch. Soon thereafter, the number of ribs per whorl tends to become invariable. There usually are 13, 12 or 11 ribs that are lined up and attached from one whorl to the next. The much smaller species* E. echinaticostum *has from 15 to 6 ribs per whorl. Again, very small shells have the most ribs. In this species there is no consistency about the ribs being lined up from whorl to whorl (the whorls can be disjunct), and the rib counts decrease throughout life. It is recommended that rib count data in epitoniid systematics be based on larger samples of shells, and that, in order to take into account ontogenetic changes, the ribs on each teleoconch whorl (or on the last whorl at each shell length) be analyzed separately.*

It is standard practice in *Epitonium* systematics for the number of axial shell ribs (= costae; = varices) on the last whorl of a species to be recorded – either as a single number or as a range. It has been shown elsewhere (Robertson, 1983a) that starvation can sometimes cause a few ribs to be abnormally closely spaced, thereby affecting rib counts. The purpose of this paper is to present data showing that in at least two species of *Epitonium* the number of ribs per whorl changes ontogenetically. Recommendations are made on what rib count data are henceforth needed in *Epitonium* systematics.

The shells of one of the species studied here – *Epitonium echinaticostum* (Orbigny, 1842) – have already been studied and commented upon by Clench and Turner (1951:253–255, pl. 109). According to them there are "from 7 to 13 costae [ribs] on the body whorl." Later, they stated that the ribs "vary in number, possibly dependent upon the rate of growth. Specimens from deeper water usually possess fewer costae [ribs] and are somewhat thinner in structure than those occurring in the low tidal areas or just below the low water line." Also according to Clench and Turner (1951:260), the other species studied here–*E. albidum* (Orbigny, 1842)–has "12 to 14 costae [ribs] on the body whorl . . ."

Materials and Methods

The observations were made incidental to life history studies of single populations of two tropical western Atlantic species, *Epitonium albidum* at southern Virgin Gorda, British Virgin Islands, and *E. echinaticostum* at Freeport, Grand Bahama Island, Bahamas. Further information on the localities and habitats is given elsewhere (Robertson, 1983b; 1983c).

There is subjectivity in counting *Epitonium* ribs. When these are not consistently lined up and joined from one whorl to the next, as on the earliest teleoconch whorl of *E. albidum* and on all whorls of *E. echinaticostum*, one has to estimate which of two ribs near the beginning of the last whorl is closest in alignment with the outer lip rib, and to begin counting with the next rib. The aligned ribs of mature *E. albidum* pose a different problem: they are prosocline and they therefore spiral counterclockwise up the spire as viewed apically (Robertson, 1983a, fig. 1). As a result, malacologists tend to count ribs on slightly less than one whorl. Continual reference has to be made to the placement of the first teleoconch rib at the apex. The beginning of each whorl, determined with reference to this first rib, is best marked on the appropriate rib with a light graphite pencil mark.

A large sample (= 128) of *Epitonium echinaticostum* was available, comprising specimens of all sizes except the tiniest juveniles. Last whorls of these were studied, and whorl counts were compared with shell lengths. A smaller sample (n = 42) of *E. albidum* was available, with few small juveniles. Each teleoconch whorl of each intact *E. albidum* shell was therefore studied, with each rib count recorded separately.

Voucher specimens: a small part of the sample of Freeport *Epitonium echinaticostum* is preserved in alcohol at Acad. Nat. Sci. Philadelphia A9513 (one dry shell ANSP 355872). The Virgin Gorda *E. albidum* shells were all dissolved in Bouins for other purposes.

Results

Data on Virgin Gorda *Epitonium albidum* are given in Fig. 1. The number of ribs on the first whorl ranges from 15 down to 12 (11 once), while on succeeding whorls it is from 14 to 10 (most commonly 13 to 11). The mean drops from 13.0 on whorl one to 11.8 on whorl two. The counts on first whorls are high because the first several ribs at the beginning of the teleoconch, grown during or immediately after metamorphisis of the planktotrophic veliger to a benthic, sea anemone-feeding postlarva, are commonly more closely spaced there than elsewhere. Ribs per whorl thereafter are nearly constant because each one is usually lined up and attached from one whorl to the next.

Data on Freeport *Epitonium echinaticostum* are given in Fig. 2. The range in number of ribs per whorl is 15 to 8, with a clear trend for rib numbers to decrease with increasing shell size throughout life. The mean on shells 1 mm long was 13.7; on shells 6 mm long it was 9.7. In other populations large shells have still fewer ribs: 7 according to Clench and Turner (1951: 253) and 6 on ANSP 253080 (Elbow Cay, Great Abaco, Bahamas) and USNM 797999 (Dania Beach, Florida). Due to corrosion and incrustations of the Freeport shells it was not possible to count ribs on first teleoconch whorls (they possibly go above 15). In this species the ribs are not consistently lined up from one whorl to the next (the whorls can be disjunct), which helps to explain why their number does not become nearly invariable from whorl to whorl as in *E. albidum*.

Conclusions

Epitoniid rib counts are usually based on too few shells (with the sample sizes unstated), and without regard for possible ontogenetic or environmental changes. Data such as given in Fig. 1 can be based on each whorl of all intact shells. When a good growth series is available, or perforce when the ribs on the early whorls are not countable, data such as given in Fig. 2 can also document the variation and trends.

Although starvation can change the spacing of *Epitonium* ribs (Robertson, 1983a), it seems unlikely that this is a major cause of rib count variation in nature. Starvation is probably rare for a parasite with a large or abundant host. Besides, only a few ribs at a time are likely to be affected. Allowing for ontogenetic change and

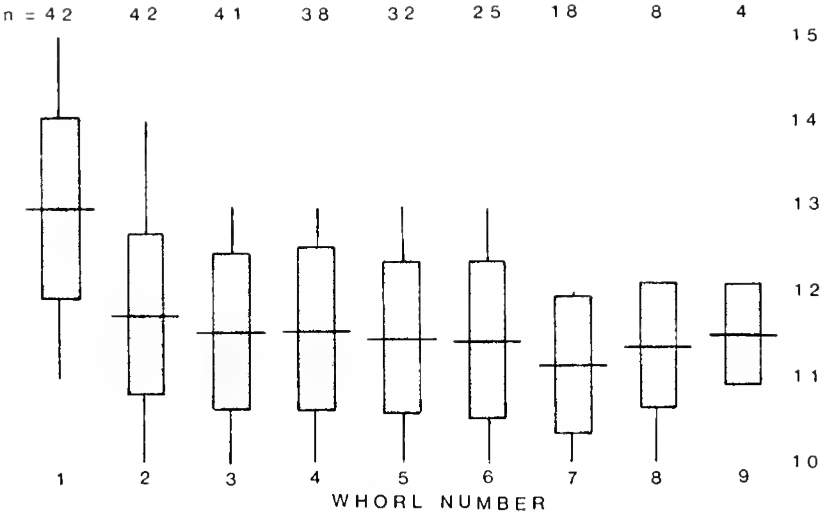

FIG. 1. Epitonium albidum: *rib frequencies per whorl on each whorl. The horizontal lines show means, the vertical stippled boxes show ± one standard deviation and the vertical lines show ranges.*

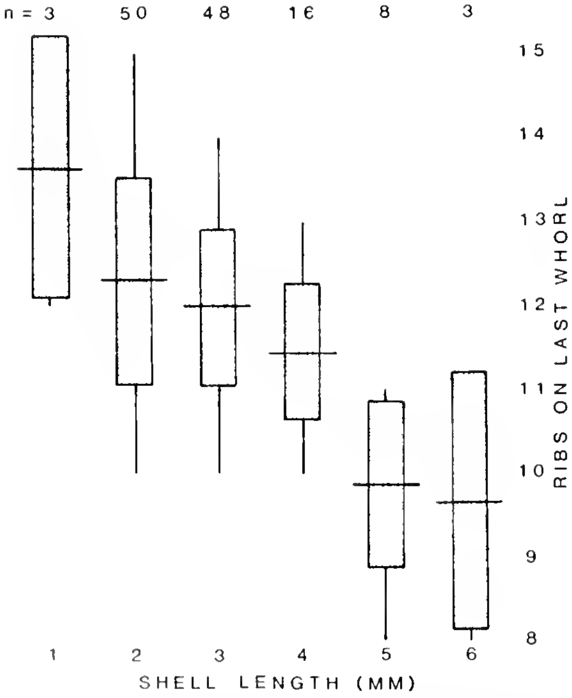

FIG. 2. Epitonium echinaticostum: *rib frequencies on last whorls of different shell lengths. The horizontal lines show means, the vertical stippled boxes show ± one standard deviation and the vertical lines show ranges.*

natural variation, epitoniid rib counts are still good taxonomic characters. It remains to be verified whether growth rates or ecology affect rib counts, as suggested for *Epitonium echinaticostum* by Clench and Turner (1951).

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I am grateful to Jack Worsfold (Freeport, Bahamas) for helping to make possible my studies of *Epitonium echinaticostum*. The following kindly read and criticized various drafts of the manuscript: Dr. Arthur E. Bogan, Dr. George M. Davis, Virginia Orr Maes and Dr. Joseph Rosewater, USNM. My personal bank account helped to support this research.

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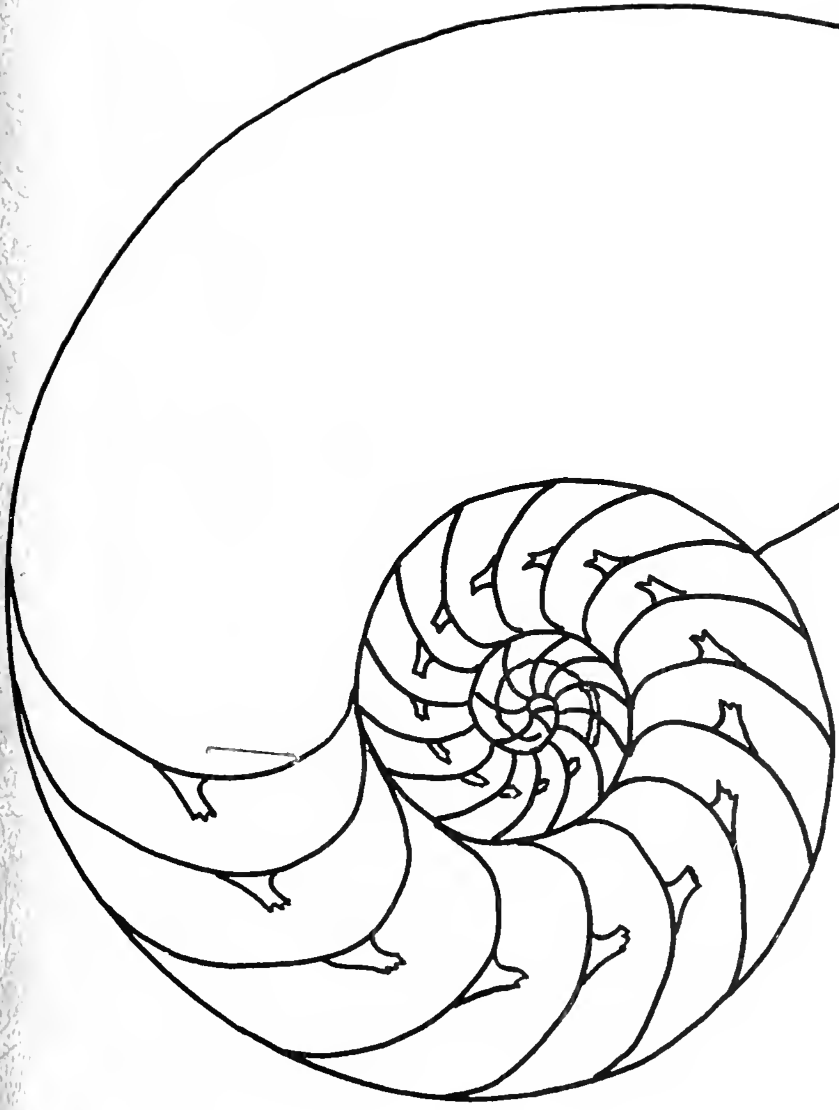

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CONTENTS

NEW RECORDS OF PROSOBRANCH GASTROPODS FROM PACIFIC PANAMA

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ABSTRACT

Recent collecting has revealed the presence of five species of marine prosobranchs not previously known to occur on the Pacific coast of the República de Panamá. Three are Indo-Pacific faunal elements, Conus chaldeus, Cypraea talpa *and* Mitra mitra. *One is a circumtropical species,* Cymatium muricinum; *and one is a Panamanian faunal constituent,* Cypraecassis tenuis. *Ten prosobranch gastropods with Indo-Pacific faunal affinities, including the three taxa newly recorded here, are now known to occur in the Pacific waters of Panama. The distribution of these species elsewhere in the eastern Pacific Ocean is reviewed.*

Through the good offices of James Ernest, proprietor of Panama Specimen Shells of Balboa, República de Panamá, a number of zoogeographically interesting records have come to light among the prosobranch gastropods submitted to me for study. These records include the first known specimens from the Pacific coast of Panama of such characteristic Indo-west Pacific species as *Cypraea talpa* Linné, *Cymatium muricinum* (Röding), and *Mitra mitra* (Linné). Additionally, Royce E. Hubert, a long-time shell dealer and resident of Panama, has generously contributed valuable material, including Panamanian records for *Conus chaldeus* (Röding) and *Conus tessulatus* Born.

