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Bathygalea, a Genus of Moderately Deep-Water and Deep-Water Miocene to Recent Cassids

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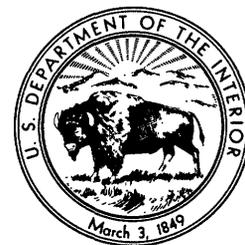
Bathygalea, a Genus of Moderately Deep-Water and Deep-Water Miocene to Recent Cassids

By W. P. WOODRING and A. A. OLSSON

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 314-B

*A study in morphologic and adaptive
evolution*



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SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

BATHYGALEA, A GENUS OF MODERATELY DEEP-WATER AND DEEP-WATER MIOCENE TO RECENT CASSIDS

By W. P. WOODRING and A. A. OLSSON¹

ABSTRACT

Bathygalea dalli, the earliest species of the genus, occurs in deposits of early Miocene age in Colombia. *B. hadra*, an early Pliocene species from Panamá, evidently is a direct descendant of *B. dalli*. These two species constitute the subgenus *Miogalea*. Though *B. hadra* is somewhat intermediate between *B. dalli* and the subgenus *Bathygalea* s.s., it probably is not the direct predecessor of that subgenus. *Bathygalea* s.s. embraces 3 Recent species: *B. pilsbryi* in the eastern Pacific Ocean, *B. coronadoi* in the western Atlantic Ocean and *B. wyvillei* in the western Pacific Ocean. On morphologic grounds *B. pilsbryi* stands by itself, but the other two Recent species, from opposite sides of the earth, are astonishingly similar.

With the possible exception of *B. pilsbryi* (for which no record of depth habitat is available), the Recent species are adapted to deeper water than the fossil species. The Recent species also are larger than the fossil species.

INTRODUCTION

This paper attempts to trace the Miocene and Pliocene ancestry of a genus embracing three Recent species of cassids, for which the name *Bathygalea* is proposed. At the present time only two fossil species of the genus are known: one of early Miocene age and the other of early Pliocene. They are collateral, if not direct, ancestors constituting the subgenus *Miogalea*.

We are indebted to Dr. H. A. Pilsbry, Curator of the Department of Mollusks, Academy of Natural Sciences of Philadelphia, for permitting us to describe the only specimen of *Bathygalea* from the eastern Pacific Ocean, and to Dr. H. A. Rehder, Curator of the Division of Mollusks, U. S. National Museum, for photographs of the 3 specimens of *Bathygalea* in the collections of that institution.

HISTORICAL BACKGROUND

In 1867 the French malacologist Crosse described the first species of *Bathygalea* as *Cassis coronadoi*, collected at Matanzas on the north coast of Cuba. "At Matanzas" presumably is not to be taken literally. It

may be surmised that the shell was brought up in a fisherman's net in Matanzas Bay, where the 200-meter line lies about 5 kilometers off shore. At all events there is no depth record for the type, the only specimen Crosse had. When Dall identified the deep-water mollusks dredged by the *Blake* in the western Atlantic Ocean in 1877-80, he recorded in 1889 the occurrence of Crosse's species 40 miles (64 kilometers) off Cape Fear, North Carolina, at a depth of 124 fathoms (227 meters). Though the *Blake* specimen is of unusual interest—and was when Dall examined it—he did no more than record it. So far it is the last specimen of the species to be found.

The second species of *Bathygalea* was named *Cassis (Bezoardica) wyvillei* by Watson in the 1886 volume on scaphopods and gastropods of the great series of *Challenger* reports. It was based on a specimen in a haul from a depth of 100 to 115 fathoms (183 to 210 meters) in Tablas Strait, off Mindoro in the Philippines. This species and *Cassis coronadoi*, from opposite sides of the earth, are astonishingly similar, so similar that Watson traveled to Paris to examine the type of Crosse's species and commented at length on the similarity. The 1907-10 cruise of the *Albatross* added two other specimens of *Cassis wyvillei* dredged at localities farther south in Philippine waters: between Cebú and Siquijor, depth 310 fathoms (567 meters), and north-west of Mindanao, depth 182 fathoms (333 meters).