A living specimen of *Cypraea talpa* (figures 13, 14), obtained by Mr. Ernest in the Golfo de Veraguas, is the first record for this Indo-Pacific species on the west American mainland.[1] A live-taken specimen of *Cymatium muricinum* (figures 15, 16), dredged off Isla Gobernadora, Golfo de Montijo, in 12 to 18 meters, confirms the presence of this circumtropical species on the western American continental borderland. This well-known Indo-Pacific and western Atlantic species was previously recorded in the eastern Pacific only in the Galapagos Islands (Emerson, *in* Radwin, 1969, p. 235). Several living specimens of *Mitra mitra* (figures 11, 12) were collected by Mr. Ernest in the Golfo de Veraguas, Golfo de Montijo, and the Golfo de Panamá. This wide-ranging Indo-Pacific faunal constituent was previously recorded in the eastern Pacific in the Galapagos Islands (Sphon, 1976, p. 63; Emerson, 1978, p. 93), on the Pacific coast of Costa Rica (Sphon, 1976, p. 63) and on Isla Gorgona, Colombia (von Cosel, 1977, p. 422). Mr. Ernest also found a living, mature example of *Cypraecassis tenuis* (Wood) (AMNH 206085) off Isla Canal de Afuera, Golfo de Veraguas, under coral in about 3 meters. This Panamanian faunal species was known from Baja California, the Islas Tres Marías, and Tehuantepec, Mexico (AMNH 135260) and in Peru (LACMNH loc. #74-6, *teste*, J. H. McLean), as well as from the Galapagos Islands and Clipperton Island (Emerson and Old, 1963, p. 13; Abbott, 1968, p. 75). The present specimen appears to be the first record for Panama.

Specimens of *Conus chaldeus* were first reported by Mr. Hubert in May, 1979. They were found living on rocks exposed by extreme low tides in the Golfo de Montijo (figures 7, 8) and were obtained by Mr. Ernest in 1982 in the Golfo de Veraguas, on dead coral in shallow water by snorkeling. This Indo-Pacific species is known elsewhere in the eastern Pacific in the Galapagos Islands, on Clipperton Island and on Isla del Caño, Costa Rica (LACMNH loc. #72-68, *teste*, J. H. McLean) and Colombia (von Cosel,

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[1] Donald R. Shasky (*teste*, Aug. 3, 1983), however, recently collected several living specimens of *Cypraea talpa* on Cocos Island, for the second known occurrence of this species in the eastern Pacific Ocean. [See his article in this issue – ed.].

1977, p. 423). The first specimens of *Conus tessulatus* (figures 1-6) were obtained by Mr. Hubert in the Golfo de Panamá in 1975 (Emerson, 1978, p. 93). Subsequently, specimens were collected in some numbers, especially at night during low tides, crawling on coral sand in the Archipielago de Perlas, Golfo de Panamá (H. DuShane, *in litt.*, 1982). This Indo-Pacific species is also known in the eastern Pacific on the oceanic islands (Clipperton and Clarion; Emerson, 1978, p. 93) and off Cabo Pulmo, Baja California Sur, Mexico (Sally Bennett coll., *teste* C. Skoglund).

Resident collectors believe these Indo-Pacific faunal elements are recent arrivals to the local waters. It seems more likely, however, that the extensive collecting now being undertaken in the area is responsible for the discovery of these "Indo-Pacific immigrants". *Cypraea teres* Gmelin (figures 9, 10), for example, was not found locally before 1975 by Mr. Hubert (*in litt.*, 1975). In fact, specimens of *Cypraea teres* had been collected by Alan Hancock Pacific Expeditions in the Golfo de Chiriquí in 1934 and 1935, but these records were not reported until some 34 years later (Bakus, 1968). As more attention is given to the faunas associated with the coral-reef biotype in eastern Pacific tropical waters, additional Indo-Pacific faunal elements can be expected to be encountered (Emerson, 1967, p. 90). The present records largely support this thesis. *Mitra mitra*, *Cypraea talpa*, *Cypraea teres*, and *Conus chaldeus* were found in areas of dead coral, coral sand and fine sand adjoining patches of living coral at Isla Canal de Afuera, Golfo de Veraguas. In similar habitats near Isla Cébaco, *Mitra mitra*, *Cypraea teres* and *Conus chaldeus* were collected. *Mitra mitra*, *Conus tessulatus* and *Cypraea teres* were obtained on coral sand in the Archipiélago de las Perlas, Golfo de Panamá. Von Cosel (1977) reported *Mitra mitra* and *Cypraea teres* living in sandy substrates on the shore-side of a coral reef on Isla Gorgona, Colombia.

The vast majority of the 49 species of prosobranch gastropods with Indo-Pacific faunal affinities now recognized as inhabitants of eastern Pacific waters occur only on the offshore islands, namely Clipperton (with 32 taxa), Revillagigedo (6 taxa), Cocos (4 taxa), Galapagos (9 taxa), and Guadalupe (1 taxon). Only 15 of these species (31%) are known to occur on the continental shelf of west America (Emerson, 1978, 1982, and herein; Robertson, 1979; Shasky, 1983). Verified records of the 10 Indo-Pacific species known from Pacific Panama are enumerated below. None of these species or the other 39 Indo-Pacific species living in the eastern Pacific has been recognized as fossils in the Western Hemisphere, including constituents of the recently discovered faunas of four Neogene basins on the west Mexican coast (Durham, *et al.*, 1981; M. C. Perrilliat, *in litt.*, 1982). Furthermore, no Indo-Pacific mollusks have been recovered from Mesoamerican archaeological sites (*teste*, L. H. Feldman, *in litt.*, 1980). The only molluscan fossil evidence for the temporal existence of the Indo-Pacific element in west America is the presence of *Cypraea cernica* Sowerby in the Pleistocene of Guadalupe Island (Lindberg, *et al.*, 1980) and *Hastula albula* (Menke) in the Miocene of California, a species that also inhabits the Revillagigedo Islands (Bratcher and Burch, 1971). Although the random distributional patterns expressed by the Indo-Pacific species living in the eastern Pacific suggest introduction into these waters largely by long-distance larval dispersion from populations in the central Pacific, there is little direct biological or paleontological evidence to substantiate this postulation.

(On opposite page)

FIGS. 1–14. *Prosobranch gastropods with Indo-Pacific faunal affinities occurring in Pacific Panama waters; all natural size.*

FIGS. 1–6. Conus tessulatus *Born.* **1, 2,** *Isla Pedro Gonzales, AMNH 203266.* **3, 4,** *Isla Membrillos, AMNH 183218.* **5, 6,** *Isla Boyarena, AMNH 206080.*

FIGS. 7 *and* 8. Conus chaldeus *(Röding), Isla Gobernadora, AMNH 203815.*

FIGS. 9 *and* 10. Cypraea teres *Gmelin, Isla Pedro Gonzales, AMNH 203809.*

FIGS. 11 *and* 12. Mitra mitra *(Linné), off Isla Cébaco, AMNH 198611.*

FIGS. 13 *and* 14. Cypraea talpa *Linné, Isla Canal de Afuera, AMNH 206760.*

FIGS. 15 *and* 16. Cymatium muricinum *(Roding), Isla Gobernadora, Panama; × 1, AMNH 206084. The first record of this circumtropical species on the west American mainland.*


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Geographic Records of Indo-Pacific Prosobranch Gastropods from Pacific Panama

An asterisk (*) denotes a new record. AMNH = American Museum of Natural History collection. LACMNH = Los Angeles County Museum of Natural History collection.

1. **Conus chaldeus* (Röding). Isla Gobernadora, Golfo de Montijo, V-1979, 2 living specimens on rocks, extreme low tide, *ex* - R. E. Hubert, AMNH 203815, here illustrated, figures 7, 8. Isla Canal de Afuera, Golfo de Veraguas, 1982, 1 living specimen, on dead coral, snorkeling, *ex* - J. Ernest, AMNH 206684.

2. *Conus tessulatus* Born. Isla Pedro Gonzales, Golfo de Panamá, 1 fresh specimen, II-1981, *ex* - R. E. Hubert, AMNH 203266, here illustrated, figures 1, 2. Isla Membrillos, Archipiélago de las Perlas, Golfo de Panamá, 1 fresh specimen. III-1975, *ex* - R. E. Hubert, AMNH 183218, here illustrated, figures 3, 4 (Emerson, 1978, p. 79). Bahía Anton Viejo, Isla Los Pájaros, Archipiélago de las Perlas, IV-6, 1981, H. DuShane leg. and coll., 1 specimen at night crawling on sand exposed at low tide (several other specimens collected by field party). Isla Boyarena, Archipiélago de las Perlas, 1982, 1 living specimen, dredged, J. Ernest leg., AMNH 206080, here illustrated, figures 5, 6.

3. *Kermia maculosa* (Pease). (Turridae). Isla Taboga, Bahía de Panamá, in 5 meters (Shasky, 1983, p. 28).

4. *Microdaphne trichodes* (Dall). (Turridae). 9 Localities from off Isla Secas, to off Bahía Honda, Golfo de Chiriquí, in 9 to 91 meters, LACMNH, 1934 to 1965, *teste* J. H. McLean.

5. **Cypraea talpa* Linné. Isla Canal de Afuera, Golfo de Veraguas, 1 living specimen, on dead coral, 1981, *ex* - J. Ernest, AMNH 206760, here illustrated, figures 13, 14.

Mr. James Ernest (*in litt.*, Sept. 15, 1983) informed me that he found off Isla Canal de Afuera nine additional mature specimens (eight living and one dead) of *Cypraea talpa* under coral by snorkeling in about 1.5 meters. The largest specimen measures approximately 66 mm in length and 38.8 mm in width.

6. *Cypraea teres* Gmelin. Islas Secas, Golfo de Chiriquí, 1 specimen, II-4, 1935 (Bakus, 1968, p. 94; Emerson and Old, 1968, p. 99, pl. 12, figs. 1-3). Bahía Honda, Golfo de Chiriquí, 1 specimen II-21, 1934 (Bakus, 1968, p. 94). Isla Pedro Gonzales, Archipiélago de las Perlas, 2 lots, *ex* - R. E. Hubert, II-75, 1 living specimen under a rock near sand, AMNH 183217; II-1981, 2 living specimens, shallow water in coral, AMNH 203809, here illustrated, figures 9, 10. Isla Taboga, Bahía de Panama, VI-1980, 1 living specimen in coral, *ex* - R. E. Hubert, AMNH 203812. Isla Gobernadora, Golfo de Montijo, IV-1980, 2 living specimens under rocks around coral, *ex* - R. E. Hubert, AMNH 203810. Isla Canal de Afuera, Golfo de Veraguas, 3 specimens, under coral in 1.8 to 3.6 meters, 1982, J. Ernest leg., AMNH 206081 and elsewhere in the Golfo de Panamá and off Isla Cébaco (*teste* J. Ernest, *in litt.* 1983).

7. **Mitra mitra* (Linné). Los Zurrones, off Isla Cébaco, 1 living specimen, on sandy bottom, 1979, J. Ernest leg., AMNH 198611, here illustrated, figures 11, 12. Off Isla Cébaco, 1 living specimen (111 mm by 34 mm), 37 meters, on white sand, 1983, J. Ernest leg., AMNH 206075, plus another, "very large" specimen (*teste* J. Ernest, *in litt.*, 1983). Isla Canal de Afuera, Golfo de Veraguas, 1 living specimen (129 mm by 36 mm) on white sand, near coral, X-1981, J. Ernest leg., AMNH 206082. Isla Mogo Mogo, Archipiélago de las Perlas, 1 living specimen (120 mm by 34.5 mm) on sand, in 1.8 to 3 meters, 1982, snorkeling, J. Ernest leg., AMNH 206083.

8. *Quoyula madreporarum* (Sowerby). "Panama" (Keen, 1971, p. 546). This wide-ranging, Indo-Pacific species is also reported from the Adriatic Sea (Parenzan, 1970, p. 170, pl. 35, fig. 666, as *Quoyula madreporarum* var. *mediterranea* Parenzan, 1970) and the eastern Atlantic Ocean on St. Vincent Island, Republic of Cabo Verde (Saunders, 1976, p. 14, fig. 39, as a "variety from the Cape Verde Islands"). This species is not known, however, to occur in the western Atlantic, but is commonly found in eastern Pacific waters from Mexico to Colombia, and on the oceanic islands, Clipperton and Revillagigedo.

9. *Terebra laevigata* Gray. "Panama Bay" (Keen, 1971, p. 680).

10. *Titiscania limacina* (Bergh). (Neritacea). "Pacific Coast of Panama" (Marcus and Marcus, 1967, p. 124).

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In addition to James Ernest and Royce E. Hubert, I am indebted to the following friends and colleagues for kindly providing data and/or specimens used in this study: Twila Bratcher of Hollywood, California; Eugene V. Coan of Palo Alto, California; J. Wyatt Durham of the Museum of Paleontology, University of California, Berkeley, California; Helen DuShane of Whittier, California; Lawrence H. Feldman of the Museum of Anthropology, University of Missouri, Columbia, Missouri; Virginia Orr Maes of the Academy of Natural Sciences, Philadelphia; James H. McLean of the Museum of Natural History, Los Angeles, California; Ma. Carmen Perrilliat of the Instituto de Geología, Universidad Nacional Autónoma De México, Mexico, D. F.; Graham D. Saunders, Gillingham, Kent, England; Donald R. Shasky, Redlands, California; and Carol Skoglund of Phoenix, Arizona. I also thank my AMNH colleagues: Glenn Rubic for the photography, Iris Calderon for processing the manuscript, and Walter E. Sage, III, for technical assistance.

Helen DuShane, James Ernest, and Royce E. Hubert kindly read a draft of the manuscript.

Note Added in Press

Mr. James Ernest submitted a live-taken specimen of *Philippia radiata* (Röding, 1798) from off Isla Canal de Afuera, Golfo de Veraguas, dredged in 18 to 24 meters in dead coral and sand/mud, August 1983 (AMNH 186182). Dr. Robert Robertson, who confirmed the identification, previously reported this Indo-Pacific species from Isla Gorgona, Colombia (Robertson, 1979). This is the second record of this taxon in the eastern Pacific.

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THE OCCURRENCE OF THE ASIATIC FRESHWATER CLAM, *CORBICULA FLUMINEA* IN THE ATCHAFALAYA DELTA, LOUISIANA

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ABSTRACT

The occurrence of the freshwater bivalve, Corbicula fluminea, *in the coastal region of Louisiana is documented and ecological reasons for this penetration are given.*

Considerable attention has been given to document the occurrence and expansion of the introduced Asiatic freshwater clam, *Corbicula fluminea* (Müller, 1777) in the United States. Recently, McMahon (1982) presented a detailed chronological map and discussed the rate of expansion of this species, but did not show *Corbicula* to be present in coastal Louisiana.

Apparently the Asiatic clam reached Louisiana in either the late 1950's or early 1960's. Previous reports on *Corbicula* from inland Louisiana include Dundee and Harman (1963), Gunning and Suttkus (1966) and Stern (1976).

In the Atchafalaya System, Bryan *et al.* (1975) found *Corbicula* infrequently in both the river-basin and bay during 1974. By 1975, Bryan *et al.* (1976) reported it was commonly taken in the bay, rarely in the lower basin, and absent from the upper basin.

Biological sampling in the newly formed Atchafalaya Delta (see van Heerden 1983 for geologic review) between March 1981 and November 1982 has shown *Corbicula* to be invading this habitat. Specimens between 10 and 20 mm have been found in both the eastern and western portions of the delta in the sand and silt shallows surrounding the islands. In addition, this species is regularly found in the stomachs of blue catfish, *Ictalurus furcatus*, an abundant delta species that preys heavily on small mollusks in the area.

McMahon (1982) noted the rapid down river expansion of *Corbicula* throughout the U.S. and felt that much of this was natural due to the ability of the larvae to use river currents as a dispersal mechanism. The connection of the Atchafalaya River with the Mississippi River would provide an adequate avenue for this dispersal in Louisiana. Hartfield and Cooper (1983) discussed the environmental factors responsible for the absence of *Corbicula* in the coastal zone of Mississippi. In the Atchafalaya region, however, the tidal influence is much less since the hydrological regime is almost completely fresh (Thompson and Deegan in press) and shifting sands, which were also found to be detrimental, are virtually absent. Thus, *Corbicula* has penetrated into the Louisiana coastal zone almost to the Gulf of Mexico by way of the Atchafalaya system. Stern (1976) cautioned that this species is a competitive threat to the native bivalve fauna (mostly Unionid clams), but whether it can replace the mactrid clam, *Rangia cuneata*, the dominant bivalve in the delta will require future studies. If *Corbicula* is able to displace *Rangia*, it could have serious ecological and economic repercussions in coastal Louisiana. The thin shell of *Corbicula* could not be used in the same ways as *Rangia cuneata* in road-building, land-stabilization or the many others outlined in Tarver and Dugas (1973). Erosion of the shell would most likely be rapid enough to preclude deposits of harvestable shell.

ACKNOWLEDGMENTS

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A NEW SPECIES OF *CADUCIFER (MONOSTIOLUM)* FROM THE WESTERN ATLANTIC (BUCCINIDAE)

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An examination of collections of *Caducifer (Monostiolum) swifti* (Tryon, 1881) has revealed the presence of a related, undescribed species. At present this new species, *Caducifer (Monostiolum) weberi*, is known only from 73 m off of Looe Key, Big Pine Key, Monroe County, Florida, and from La Chorrera, Havana, Habana Province, Cuba.

Caducifer (Monostiolum) weberi n. sp.

(Figs. 1-6, 11)

Description: Holotype 16 mm in length, fusiform, the spire approximately 3/5 the total length. Protoconch blunt, consisting of 1½ smooth, rounded whorls. Postnuclear whorls 6¼ - 7½ in number, abruptly arising from the protoconch, the earlier postnuclear whorls strongly sculptured (Fig. 11), becoming less so on successive whorls. The postnuclear sculpture consists of distinct spiral threads separated by grooves of equal width. The axial ribs become less pronounced and more irregularly spaced on later whorls, barely perceptable on the last ½ whorl. The threads do not diminish in strength as they pass over the axial ribs. By the sixth whorl the axial threads become more subdued and secondary threads appear in the interstices; these quickly become equal in strength to the primaries, resulting in a sculpture of close-set, low-lying threads. On the last ½ whorl microscopic tertiary threads may originate between the existing ones. Several threads on the siphonal canal are distinctly wider and more pronounced than those of the remaining portion of the whorl. The last ¼ whorl flares outward to form a varix over which the spiral threads continue. The varix abruptly constricts and forms a short but distinct, thick outer lip. The aperture is oval, weakly crenulated, bearing 4-5 indistinct teeth within the outer lip. Posteriorly the siphonal canal is delineated by a tooth on the outer lip and an internally directed ridge on the parietal wall. Parietal callus smooth, distinct, adherent to the body whorl along its length. Columella straight, terminating in a short, open siphonal canal; the siphonal canal notch shallow. The color is orangish-brown with the protoconch and occasional axial ribs white. A prominent, uninterrupted white band encircles the whorl just below the periphery of the shoulder; this is seen as a sutural band on previous whorls. Aperture white.

Type locality: 40 fathoms (73m) off of Looe Key, Big Pine Key, Monroe County, Florida. *Holotype:* ANSP 355365. *Paratypes:* AMNH 206077; USNM 617392 - both La Chorrera, Havana, Habana Province, Cuba.

Measurements (in mm):

	Length	*Width*	*Number of postnuclear whorls*
Holotype ANSP 355365	16.0	6.0	7.5
Paratype AMNH 206077	14.0	5.7	6.3
Paratype USNM 617392	12.6	5.0	7.5