The third Recent species of *Bathygalea*, heretofore unrecorded, is based on a specimen collected by H. A. Pilsbry in 1929, when the Pinchot South Sea Expedition stopped at Seymour Bay on Indefatigable Island (Isla de Santa Cruz), in the Galápagos. The depth at which it lives is unknown.

Anderson in 1929 described *Cassis (Phalium) dalli*, an early Miocene species from Colombia. Its affinities were not understood until an early Pliocene cassid from Panamá was studied, when it was apparent that the

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early Pliocene species is somewhat intermediate between Anderson's species and the Recent species.

DESCRIPTION OF SPECIES

Family CASSIDIDAE

Genus BATHYGALEA Woodring and Olsson, n. gen.

Type: *Cassis coronadoi* Crosse, Recent, north coast of Cuba, off Cape Fear, North Carolina.

Of medium size to large (45 to 115 mm), thin-shelled to thick-shelled, *Galeodea*-like in outline, strongly shouldered, spire turreted. Varices generally absent, except for terminal varix. Later part of adult body whorl of large species as tightly coiled as preceding whorls, or more loosely coiled. Shoulder reduced on adult body whorl of large species. Protoconch consisting of about 3 naticoid whorls. Earliest sculptured whorls shouldered or rounded. Shoulder of body whorl, and of at least late spire whorls, bearing short blunt, or long sharply pointed, knobs. One to 3 low spiral swellings on body whorl below shoulder bearing lower blunt knobs. Swellings and their knobs reduced to vanishing point on later part, or near end, of body whorl, at progressively later stage from anterior to posterior swelling. Knobs on shoulder continuing at regular intervals up to outer lip, or one missing near outer lip. Spiral threads closely spaced, strong on early sculptured whorls, weak or strong on body whorl. Early sculptured whorls bearing very fine retractive axial threads, or exaggerated growth lines, overriding knobs. Late whorls faintly wrinkled at suture. Outer lip relatively thin and reflexed, or thickened to include reflexed part. Interior of outer lip practically smooth, weakly undulate, weakly denticulate, or bearing moderately strong to strong ridges. Siphonal canal short, wide, very deeply and asymmetrically notched; apex of notch adjoining posterior edge. Siphonal fasciole strongly swollen, limited posteriorly by a strong narrow ridge. Parietal callus thin or thick, extending anteriorly as a thin or thick shield. Columellar lip bearing several continuous or discontinuous ridges in front of swelling produced by siphonal fasciole and several ridges behind it.

Bathygalea combines a *Galeodea*-like outline with a siphonal canal and siphonal fasciole unlike those of *Galeodea*. Whereas *Galeodea* Link (1806-07, p. 113, 1807; type (monotype): *Galeodea echinophora* (Linné) (*Buccinum echinophorum* Linné), Recent, Mediterranean Sea and eastern Atlantic Ocean) has a long, narrow, strongly bent, truncated siphonal canal and an unswollen siphonal fasciole, *Bathygalea* has a short, wide, very deeply and asymmetrically notched siphonal

canal and a strongly swollen siphonal fasciole limited by a strong narrow ridge. In the features of its siphonal canal and siphonal fasciole *Bathygalea* is similar to *Phalium* Link (1806-07, p. 112, 1807; type (logotype,² Dall, 1909, p. 62) *Phalium glaucum* (Linné), (*Buccinum glaucum* Linné), Recent, western Pacific Ocean), *Semicassis* Mörch (1852, p. 112; type (logotype, Harris, 1897, p. 198): *Cassis japonica* Reeve, Recent, western Pacific Ocean), and other genera and subgenera closely allied to *Phalium* and *Semicassis*.

The species of *Bathygalea* are described in order of decreasing geologic age. The following key to the species is based on readily observed features.

Key to species of genus *Bathygalea*

Thick-shelled or moderately thick-shelled; interior of outer lip bearing strong or moderately strong ridges.

Subgenus *Miogalea*

Thick-shelled; interior of outer lip bearing strong ridges.

B. (M.) dalli

Moderately thick-shelled; interior of outer lip bearing moderately strong ridges.....*B. (M.) hadra*

Thin-shelled or moderately thin-shelled; interior of outer lip weakly denticulate, weakly undulate, or practically smooth.