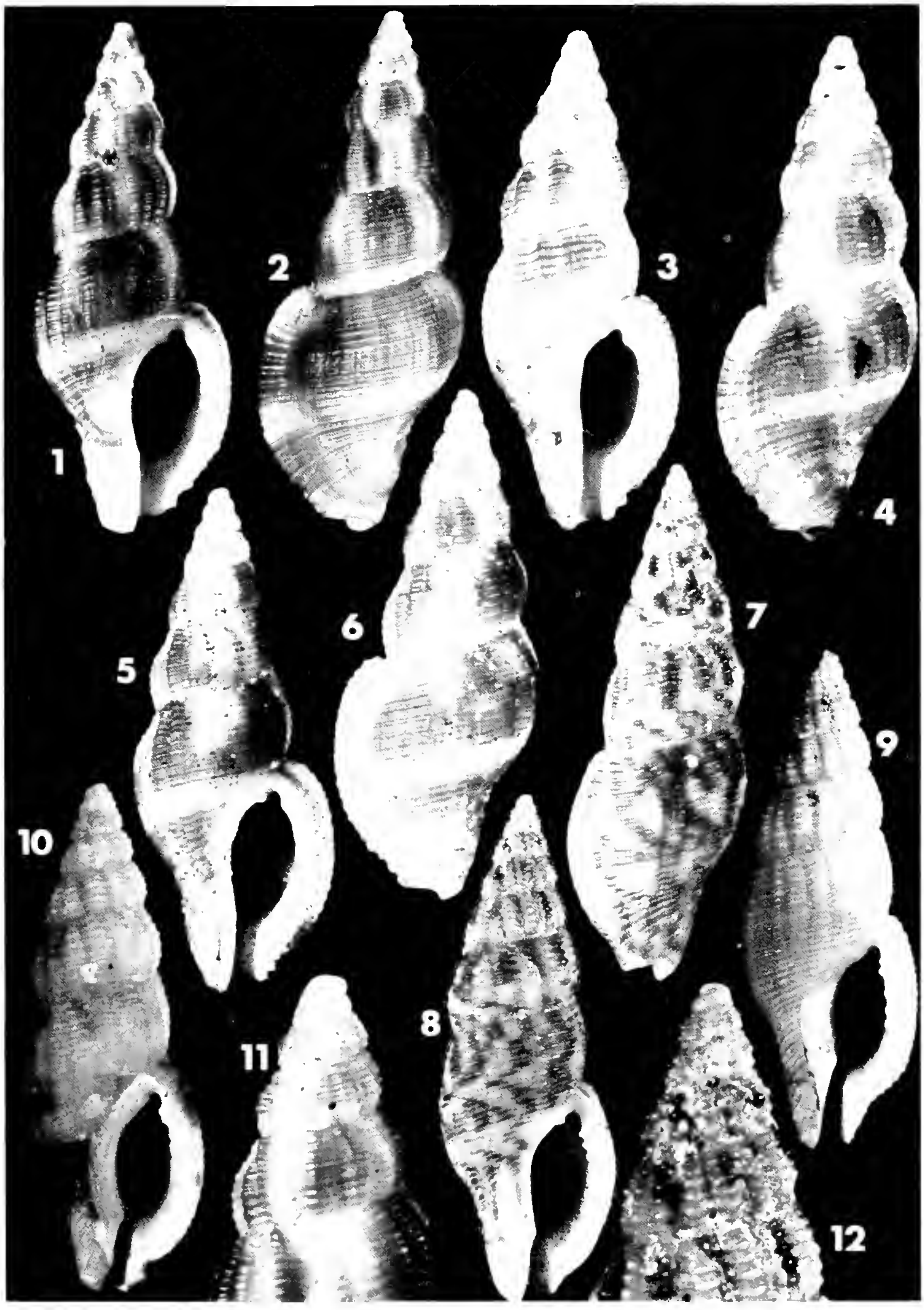
Remarks: Caducifer (Monostiolum) swifti (Tryon, 1880) is the only other species of the subgenus known to occur in the western Atlantic (Figs. 7-10, 12). Both *C. swifti* and *C. weberi* have similar protoconchs (Figs. 11, 12) and overall sculpture; however, the axial ribs of *C. swifti* are more clearly defined and more numerous, persisting longer on the later whorls than those found on *C. weberi*. The body whorl of *C. swifti* is only as wide as the penultimate whorl and terminates in only a slightly expanded varix while the body whorl of *C. weberi* expands at the same rate as the earlier whorls and forms a wider varix. This results in a less pupoid outline in *C. weberi*, giving that species much the same appearance of a *Bailya* M. Smith, 1944. The aperture of *C. weberi* lacks the well-defined teeth on the outer lip evident in *C. swifti* and the columella is straight along its entire length, not bent at a distinct angle delineating the siphonal canal as in *C. swifti*. The color pattern of *C. swifti*, when present, is of zig-zag axial markings, although the color of these markings may range from dark brown to yellow. The single white spiral band on the uniformly orangish-brown background of *C. weberi* is never found on *C. swifti*.

Authors such as Abbott (1954, 1974), Rios (1975), and Warmke and Abbott (1962) have considered *Monostiolum* Dall, 1904, a subgenus of *Colubraria* Schumacher, 1817, which has been variously considered a buccinid or a cymatiid. Despite their cymatiid form, such genera as *Colubraria*, *Caducifer*, and *Bailya* are now known to be more closely related to the buccinids (Abbott, 1954; Keen, 1971). Keen considered *Monostiolum* to be a subgenus of *Caducifer*, Ponder (1972) placed *Caducifer* under *Monostiolum*, and Cernohorsky (1972) placed *Caducifer* under *Pisania* Bivona-Bernardi, 1832. Clearly the exact relationship of *Monostiolum* to other buccinids is not understood. The taxonomy adopted here follows Keen in considering *Monostiolum* a subgenus of *Caducifer*.

Keen (1971) has allocated several east Pacific species to *Monostiolum*, all of which are considerably more rugosely sculptured than either *C. swifti* or *C. weberi*. Only one species of *Caducifer s.s.* has been reported from the New World: *C. atlanticus* Coelho, Matthews, and Cardoso, 1970, from northeast Brazil. Sander and Lalli (1982) have reported shells of a *Colu-*

(opposite page)

FIGS. 1-12. **1-6**, Caducifer (Monostiolum) weberi *new species*. **1** *and* **2**, *Holotype ANSP 355365, 73 m off of Looe Key, Florida, 16 mm in length*. **3** *and* **4**, *Paratype USNM 617392, 12.6 mm in length*. **5** *and* **6**, *Paratype AMNH 206077, 14.0 mm in length. Both paratypes from La Chorrera, Cuba*. **7-10**, Caducifer (Monostiolum) swifti *(Tryon, 1881)*. **7** *and* **8**, *Watters coll. 4068A, Bermuda, 18 mm in length*. **9**, *USNM 54542, "Bahamas", 14.4 mm in length*. **10**, *USNM 682304, Buccoo Reef, Tobago, 14.3 mm in length*. **11**, C. (M.) weberi *new species, Holotype, sculpture of early whorls*. **12**, C. (M.) swifti *(Tryon, 1881), Watters coll. 4068A, sculpture of early whorls.*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braria (Monostiolum) species from 125 and 175 m off of the Barbados which may prove to be *C. weberi*, but I have been unable to gather any further information on these specimens.

This species is named in honor of the late Jay Weber, an ardent collector whose contributions to malacology have yet to be completely appreciated. I would like to thank Dr. Joseph Rosewater and Dr. Harald Rehder (USNM), Ms. Mary A. Garback (ANSP), and Dr. William Emerson (AMNH) for their assistance in this study.

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NOTES ON MISSISSIPPI RIVER BASIN MOLLUSCA PRESENTLY OCCURRING IN THE HUDSON RIVER SYSTEM

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ABSTRACT

The Hudson River system in northeastern North America contains an aquatic molluscan fauna that is comprised of both Atlantic coastal drainage and Mississippi River faunal group species. The occurrence of Mississippian basin mollusk species in the Hudson River system, however, has received little study. Besides those species that invaded the Hudson River system from the Mississippi River basin during late-glacial dispersal, other species have entered the Hudson River system by way of the Erie and Champlain canals. The present report discusses Mississippian basin mollusk species that have been previously unreported, of restricted distribution, or poorly known in the Hudson River system.

The Hudson and St. Lawrence Rivers are biologically unique among major northeastern North American drainage systems for they contain aquatic mollusk faunas that are derived from both Atlantic coastal and Mississippian basin faunal regions. Concerning the Hudson River system both natural and artificial causes are responsible for the presence of Mississippian basin species within its watershed. A former natural connection between the Great Lakes and the Mohawk River, a major tributary of the Hudson River, during late-glacial times allowed passage of some species from west to east (Simpson, 1896; Smith, 1982), and possibly viceversa. Additionally, the completion by 1840 of an extensive canal system in central New York (McNown, 1976) provided an artificial passage way that enabled interdrainage transfer of other species (Call, 1878; Clarke and Berg, 1959; Harman and Berg, 1971).

Despite the coexistence of Mississippian and Atlantic drainage species in the Hudson River system, and the zoogeographical intrigue of such an occurrence, the aquatic mollusk fauna of the Hudson River system has received little attention (Smith, 1982). Although the representation of Mississippian basin molluscan species in the Hudson River system is somewhat less than that recorded for the St. Lawrence watershed (La Rocque, 1966; Clarke, 1973, and papers cited there in) the Hudson River system nonetheless possesses several Mississippian basin species, some possibly yet to be reported. The present paper discusses species of mollusks whose range in the Hudson River system was in the past restricted to the upper most Mohawk River, or were either poorly known or previously unknown in the Hudson River system.

Material and Methods

Field work was conducted during the summer of 1982 within a small section of the Hudson River system extending from the mouth of the Mohawk River and the vicinity of Troy (Rensselaer County) northward to include eastern tributaries in Fort Edward, (Washington County), or an area covering approximately 250 sq. km.

In addition to field work, historical collections housed in the New York State Museum in Albany, New York (N.Y.S.M.), and in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (M.C.Z.), were examined.

Voucher collections of live animals were made and preserved following the method of Smith (1982) except for specimens of the gastropod family Pleuroceridae which were placed directly into 10% formalin following narcotization. All fluid preserved specimens have been placed in the Invertebrate Division of the Museum of Zoology, University of Massachusetts, Amherst, Massachusetts. Additional conchological material collected has been deposited into the collections of the Department of Living Invertebrates, American Museum of Natural History, New York.

Results and Discussion

Family Pleuroceridae

Goniobasis livescens livescens (Menke 1830)[1]

Records of *G. l. livescens* from the Hudson River, prior to the present report, are inconclusive. Goodrich's (1942) listing of the Hudson River as being within the range of this species is taken from Letson (1905), but is inaccurate. Letson (1905) wrongly interpreted De Kay's (1843) version of an account by Adams (1841) which read "no species . . . (of pleurocerids) . . occur in the New England states, with this single exception, although some are abundant in New York." De Kay (1843) assumed that the Hudson River and Lake Champlain formed the eastern range limit for North American pleurocerid species, with no specific mention of which species occurred in the Hudson River. Otherwise, the previously published eastern most locality in the Hudson River system for *G. l. livescens* is in the vicinity of Mohawk, New York, in the Mohawk River system (Lewis, 1872; Dazo, 1965, fig. 2; La Rocque 1968, fig. 273).

Goniobasis l. livescens was collected in this study near the mouth of the Mohawk River in Cohoes (Albany Co.), and in the Hudson River in Troy (Rensselaer Co.). The species presence in the Hudson River system is probably the result of migration through the Erie canal (Lewis, 1872). In earlier papers, Lewis (1856, 1861) mentioned "*Melania exilis*" from the Mohawk River and Erie Canal. The nomen "*exilis*" has since been synonymized under *G. semicarinata* (Say 1829), which does not occur in the Great Lakes drainage (Goodrich, 1940). The specimens assigned to "*exilis*" may have been *G. livescens*. The only species of *Goniobasis* from this region in the M.C.Z. is *G. livescens*.

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[1] Burch (1982) recently resurrected the genus name *Elimia* to replace *Goniobasis*. However, there is disagreement in the literature regarding the use of the name *Elimia*. I withhold using it in favor of the more widely known and established name *Goniobasis*.

Pleurocera acuta acuta Rafinesque 1831

Lewis' (1856) mention of *Melania acuta (=P. a. acuta)* from the upper Mohawk River near Mohawk, New York, is the earliest record of this species from the Hudson River system. Subsequently Aldrich (1869), using De Kay (1843) as a taxonomic reference, reported *"Melania elevata"* and *"Melania subularis"* from near the mouth of the Mohawk River in the vicinity of Cohoes, New York. Lewis (1872) discussed difficulties in separating species of pleurocerids he collected in the Erie canal. Later, without having examined De Kay (1843), Lewis (1875) suggested that Aldrich's (1869) records of *"Melania elevata"* were referable to *G. l. livescens.* A persusal of De Kay (1843), though, shows that *"Melania elevata"* as described is clearly a *Pleurocera* (see also Tyron, 1873). Goodrich (1939, 1940) later synonymized the forms *"subularis"* and *"elevata"* under *P. a. acuta* and *P. canaliculatum* s. l. respectively. It is believed that Aldrich (1869) collected *P. a acuta* rather than *G. l. livescens.*

Specimens collected during the present study were from near the mouth of the Mohawk River, Cohoes (Albany Co.) and from the Hudson River, Troy (Rensselaer Co.). *Pleurocera a. acuta* most likely entered the Hudson River system through the Erie canal; however, because of its early documentation in the lower Mohawk River the species possibly reached the Hudson River system in late-glacial times.

Family Unionidae

Lasmigona (Lasmigona) costata (Rafinesque 1817)

The occurrence of this species in the Hudson River system has been recently discussed (Smith, 1982). Until now the species was known in the Hudson River system from only a handful of specimens collected during the Nineteenth century. Recently *L. costata* was collected in the lower Moses Kill, a tributary of the Hudson River, in Fort Edward (Washington Co.). This population might represent a relict of late-glacial migration via the Glacio-Iromohawk River, or a secondary recent invasion through the Champlain canal.

Anodonta (Pyganodon) grandis grandis Say 1829

The occurrence of *A. g. grandis* in the Hudson River and vicinity was well documented in early literature on New York unionids. Aldrich (1969) remarked that *"Anodonta Benedictensis" (=A. g. grandis)* was common in the Hudson and lower Mohawk Rivers near Troy. Marshall (1890) listed *"A. lewisii" (=A. g. grandis)* from Normans Kill, near Albany, and three lots of this species presently exist in the New York State Museum, including those specimens figured by Marshall (1890). Marshall (1895) later included the Hudson River system with the range of *A. g. grandis.*

Records made in the present study include the Hudson River in Troy and Schaghticoke (both Rensselaer Co.), the lower Moses Kill, and Dead Creek, both in Fort Edward (Washington Co.).

Clarke (1973) discussed the difficulty in diagnosing *A. g. grandis* when in contact with *A. c. cataracta;* however, specimens examined in this study were clearly distinguished from sympatric *A. c. cataracta* and *A. implicata* when using shell and beak structure characteristics.

The distribution of *A. g. grandis* in the Hudson River system is similar to that of three other Mississippian basin unionoid species in the Hudson River system: *Anodontoides ferussacianus* (Lea 1834), *Lasmigona compressa* (Lea 1829), and *L. costata.* As with the latter three species as discussed by Smith (1982), *A. g. grandis* is suggested to represent part of the early post-glacial mussel fauna of the Hudson River system, having reached the Hudson River by way of the Rome outlet through which the Glacio-Iromohawk River and late-glacial Lake Ontario were connected. This belief, which is in opposition to Ortmann (1919), who believed that *A. g. grandis* reached the Hudson River system through the Erie canal, is based on the fact that this species was known well within the Hudson River system by the mid-Nineteenth century.

Lampsilis ovata (Say 1817)

This species is known historically from Lake Champlain (Adams, 1841) and has been recently collected in upper Lake Champlain drainages (Smith 1982, unpublished records). *Lampsilis* *ovata* is now known to occur in the Hudson River system. The species probably entered the Hudson River system by way of the Champlain canal. Specimens have been collected in the lower Moses Kill, Fort Edward (Washington Co.).

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A *SEMELE* STORY (BIVALVIA: SEMELIDAE)

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In her review of the eastern Pacific molluscan taxa proposed by Mörch (1859-1861), Keen (1966) discovered that the type material of the previously unillustrated *Semele verrucosa* Mörch, 1860, was something very different from what most authors had assumed. Mörch's taxon, she concluded, was probably conspecific with *S. margarita* Olsson, 1961, and later she synonymized the two without question (Keen, 1971).

This discovery was presumed to leave without a name the species that had been illustrated by previous authors as *S. verrucosa* Mörch. For this, she proposed a new species, *S. verruculastra* Keen, 1966, selecting as holotype a specimen in the collection of the California Academy of Sciences that had been illustrated by Hertlein & Strong (1949) as *S. verrucosa.*

Unfortunately, her description of *Semele verruculastra* was predicated upon the distinctions drawn by Hertlein & Strong and other earlier workers between their "*S. verrucosa*" and a similar species, *S. formosa* (Sowerby, 1833). These distinctions prove illusory, and *S. verruculastra* falls into the synonymy of *S. formosa.*

Semele formosa (Sowerby) was only briefly discussed by Hertlein & Strong (1949), who evidently believed that the material they assigned to *Semele verrucosa* was separable from *S. formosa* by means of the same features with which Mörch had originally differentiated his taxon – more elongate, more subtruncate posteriorly, and with a more gently arcuate ventral margin – and pronounced, scaly, verrucose sculpture.

Olsson (1961) figured a specimen of *Semele formosa* from the BM(NH), and he apparently had no material of his own. He also discussed and illustrated material he believed to be *Semele verrucosa*, and he indicated that the latter differed from *S. formosa* in its less convex valves, and its coarser concentric ribs that become divided and scalloped, frilled, or scalelike at their posterior and anterior ends.

I have examined a number of specimens of this uncommon species and find that none of these distinctions stands up under close scrutiny. In addition to the two type specimens, I have examined 3 lots in the United States National Museum of Natural History, 2 lots in the California Academy of Sciences, and 3 lots from the collection of Mrs. Carol Skoglund of Phoenix, Arizona. Olsson (1961) provides measurements of two additional specimens, and Draper (1980) of two more.

Semele formosa becomes higher and more inflated as it matures. Its length ranges from 1.23 to 1.33 times its height, with young specimens more elongate. Similarly, its thickness is between 0.43 and 0.52 times its height, the valves becoming more convex as individuals mature. Large specimens may expand somewhat anteroventrally, making that margin appear more curved. Nor can I see any distinction in the degree of posterior truncation among material that has been illustrated or that has been available to me.

The feature that has been relied upon to the greatest degree in differentiating two species is the nature of the concentric ribbing. Contrary to Olsson's assertion, the material that had been assigned to "*S. verrucosa*" has ribbing that is no coarser than that on the lectotype (designated here) of *Amphidesma formosum.* Moreover, growth and the sculptural differences between right and left valves account for the supposed distinction in rib roughness. Small specimens have rougher sculpture, as do right valves. The holotype of *S. verruculastra* is a right valve, as is the specimen figured by Olsson (1961) as "*S. verrucosa*," whereas he illustrated a left valve of *S. formosa.*

The following is a partial synonymy of this species:

Semele formosa (Sowerby, 1833)

Amphidesma formosum Sowerby, 1833
Sowerby, 1833a: 7; plt. 19, figs. 8; Sowerby, 1833b: 199; Hanley, 1843: 44; 7 (plt. expl.); plt. 12, fig. 48; Reeve, 1853: plt. 4, fig. 27 [as *A.* "*formosa*"].
Semele formosa (Sowerby)
Hertlein & Strong, 1949: 249; Keen, 1958: 196, 197; fig. 482; Olsson, 1961: 365; 558 (plt. expl.); plt. 85, fig. 8; Keen, 1971: 251, 252; fig. 631; Abbott & Dance, 1983, p. 350 (in color).
Semele verrucosa Mörch, *auctt.*, *non* Mörch, 1860
Hertlein & Strong, 1949: 249; 258 (plt. expl.); plt. 1, figs. 21, 24; Keen, 1958: 202, 203; fig. 504; Olsson, 1961: 366; 538 (plt. expl.); plt. 65, figs. 1-1b; Emerson & Hertlein, 1964: 359-360; 357 (plt. expl.); 356, figs. i, j; [*non* Mörch, 1860: 190-191].
Semele verruculastra Keen, 1966
Keen, 1966: 32-33; Keen, 1971: 255-257; fig. 653.

Type Material: Amphidesma formosum – BM(NH) 1907.10.28.20, lectotype (herein), a right valve, the specimen in Sowerby's uppermost figure; length, 50.7 mm; height, 41.2 mm; thickness, 9.6 mm (Fig. 1). Sowerby (1833b) specifically mentions that only two single valves were collected, of which the lectotype matches the original measurements. Thus, the specimen figured as "holotype" by Olsson (1961), BM(NH) 198224/1, cannot be from the original lot because it is a pair of matched valves, 64.4 mm in length. It is the specimen figured by Reeve (1853). Bahía Santa Elena, Guayas Prov., Ecuador (2°10′S, 80°50′W); H. Cuming; 13 meters. *Semele verruculastra* – CASIZ 036679 (formerly CASGTC 9256), holotype, a right valve; length, 42.8 mm; height, 32.8 mm; thickness, 7.1 mm (Fig. 2). Hannibal Bank, Panama (7°23′30″N, 82°3′W); CAS Loc. 17996; about 68 meters.

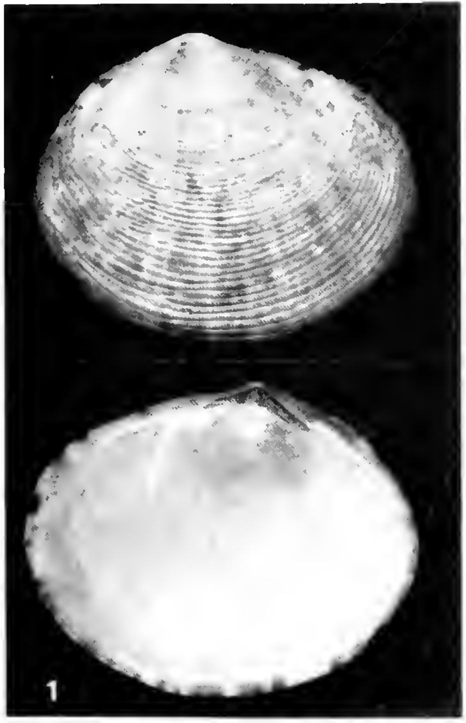

FIG. 1. Semele formosa *(Sowerby), lectotype (herein), BM(NH) 1907.10.28.20; length, 50.7 mm; Bahía Santa Elena, Ecuador.*

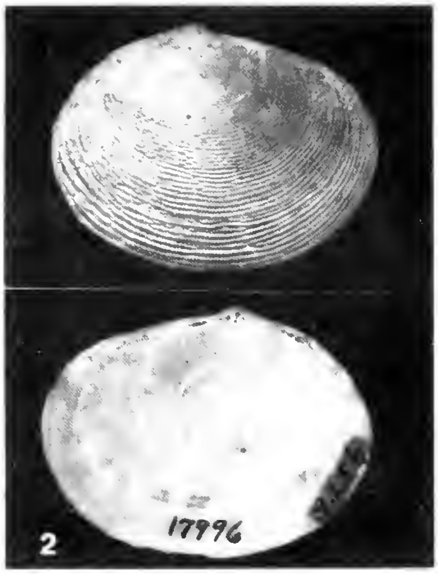

FIG. 2. Semele formosa *(Sowerby). Holotype of* Semele verruculastra *Keen, CASGTC 9256, length, 42.8 mm; Hannibal Bank, Panama.*

This striking species occurs from the Gulf of California to Bahía Santa Elena, Ecuador. The largest specimen I have seen is in the collection of Carol Skoglund of Phoenix, Arizona. It was collected at Isla Catalina, Bahía San Carlos, Sonora, Mexico, in about 20 meters of water and measures 73.3 mm in length, 59.1 mm in height, and 29.7 mm in thickness.

ACKNOWLEDGMENTS

I appreciate the loan of the lectotype of *Amphidesma formosum* by the British Museum (Natural History) through the courtesy of

Solene Morris and the loan of specimens by Carol Skoglund. I also appreciate the advice of Carol Skoglund, James McLean, Barry Roth, Helen DuShane, and Myra Keen on this project.

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NOTES ON NIDIFICATION AND OVULATION IN *DRYMAEUS MULTILINEATUS* (SAY) (PULMONATA, BULIMULIDAE)

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During field work near Key West, Florida, *Drymaeus multilineatus* (Say, 1825), an arboreal snail native to Florida and the Caribbean, was observed nesting and laying eggs. No previous reports on the reproductive behavior of this species are known, although observations on *D. dormani* (Binney, 1857), a species of northern and central Florida, have been reported (Muma

1955). The systematics and anatomy of the Florida species of *Drymaeus* are summarized by Pilsbry (1946, p. 21) and Breure and Eskens (1981).

On 26 September 1982, during a heavy rainstorm, four specimens from a small colony of *D. multilineatus* were seen descending two trees (*Bursera simaruba*) on which they had been seen feeding earlier at the study site on Stock Island. The snails burrowed into the upper layers of the leaf mold immediately at the base of the trees once they had reached the ground. Burrowing continued until all but the extreme tip of the shells were covered loosely by leaf fragments, a depth of approximately 2 cm.

Ovulation occurred over a period ranging from 18 to 22 hours subsequent to burrowing. The eggs were small and round with a maximum diameter of 2 mm. They were yellow-white and moderately hard but not calcareous and were deposited in a slightly sticky mass of 40-99 eggs.