Subgenus *Bathygalea* s.s.

Moderately thin-shelled; earliest sculptured whorls rounded; later part of body whorl loosely coiled....*B. (B.) pilsbryi*

Thin-shelled; earliest sculptured whorls shouldered; later part of body whorl tightly, or relatively tightly, coiled.

Early spiral threads 6.....*B. (B.) coronadoi*

Early spiral threads 3.....*B. (B.) wyvillei*

Subgenus *Miogalea* Woodring and Olsson, n. subgen.

Type: *Cassis (Phalium) dalli* Anderson, Miocene, Columbia.

Of medium size (45 to 50 mm), thick-shelled or moderately thick-shelled, strongly shouldered at early stage. Varices generally absent, except for terminal varix. Later part of adult body whorl tightly coiled. Knobs on shoulder of body whorl relatively long and sharply pointed, continuing to outer lip. Spiral threads strong on body whorl. Outer lip thick or moderately thick; its interior bearing strong or moderately strong ridges. Parietal callus and shield thick or thin.

Age range: Early Miocene (Colombia) to early Pliocene (Panamá).

Miogalea is distinguished from *Bathygalea* s.s. by its smaller size; thicker shell and correspondingly thicker outer lip; longer and more sharply pointed knobs on the shoulder of the body whorl; stronger spiral sculpture; and strong or moderately strong ridges on the interior of the outer lip.

² A logotype is a subsequently designated type species.

Bathygalea (Miogalea) dalli (Anderson)

Plate 7, figures 1-4, plate 8, figs. 3, 4

Cassis (Phalium) dalli Anderson, Calif. Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 141, pl. 14, figs. 10-13, 1929 (Miocene, Colombia).

Thick-shelled. Varix on body whorl preceding terminal varix generally absent, but present on 1 specimen. Protoconch and first few sculptured whorls worn. Body whorl bearing 10 or 11 sharply pointed knobs on shoulder. Three low swellings on body whorl below shoulder bearing low blunt knobs on early part of whorl. Outer lip, parietal callus and shield very thick. Interior of outer lip bearing long strong ridges.

Height (practically complete) 49.5 mm, diameter 39.5 mm (largest figured specimen). Height (incomplete) 44.3 mm, diameter (incomplete) 35.4 mm (figured specimen of intermediate size).

Type: Calif. Acad. Sci. 4649; paratype, Calif. Acad. Sci. 4650.

Type locality: A mile (1.6 kilometers) or more west of pier at Puerto Colombia, Department of Atlántico, Columbia, Las Perdices shale.

Bathygalea dalli occurs in the Las Perdices shale, of early Miocene age, near Puerto Colombia on the Caribbean coast of Colombia. It is the oldest species and has the thickest shell, thickest outer lip, parietal callus and shield, and strongest ridges on the interior of the outer lip.

The type and paratype are immature. One of the other 20 specimens examined, all of which are virtual topotypes, has a varix on the outer lip preceding the terminal varix.

Occurrence: Las Perdices shale (early Miocene). Sea cliff 1 mile (1.6 kilometers) or more west of pier at Puerto Colombia (type locality); about 3.5 miles (5.6 kilometers) west of Puerto Colombia (Olsson locality 294 and Socony Mobil Oil Company locality 30); and Univ. Calif. localities in same area; Department of Atlántico, Colombia.

Material examined: Type and paratype. Olsson locality 294, 2 specimens and a fragment; Socony Mobil Oil Company locality 30, 2 specimens and 3 fragments; Univ. Calif. localities: S2088, 1 specimen; S8012, 4 specimens; S8068, 11 specimens; all virtual topotypes.

***Bathygalea (Miogalea) hadra* Woodring and Olsson, n. sp.**

Plate 8, figures 1, 2

Moderately thick-shelled. Varices absent, except for terminal varix. Protoconch worn, consisting of about 3 whorls. Body whorl bearing 10 sharply pointed knobs on shoulder. Three low swellings on

body whorl below shoulder bearing lower blunt knobs on early two-thirds of whorl. Outer lip moderately thick; its interior bearing short moderately strong ridges. Parietal callus and shield thin. Siphonal canal and siphonal fasciole missing. Insertion of siphonal canal wide.

Height 43.7 mm, diameter 33.6 mm (type).

Type: USNM 562268.

Type locality: USGS 8437, Caribbean coast at mouth of Río Indio, Colón Province, Panamá (locality 208 of U. S. Geol. Survey Prof. Paper 306), Chagres sandstone.

The type and a small damaged shell were found by Olsson in the early Pliocene Chagres sandstone at the mouth of the Río Indio in 1918. (The mouth of Río Indio is 37 kilometers southwest of Colón.) Part of the type opposite the outer lip, exposed when the shell was collected, is corroded and the entire shell is slightly or faintly worn. Though the siphonal canal and siphonal fasciole are missing on both specimens, the wide insertion of the siphonal canal on the type shows that the canal itself was wide.

Bathygalea hadra has a thinner shell than *B. dalli*, correspondingly thinner outer lip, parietal callus and shield, and weaker ridges on the interior of the outer lip. The outer lip, however, is thickened as well as reflexed.

Occurrence: Chagres sandstone (early Pliocene), type locality only.

Material examined: Type and a small damaged specimen.

Subgenus *Bathygalea* s.s.

Moderately large to large (65 to 115 mm), thin-shelled or moderately thin-shelled, early whorls shouldered or rounded, later whorls shouldered. Varices absent, except for terminal varix. Later part of body whorl as tightly coiled as preceding whorls or more loosely coiled. Knobs on shoulder of body whorl short and blunt, 1 knob missing near outer lip. Spiral sculpture weak on body whorl. Outer lip reflexed, but relatively thin; its interior weakly denticulate, weakly undulate or practically smooth. Parietal callus and shield thin.

Age range: Recent.

Bathygalea s.s. includes two minor groups: one consists of *B. pilsbryi*, which is moderately thin-shelled and has a loosely coiled body whorl and weak denticles on the interior of the outer lip; the other embraces *B. coronadoi* and *B. wyvillei*, which are thin-shelled and have a tightly coiled body whorl and a weakly undulate or practically smooth outer lip.

Though 3 species are recognized, only 6 specimens are known: 1 in the Muséum National d'Histoire Naturelle in Paris, 1 in the British Museum (Natural

History), 1 in the Academy of Natural Sciences of Philadelphia and 3 in the U. S. National Museum.

Bathygalea (Bathygalea) pilsbryi Woodring and Olsson, n. sp.

Plate 10, figures 1, 2

Moderately large, moderately thin-shelled, early whorls rounded. Later part of body whorl loosely coiled. Protoconch consisting of 3 whorls. Earliest sculpture consisting of 7 spiral threads, gradually followed by addition of retractive axial swellings. Sculptured whorls rounded until third whorl, on which shoulder gradually appears. Body whorl bearing 11 blunt knobs on shoulder. Three knob-bearing low swellings on body whorl below shoulder and a minor band, bearing a few slightly swollen knobs, immediately below shoulder. Except on shoulder, knobs confined to early part of body whorl and on anteriormost swelling limited to one knob near parietal callus. Interior of outer lip weakly denticulate.

Height 66.3 mm, diameter 47 mm (type).

Type: Acad. Nat. Sci. Phila. 153618.

Type locality: Seymour Bay, Indefatigable Island (Isla de Santa Cruz), Galápagos.

The type, which is the only specimen, is a bleached but undamaged shell collected by H. A. Pilsbry in the Galápagos. According to a personal communication, he does not recall the circumstances under which it was found. Though this shell evidently was picked up on the beach, it surely is not a shallow-water shell, unless it lived in relatively shallow water as a result of the pronounced upwelling characteristic of the Humboldt Current, which bathes the Galápagos. Another—and perhaps more plausible—possibility is that the type of *B. pilsbryi* was discarded by shrimp fishermen during the cleaning of gear at Seymour Bay. There was no settlement at Seymour Bay at the time of Pilsbry's visit, but perhaps fishermen may have used the anchorage there. Though *B. pilsbryi* probably lives at a shallower depth than the other 2 species of *Bathygalea* s.s., it is surmised to indicate a depth of at least 150 meters.