Two weeks later, on 9 October 1982, the nests were re-examined. It was found that all of the egg masses had shriveled up due to dessication. Similar shriveled egg masses were found throughout the study area, indicating that this may be a major source of mortality.

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A NEW SINISTRAL TURRID FROM BRAZIL (GASTROPODA: TURRIDAE)

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ABSTRACT

A new turrid species, Borsonia brasiliana, *characterized by sinistral coiling is described and figured. A columellar plait and other features places it in the subfamily Borsoniinae and the genus* Borsonia. *The sinistral turrids are reviewed briefly.*

The discovery of a lot consisting of 144 specimens of an undescribed and unusual turrid in the collection of Recent mollusks of the U. S. National Museum of Natural History, Washington, D. C., warrants the establishment of a new species. This is by virtue of its distinctive features including sinistral coiling, the presence of a columellar plait, and other aspects of shell morphology. The proposed taxon, *Borsonia brasiliana,* is based on conchological characters as no animal material was available. A few dried animals were present, but attempts to recover radular teeth by dissolving in KOH were unsuccessful.

Subfamily: **Borsoniinae** Bellardi, 1875

Genus: ***Borsonia*** Bellardi, 1839

Borsonia brasiliana *new species*

(Figs. 1–5)

Description: Shell small (largest specimen 12.9 mm), sinistrally coiled, biconic fusiform, spire with a somewhat blunt apex, body whorl large and tapering gently to a moderately elongate open, weakly notched anterior canal. A small umbilical chink and a rounded anterior siphonal fasciole of variable strength are usually present in larger specimens. Columella slightly twisted to the right and bearing a narrow, moderately elevated plait just above the center. The plait tends to be placed well back in the aperture but is usually easily visible. Occasionally it can be seen to terminate or fade within the recess of the aperture. It is occasionally weak or, rarely, rudimentary. The plait can usually be seen on earlier whorls when breaks or drilled holes permit viewing. A suggestion of a second, broader, fold below the plait is present in about 10% of specimens. The columellar lip shows a thin glaze of callus, margined below in large specimens. Protoconch of 2 to 2½ smooth whorls with a slightly immersed and somewhat laterally placed tip. Protoconch usually preserved. Adult sculpture marked by the appearance of small axial ribbing. Post-nuclear whorls 5 to 6, sharply angled just above mid-whorl by the ends of the axial ribs, and with a concave sulcus extending to the preceding suture. Suture minutely channeled producing the impression of a spiral subsutural thread. Sculpture of oblique axial ribs, 12 to 14 on the penultimate whorl. These are regularly spaced, about the same width of that of the interspaces, broader at the shoulder where they are angled and often finely noded or even slightly cusped. Although rather constant, the axials are reduced in strength occasionally, approaching peripheral nodulation only. This is never to the degree seen in *Borsonia ceroplasta* or *B. silicea* however. In some large specimens the axials become nearly obsolete on the last whorl. Posterior sinus occupying the whole of the shoulder slope, moderately deep, U-shaped. Lip thin, fragile, usually broken. No "stromboid notch" or varix. Color uniformly milky white, glistening and somewhat translucent when fresh. A few specimens contained dried animals retracted too deeply within the shell to observe for an operculum. Two specimens were sacrificed to attempt recovery of radular teeth. No operculum was identified on the broken pieces of animal thus obtained.

FIGS. 1–5. Borsonia brasiliana *new species.* **1, 2, 3,** *Anterior, lateral and posterior views of Holotype, USNM 810567, 11.9 mm length, 4.3 mm width.* **4,** *Specimen with lip broken back showing columellar plait.* **5,** *Specimen with enlarged siphonal fasciole. (Photos courtesy Smithsonian Institution, V. Krantz).*

Type locality: 200 miles north of Sao Luis, Brasil, on the edge of the continental shelf at 150 fathoms; lat. 00°18'N, long. 004°17'W. R/V *Oregon,* station 4226, Mar. 9, 1963, in one dredge haul using a six foot dredge. No record of substrate.

Types: Holotype: USNM 810567, 11.9 mm

TABLE 1. *Ratios of major shell dimensions in percentages. Based on measurements of 20 largest, intact (presumably adult) specimens. Range of measurements: Total length 10.9–12.9 mm; Maximum width 4.0–5.1 mm; Body whorl length 6.2-8.5 mm; Length aperture plus canal 5.0-6.0 mm. Spire angle 27°-35°, mean 30°, standard deviation 2.1°.*

	Max. width to total length	*Body whorl to total length*	*Apert. plus canal to total length*
Range	34-40	55-69	42-52
Mean	36	64	46
Standard deviation	1.7	3.9	3.2

length, 4.3 mm width. Paratypes: USNM 818743 (119 specimens). Two additional paratypes deposited at each of the following institutions: Academy of Natural Sciences of Philadelphia, Pennsylvania; American Museum of Natural History, New York; Auckland Institute and Museum, New Zealand; British Museum (Natural History), London; California Academy of Sciences, San Francisco; Delaware Museum of Natural History, Greenville, Delaware; Los Angeles County Museum, Los Angeles; Museum of Comparative Zoology, Cambridge, Massachusetts; Museum National d'Histoire Naturelle, Paris; Zoological Museum, Copenhagen; and the Museu Oceanografico, Rio Grande, Brasil.

Remarks: The museum lot apparently represents sampling of a homogeneous population. There is little variation among individuals. Range of variation of major dimensions is noted in Table 1. As can be seen, the greatest variability is in the ratio of body whorl length to total length, although this is not evident simply by inspection. The most obvious variation, besides that described for the axial ribs, is in the strength of the siphonal fasciole. This is well marked in perhaps a dozen large specimens. It would appear to be a function of maturity, possibly a gerontic phenomenon, however other individuals of equal size do not show equivalent enlargement. A few of the specimens with fasciolar enlargement show a less well-developed plait and a slightly "fatter" shell outline, but there is no clear cut correlation between any grouping of shell characters suggesting distinct forms. About 60% of specimens are drilled, the hole being typical of that made by naticids.

Discussion

Borsonia brasiliana is considered a member of the subfamily Borsoniinae on the basis of the presence of a columellar plait, which is the primary feature of the group with respect shell morphology. Placement in the genus *Borsonia* is based on similarity of shell structure to other members of the genus, all dextral, especially *B. prima* from the Italian Miocene. (Bellardi, 1839, p. 30). There are adequate specific differences to warrant the conclusion that *Borsonia brasiliana* is a distinct species and not a sinistral mutation of another. Similarity to *Borsonia prima* is evident on comparison with that species. (Bellardi, 1847, pl. 4, fig. 13; Powell, 1966, pl. 8, figs. 9, 10). The two are reasonable "mirror images", however *Borsonia prima* has spiral sculpture, less well-developed axials, and is larger. A further modification of the axial ribbing in their reduction to peripheral nodules is seen in the Recent species of the genus from the Western Atlantic: Watson's *Borsonia ceroplasta* from off Puerto Rico, and *B. silicea* of Brazilian waters. (Watson, 1886, pl. 18, fig. 2, and pl. 21, fig. 8 respectively). Other differences are also present. Interestingly, a species widely separated geographically, *Borsonia jaffa*, is the only other form lacking spiral sculpture. (Cotton, 1947, p. 14 and accompanying plate). *Borsonia jaffa* shows peripheral nodules only and has an elongated anterior canal.

A new sinistral form invites comparison with the other known sinistral turrids, although there is little similarity besides left-handed coiling. None are borsoniids. The genus *Antiplanes* Dall (1902, p. 513), a Recent and fossil group from the American west coast, has the sinus nearly on the periphery, no axial ribs, and a very different shell outline. It is a member of the subfamily Turrinae according to Powell (1966, p. 52). The genus contains a number of species names many of which are undoubtedly synonyms and needs review. The gemmate *Sinistrella* Meyer (1887, p. 18), with two species, from the S. E. United States Eocene is also turrinine, having the sinus on the periphery. A left-handed species known only as *Pleurotoma sinistralis* (Petit, 1839, pl. 1) from the Senegal coast has a rather pupoid shell outline, the sinus near the periphery, and no axials. It was figured by Reeve (1843, pl. 10, sp. 81) and Tryon repeated Reeve's illustration (1884, pl. 13, fig. 64). The figure is poor but nevertheless differs from Petit's in showing what appears to be a beaded subsutural cord. Perhaps two species are involved. The species should be investigated. Reeve's illustration of Hind's *Conopleura striata* (1846, pl. 36, sp. 330a), unnecessarily renamed *partita*, is sinistral but in error. The species is dextral. Reeve makes no mention of the shell being sinistral and his other figure (sp. 330b) is dextral. Tryon (1884, pl. 8, fig. 7) continues the error, commenting that "one of Reeve's figures shows a reversed shell, a rarity in this genus". He recognizes Reeve's name as unnecessary.

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A NEW SPECIES OF *CATINELLA* (SUCCINEIDAE): PULMONATA FROM SOUTHERN MICHIGAN

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ABSTRACT

A new species of Catinella *(Succineidae) with its shell characteristics, reproductive organs, pigmentation and habitat is described. It is known only from the type locality, Long Lake, Cass County, Michigan.*

In the course of field studies on succineid gastropods in the midwestern states I found a small, slender, hitherto undescribed species of *Catinella*.

Catinella protracta *n. sp.*

(Figs. 1 and 2)

Description of holotype: **Shell:** (Fig. 1, A, B) Amber-colored, translucent, shining, imperforate, slender, elongate, composed of 3¼ inflated, tightly twisted whorls separated by a sharply incised suture; height 7.8 mm, width 4.2 mm. A knoblike nuclear whorl tops the turreted spire; whorls increase rapidly in size resulting in a tumid ultimate whorl. Ovate aperture equals about six-tenths of height of shell (Table 1). Sharply edged peristome very fragile. Very slender, amber columella follows inner border of peristome, curves as it disappears into the ultimate whorl (Fig. 1 B). Nuclear whorl finely wrinkled and pitted. Remainder of shell surface finely striated resulting in a shining appearance.

Body and Mantle Surfaces: Surface of head and body white, irregularly tuberculate. Superior (posterior) tentacles finely tuberculate. Pigmentation lacking from tentacles, dorsal and lateral surfaces of body. Genital aperture crescent-shaped, about 0.7 mm in length, situated on anterior right-hand side of body. On either side of body a pedal groove, continuous from labial palp to posterior tip of body, separates foot from lateral body wall; a suprapedal groove parallels the pedal groove. Shallow, vertical grooves incise the pedal and suprapedal grooves. These vertical grooves produce shallow scallops along the margin of foot and along the body wall especially when the animal is in a somewhat contracted state. Sole of foot white and unpig-

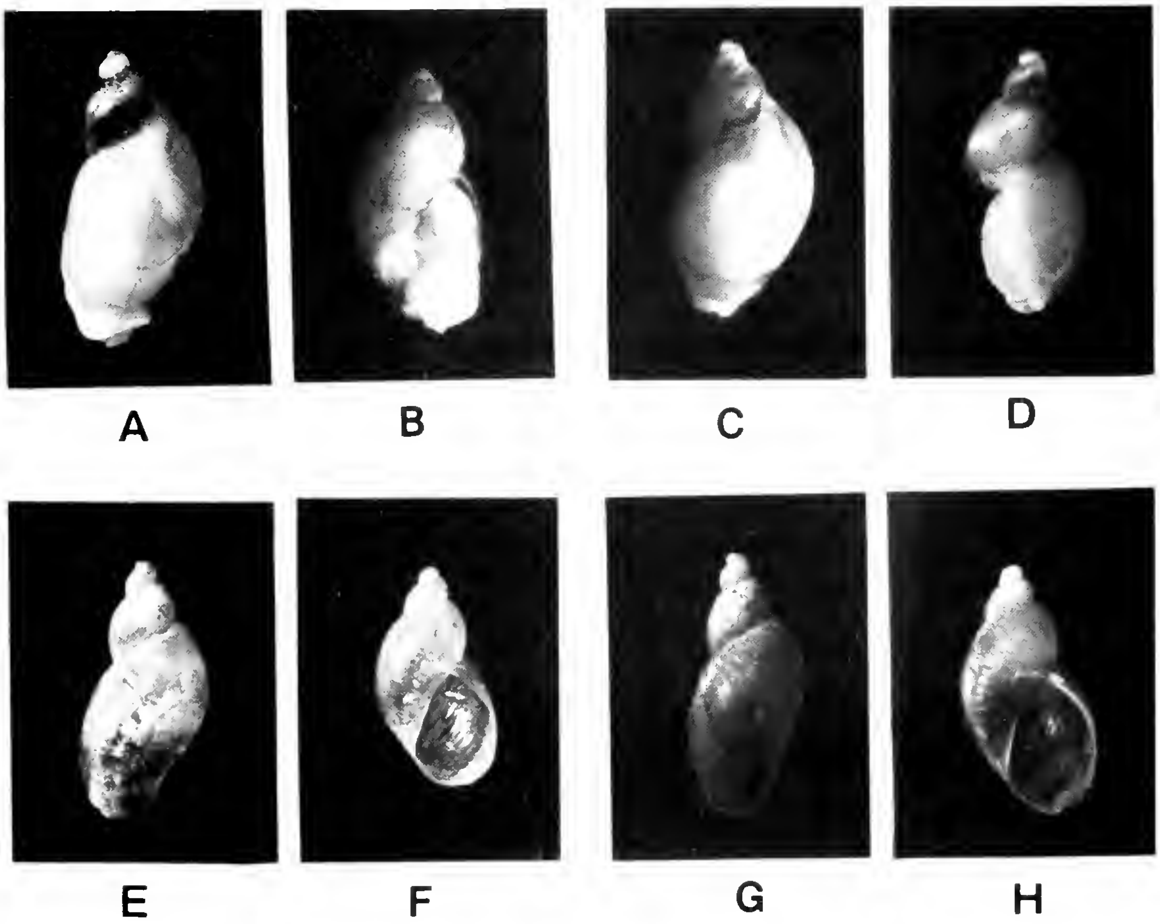

FIG. 1. **A, B,** *Holotype of* Catinella protracta *n. sp. (Height 7.8 mm); Paratypes of* Catinella protracta *n. sp:* **C, D** *(Height, 7.5 mm);* **E** *(Height, 9.1 mm);* **F** *(Height, 7.2 mm);* **G, H** *(Height, 7.0 mm).*

TABLE 1. *Dimensions of shells of* Catinella protracta *n. sp. The measurements are of the ten largest shells of each of the two series. In the 4th column of measurements are listed the ratios of the width of the shell over its height. In the last 3 columns are listed the ratios of the height of the aperture over the height of the shell, width of aperture over width of shell, width of aperture over height of aperture.*

	No. of Whorls	Height	Width	Width/ Height	Height of Aperture	Width of Aperture	H. Ap./ H. Shell	W. Ap./ W. Shell	W. Ap./ H. Ap.
Holotype	3 1/4	7.8 mm	4.2 mm	.538	4.7 mm	3.1 mm	.602	.738	.659
Type Locality	3 1/4	9.1	5.1	.560	6.0	3.8	.659	.745	.633
Field #D.S.F.359	3 1/2	8.0	4.2	.525	4.6	3.2	.575	.761	.695
Long Lake	3 1/2	8.0	4.0	.500	4.5	2.8	.562	.700	.622
Cass Co., Michigan	3 1/4	7.8	4.4	.564	4.8	3.0	.615	.681	.625
July 15, 1975	3 1/4	7.7	4.0	.519	4.2	2.8	.545	.700	.666
	3 1/4	7.6	4.9	.644	4.5	3.1	.592	.632	.688
	3 1/4	7.5	4.0	.533	4.7	3.0	.626	.750	.638
	3 1/4	7.5	4.2	.560	4.5	3.1	.600	.738	.688
	3 1/4	7.4	4.1	.554	4.2	2.9	.567	.707	.690
Range (59 shells)	3- 3 1/2	5.7- 9.1	3.2- 5.1	.50- .666	3.5- 6.0	2.2- 3.8	.542- .701	.632- .794	.560- .731
Median		6.7	3.8	.552	4.1	2.7	.611	.702	.65
Field #359	3 1/2	8.0 mm	4.4 mm	.550	4.6 mm	3.0 mm	.575	.681	.652
Long Lake	3 1/4	7.8	4.2	.538	4.4	3.0	.564	.714	.681
Cass Co., Michigan	3 1/4	7.8	4.6	.589	5.5	3.2	.705	.695	.581
July 14, 1967	3 1/4	7.5	4.0	.533	4.5	3.0	.600	.750	.666
	3 1/4	7.5	4.2	.560	4.5	3.1	.600	.738	.688
	3 1/2	7.4	4.2	.567	4.3	3.0	.581	.714	.697
	3 1/4	7.2	3.9	.541	4.4	2.7	.611	.692	.613
	3 1/4	7.1	4.0	.563	4.7	3.0	.661	.750	.638
	3 1/4	7.1	3.8	.535	4.0	2.5	.563	.657	.625
	3 1/4	7.0	4.0	.571	4.5	2.9	.642	.725	.644
Range (33 shells)	3- 3 1/2	5.4- 8.0	3.2- 4.6	.492- .615	3.5- 5.5	2.4- 3.2	.563- .705	.648- .843	.581- .714
Median		6.7	3.8	.565	4.1	2.8	.611	.714	.658

mented. Mantle collar and transparent mantle are unpigmented.

Colors of some of the viscera seen through the mantle and translucent shell: the elongate crescent-shaped, light golden nephridium; the slightly darker golden digestive gland; an irregularly-shaped, netted, brown band located on the body along the anterior and posterior borders of the second body whorl.

Holotype: Catalogue No. FMNH 205821. Paratypes No. FMNH 205822, Molluscan Collection, Field Museum of Natural History, Chicago, Illinois. Additional paratypes in the private collection of the author.

Description of Paratypes: Shell; (Fig. 1, C, D, E, F, G, H) Shells of mature snails attaining a height of 9.1 mm are comprised of 3 - 3½ inflated whorls. Dimensions of the ten largest shells of the two series included in this study, number of shells measured and the median of each series measured are recorded in Table 1. Of the ten largest shells of the two series the range of height is 7.0 - 9.1 mm; the range of the width is 3.8 - 5.1 mm; the largest apertures occupy from 54.5 to 70.5 percent of entire height of shell; the median of width/height are: 1967, .565, of 1975, .552. Other dimensions and relative dimensions are also to be noted.

A SEM photograph of a nuclear whorl (Fig. 2) shows the surface to be finely wrinkled and pitted. Granules of sand and/or soil are frequently adherent to the shell.

Body, mantle and viscera: The white body, mantle collar and mantle are usually unpigmented. On some individuals scattered black flecks occur on body wall, mantle collar, mantle and sole of foot. Occasionally part of edge of sole of foot is tinted with black pigment. There is an absence of patterns of pigmentation as observed in other species of *Catinella: C. parallela* Franzen (Franzen, 1979, p. 64); *C. vagans* (Pilsbry) and *C. waccamawensis* Franzen (Franzen, 1981, pp. 118, 121). The transparent membrane of the floor of the mantle cavity is sometimes pigmented with small brown flecks. A broad, irregularly shaped, netted, brown band is located on the body along the posterior and anterior borders of the second body whorl; the anterior (lower) band is frequently the larger of the two. Color of viscera (seen through mantle and shell): the elongate, crescent-shaped, cream or light to darker golden colored nephridium is not outlined by a band of pigment characteristic of other species of *Catinella;* the digestive gland varies from a cream color to a golden brown; the gut twines around lobes of the digestive gland.

FIG. 2. *Scanning-electron-photomicrograph of the nuclear whorl of* Catinella protracta *n. sp.*

Reproductive System: (Fig. 3) The albumin gland (AG) triangular, composed of fine acini, enclosed within a thin, transparent, unpigmented sheath, seminal vesicle (SV) elongate, subequally bilobed, enclosed within a thin sheath

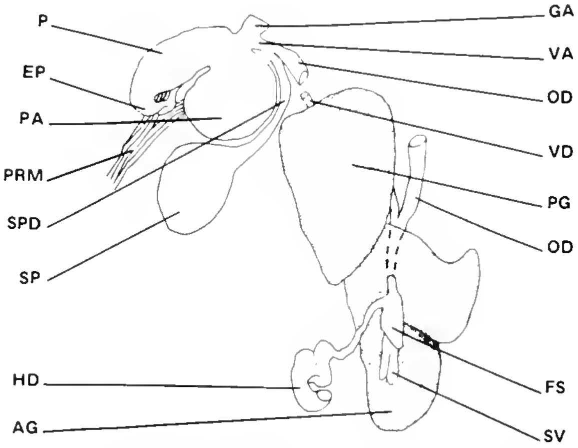

FIG. 3. *Reproductive organs of* Catinella protracta *n. sp. P, penis; EP, epiphallus; PA, penial appendage; PRM, penial retractor muscle; SPD, spermathecal duct; SP, spermatheca; HD, hermaphroditic duct; AG, albumin gland; GA, genital atrium; VA, vagina; OD, oviduct; VD, vas deferens; PG, prostate gland; FS, fertilization sac; SV, seminal vesicle.*

sparsely pigmented with brown flecks. The hermaphroditic duct (HD), sparsely pigmented with brown flecks, and the seminal vesicle join to form the fertilization sac (FS) from which a duct divides to form the convoluted oviduct (OD) which leads to the vagina (VA) and the sperm duct (SD) which leads into the prostate gland (PG). The oval prostate gland (PG), enclosed within a thin, transparent, unpigmented sheath, is composed of small acini slightly larger than those of the albumin gland. As the vas deferens approaches the penis (P) from the prostate gland it follows the penis along its dorsal surface and enlarges to form the epiphallus (EP) which enters the distal end of the unsheathed penis. The penis enlarges immediately into an elongate cylindrical form. The penial appendage (PA) is spherical; its base less than half the length of the penis; the vertical dimension is almost twice the body of the penis. Penial retractor muscle (PRM) is broad; its fibers insert onto the epiphallus, penis and penial appendage.

The globular spermatheca (SP) is connected to the vagina by an elongate, slender, spermathecal duct (SPD). The short vagina (VA) expands as it enters into the genital atrium (GA).

Radula and Jaw: Radulae of three paratypes were mounted and stained. The number of rows of teeth occurring on the radulae examined range from 93 to 95. There are few teeth on the anterior-most rows; the number increases rapidly posteriorly. The number of marginals and laterals of representative rows of those radulae are recorded in Table 2.

TABLE 2. *Formulae of representative rows of teeth of* Catinella protracta *n. sp. from two specimens, field no. 359, Long Lake, Cass County, Michigan.*

Slide	No. of Rows of Teeth	Row	M	L	C	L	M
A	95	20	7	9	1	7	6
		30	8	9	1	8	7
		50	9	8	1	8	8
		55	8	9	1	8	8
		60	9	8	1	8	8
		66	9	8	1	8	8
B	93	30	9	9	1	8	10
		31	10	8	1	9	9
		35	10	8	1	8	10
		40	9	9	1	9	9
		45	9	8	1	9	9
		50	9	9	1	9	9
		59	9	9	1	9	9
		70	10	8	1	9	9

The characteristics of the teeth of *Catinella protracta* n. sp. are described as follows and illustrated in Fig. 4A. The central tooth (C) bears a broad, long basal plate having a posterior serrated margin flanked on either side by a rounded boss. The pointed mesocone extends downward to about the lower fourth or beyond the basal plate. A short, pointed ectocone flanks the mesocone on either side. The laterals (2-L-L, 5-L-L) have a pointed mesocone varying in length from a short structure (probably worn) to many extending downward to the posterior margin of the basal plate. The mesocone is flanked medially by a small, pointed endocone and laterally by a larger, undivided, pointed ectocone. The basal plate of the outermost laterals is shorter than of the more medial laterals. The marginals (1-L-M, 4-L-M, 6-L-M) smaller than the laterals have a short basal plate which is broader than long, especially true of the outermost marginals. The small endocone is pointed. The larger, pointed mesocone extends to or beyond the posterior margin of the basal plate. The ectocone of the inner-most marginals is divided into two, that of the outermost into

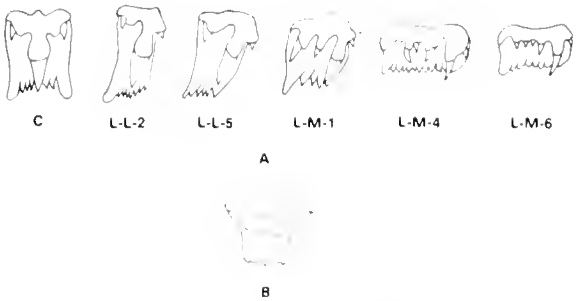

FIG. 4. *A: Representative radula teeth of* Catinella protracta *n. sp. C, central tooth; L-L-2, 2nd left lateral; L-L-5, 5th left lateral; L-M-1, 1st left marginal; L-M-4, 4th left marginal; L-M-6, 6th left marginal. B: A jaw of* Catinella protracta *n. sp.*

three, four or five cusps. The distinction between the laterals and marginals is not always clear because a tooth with a relatively short basal plate whose ectocone is divided into two cusps may be flanked on either side by one whose ectocone is undivided, or a tooth with a relatively long basal plate may have an ectocone divided into two cusps.

The structural details of the teeth of *Catinella protracta* n. sp. compare with those of the species of the genus, namely (1) the ratio of the laterals to the marginals approximates 1:1 and (2) the short basal plate of the marginals is broader than long. Such features of the genus were noted by Quick to be true of *Catinella (Succinea) arenaria* ("B.-Ch.") (Quick, 1933, Fig. 4, p. 296) and by Franzen of *C. parallela* Franzen (Franzen, 1979, p. 66, Table 2; p. 67, Fig. 3A); of *C. vagans* (Pilsbry) Franzen, 1981, p. 120, Table 2 and Fig. 3; of *C. waccamawensis* Franzen (ibid, p. 122, Table 4; p. 123, Fig. 6A).

The jaw (Fig. 4B) is amber colored. Anteriorly the collar has a median, bluntly pointed fold. The median indentation of posterior edge of collar is flanked on either side by a lesser indentation.

Geographic Distribution and Habitat: Catinella protracta n. sp. known only from type locality. Type locality: Field No. D.S.F. 359; Long Lake, Cass County, Michigan, Sunset Boulevard, 0.4 mi S of U.S. Hwy 12, west shore of north end of lake. The locality, an unimproved portion of the shore. Just beyond the collecting site a point of land extended into the lake. July 14, 1967: *C. protracta* n. sp. found living on and under boards of a broken dock and on wet ground at base of and among roots of sedges and reeds. The area, unshaded. July 15, 1975: *C. protracta* n. sp. was living on wet (soggy) ground under matting of dead sedges as was, also, *Oxyloma retusa* (Lea).

Distinctive Features: **Shell:** Comprised of 3 -3½ inflated, tightly coiled, sharply incised whorls, attaining a height of 9.1 mm; spire elongate. As shown in Table 3 comparisons of ratios of height of aperture to height of shell of three species of *Catinella* verify that the shell of *C. protracta* n. sp. is comparatively narrower and the spire relatively longer. Comparative data taken from Franzen, 1979, p. 65; 1981, pp. 118, 121.

TABLE 3. *Comparisons of ratios of shell dimensions of four species of* Catinella.

	Width/Height		H. of Aperture/H. of shell	
	Range	Median	Range	Median
C. protracta n. sp.	.50 - .66	.552	.542 - .701	611
	.492 - .615	.565	.563 - .705	.611
C. waccamawensis Franzen	.58 - .68	.647	655 - .75	.69
C vagans (Pilsbry)	.567 - .663	.619	.726 - .797	.766
	.585 - 679	632	.720 - 819	.777
C. parallela Franzen	.56 - .62	59	.66 - 72	67
	.53 - 628	.573	.623 - .711	.67
	.49 - 64	.59	56 - .70	.64
	.474 - 643	597	528 - 658	.577
	.518 - 645	.60	606 - .711	.653

The specific name *protracta* refers to the comparatively narrower and relatively longer or protracted spire as noted above.

Pigmentation: A pattern of pigmentation on the mantle, head, dorsal and lateral body surface lacking which is in contrast to characteristic patterns of other species of *Catinella* noted by Franzen: *C. parallela* Franzen (Franzen, 1979, p. 64); *C. vagans* (Pilsbry) and *C. waccamawensis* Franzen (Franzen, 1981, pp. 118, 121). Sometimes scattered flecks of black pigment are present on head, body and sole of foot. The nephridium not outlined by a black band such as noted to be present in the above listed species.

Pigmentation of the sheath covering seminal vesicles, fertilization sac, and oviduct are lightly pigmented with brown flecks. A broad, irregularly-shaped, netted brown band is located on the body along the posterior and anterior borders of the second body whorl. The conspicuous band is seen through the shell.

Reproductive System: Prostate gland equal in size to, or larger than, albumin gland. Seminal vesicles elongate, bilobed, subequal in length. Penial appendage large, inflated, spherical.

ACKNOWLEDGMENTS

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NEW RECORDS OF INDO-PACIFIC MOLLUSCA FROM COCOS ISLAND, COSTA RICA

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In April of this year, Captain Richard Callaway, of Balboa, Panama, and I spent 6½ days SCUBA diving for mollusks at Cocos Island, approximately 300 miles south by southwest of Puntarenas, Costa Rica. Dives were made from the *Victoria*, an 82 foot motor-schooner based at Puntarenas, Costa Rica.

On my return to the Costa Rican mainland, I met Dr. Michel Montoya, who has a paper in press titled, "Los Moluscos de la Isla del Coco, Costa Rica. Lista Anotada de Especies."

His paper is a complete literature review listing 16 species of bivalves, 89 gastropods, 4 chitons, and 9 cephalopods. No scaphopods or nudibranchs have been reported from the island. This is a total of only 118 species.

Dr. Montoya, who also spent 6½ days diving at Cocos Island, in June, and I, are now preparing our own check-list which will add approximately 100 additional molluscan species to the known Cocos Island marine fauna.

The new Indo-Pacific records that we found at Cocos Island are:

Viriola abbotti (Baker and Spicer, 1935)
Scalenostoma subulata (Broderip, 1832)
Cypraea (n. sp.) Burgess, 1983 – in press (Venus)
Charonia tritonis (Linnaeus, 1758)
Favartia garretti (Pease, 1868)
Persicula pulchella (Kiener, 1834)
Spondylus nicobaricus Schreiber, 1793. (Syn: *S. histrix* Röding, 1798)

Viriola abbotti was described from Samoa, and has recently been reported living in Hawaii. A single dead specimen was found.

Scalenostoma subulata has, according to Warén, 18 synonyms. It has been reported in all tropical seas except for the eastern Pacific.

A single live specimen of *Charonia tritonis* was taken at 40 meters. A previously unreported *Charonia tritonis* from the Galapagos is cited in a letter dated August 26, 1965, from Mrs. Carmen Angermeyer to William Old at the American Museum of Natural History. Mrs. Angermeyer purchased this shell from Jorge Pincay, who collected it in 2 meters of water just north of Punta Mangle, Fernandina Island. Mr. Pincay was a crew member of the Charles Darwin Research Station's vessel, *Beagle*.

Favartia garretti, has up until now, been known only from the Hawaiian Islands. Numerous specimens were taken at Cocos Island, under dead coral at depths of 13-26 meters. I have had an unidentified *Favartia* in my collection from La Cruz de Huantecoxtle, which is approximately 30 miles north of Puerto Vallarta, Mexico. It appears to be this species.

The *Persicula pulchella* was a single dead specimen.

The *Cypraea* (n. sp.) Burgess, 1983, has been examined by Dr. Burgess. He examined my specimen after this new species was already in press. He has informed me that it is a fairly widespread species being found as far west as Australia.

Dr. William Emerson has cited my specimens of *Cypraea talpa* Linnaeus, 1758, in a companion paper in this issue of the Nautilus. Captain Callaway and I took 7 specimens in depths of 7-14 meters.

Although I have not had comparative material, the specimens of *Spondylus nicobaricus* from Cocos Island, seem to match the size, color, and hinge serrations as outlined by Dr. Kay, for *S. histrix*.

I wish to thank Dr. William Emerson for allowing me to read the correspondence between Mrs. Angermeyer and William Old and Dr. Emerson. I also wish to thank Dr. Montoya for sharing the results of his trip with me and to the crew of the *Victoria* and to Mary Crowley of Ocean Voyages, Sausalito, California, for making our trips possible. I also wish to thank Dr. R. Tucker Abbott for pointing out that *Spondylus histrix* is a junior synonym of *S. nicobaricus*.

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OCCURRENCE OF THE UNIONID, *ANODONTA IMPLICATA* SAY, IN NORTH CAROLINA

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ABSTRACT

Authentic valves of the naiad, Anodonta implicata *Say, have been collected along the Chowan River in North Carolina approximately 5 miles south of the Virginia state line, a range extension of some 175 miles from the Potomac River. The mollusk is considered a "threatened species" in North Carolina.*

Previous publications have reported the range of *Anodonta implicata* Say as being from Nova Scotia and New Brunswick, Canada, to the Potomac River of Maryland and Virginia (Johnson 1946, 1970; Burch 1975). Records by Athearn and Clarke (1962) and Fuller (1977) of material from South Carolina and the upper Cape Fear River basin of North Carolina,

FIG. 1. Anodonta implicata *Say from the Chowan River, North Carolina.*

respectively, are erroneous and were based on heavy specimens of *A. cataracta* Say with distinct pallial lines, the latter also having discolored nacre similar to that of *implicata* (Johnson 1970, personal communication). However, I can now positively report the occurrence of *implicata* in North Carolina from four valves I collected on the east bank of the Chowan River in Gates County, 5.5 miles NW of Eure, on 16 September 1971. The valves agree with Johnson's descriptions (1946, 1970) in the color of the nacre and the thickening of the anterior margin below the pallial line, and match known specimens of *implicata* from Massachusetts. They are deposited in the North Carolina State Museum invertebrate research collection under catalog numbers 1151 and 1621. This site, which is about 5 miles south of the Virginia state line, represents a range extension of around 175 miles and indicates that the mollusk can be expected in Coastal Plain parts of the intervening river systems of Virginia.

Fuller's report (1977) was part of the North Carolina Endangered Species Symposium, where *implicata* was assigned to the "undetermined" category because of insufficient data to assess its statewide conservation status. Since so little of the Chowan drainage is in North Carolina and this is its known southern limit, *implicata* should properly be regarded as "threatened" in the state, based on the criteria of the symposium's mollusk committee. This designation is substantiated by the occasional eutrophication-algal bloom problems in the Chowan River not far from the sample site, as these could have deleterious effects on the molluscan fauna. Extensive collections in piedmont sections of the Cape Fear, Neuse, and Tar-Pamlico drainages have produced many specimens of *cataracta* but none of *implicata*, and if the latter is in these systems, it probably is in the Coastal Plain. It is also a potential inhabitant of the Coastal Plain part of the Roanoke drainage, located between the Chowan and Tar-Pamlico.

ACKNOWLEDGMENTS

I am grateful to Richard I. Johnson, Museum of Comparative Zoology, for confirming my identification of the Chowan specimens of *implicata*, for comparative material from Massachusetts, and for advice on Fuller's record. The accompanying figure was kindly prepared by Mary Kay Clark of the North Carolina State Museum.

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