B. pilsbryi has a somewhat thicker shell than the other 2 species of *Bathygalea* s.s. and the interior of its outer lip is more distinctly denticulate. The rounded early whorls and the loose coiling of the later part of the body whorl are unique in the genus. The photographs of this species were retouched slightly to bring out shadows.

This species is named for the collector, our friend and counselor for many years.

Occurrence: Recent, type locality only.

Material examined: Type.

Bathygalea (Bathygalea) coronadoi (Crosse)

Plate 9, figures 2, 3

Cassis coronadoi Crosse, Jour. Conchyliologie, v. 15, p. 64, pl. 4, fig. 1, pl. 5, fig. 1, 1867 (Recent, Cuba).

Galeodea coronadoi (Crosse), Dall, Mus. Comp. Zoology, Harvard College, Bull., v. 18, p. 231, 1889 (Recent, North Carolina). Clench, Johnsonia, v. 1, no. 16, p. 4, pl. 2 (Crosse's illustrations), 1944 (Recent, Crosse's and Dall's records).

Very large, thin-shelled, strongly shouldered at early stage. Later part of body whorl tightly coiled. Protoconch worn, tip broken, apparently consisting of about 3 whorls. Earliest discernable sculpture consisting of 6 spiral threads, followed by addition of retractive axial swellings. Strong shoulder apparently beginning on first sculptured whorl. Body whorl bearing 9 blunt knobs on shoulder. Three low swellings on body whorl below shoulder; the posteriormost bearing low knobs on early half of whorl or entire whorl, the other 2 bearing a few low knobs or faint swollen knobs on early part of whorl. Interior of outer lip weakly undulate.

Height 99 mm, diameter 85 mm (Crosse's dimensions of type). Height 117 mm, diameter 82 mm (figured specimen).

Type: Mus. National Hist. Nat., Paris.

Type locality: Matanzas, Cuba.

Bathygalea coronadoi is the largest species of the genus and was the first to be described. So far it has been found at 2 localities in the western Atlantic Ocean that are 1,200 kilometers apart. The specimen dredged by the *Blake* off North Carolina is somewhat larger than the type and, according to Crosse's illustrations, has fewer knobs on the posteriormost swelling on the body whorl below the shoulder and weaker knobs on the other two swellings. The photograph reproduced as plate 9, figure 2, was retouched to delete lettering on the parietal wall.

Occurrence: Recent, Matanzas, Cuba; *Blake* station 2603, 40 miles (64 kilometers) off Cape Fear, N. C., depth 124 fathoms (227 meters).

Material examined: *Blake* specimen (USNM 83215).

Bathygalea (Bathygalea) wyvillei (Watson)

Plate 9, figures 1, 4, plate 10, figures 3, 4

Cassis (Bezoardica) wyvillei Watson, *Challenger* Rept., Zoology, v. 15, p. 408, pl. 14, fig. 13, 1886 (Recent, Philippines).

Moderately large, thin-shelled, strongly shouldered at early stage. Later part of body whorl tightly, or relatively tightly, coiled. Protoconch consisting of 3 or 3½ whorls, covered with thin brown periostracum, partly peeled off. Earliest sculpture consisting of 3 spiral threads and retractive finer axial threads.

Shoulder appearing after a half whorl. Body whorl bearing 10 or 11 blunt knobs on shoulder. Three low swellings on body whorl below shoulder or only 1, corresponding to posteriormost of the 3. Swellings bearing low knobs on early half of whorl, but on specimen that has only 1 swelling knobs very low and limited to middle of whorl. Knobs on early half of whorl more closely spaced than those on shoulder. Posteriormost knob-bearing swelling visible on penult whorl or barely visible at suture of body whorl. Interior of outer lip practically smooth. Periostracum forming a thin dark brown varnish, partly peeled off.

Height 4 inches (101.6 mm), diameter 2.6 inches (66 mm) (Watson's dimensions of type). Height 75.6 mm, diameter 52.8 mm (larger figured specimen). Height 62.7 mm, diameter 47.5 mm (smaller figured specimen).

Type: British Mus. (Nat. Hist.).

Type locality: *Challenger* station 204a, latitude 12° 43'–46' N., longitude 122° 9'–10' E., off Tablas Island, Philippines, depth 100 to 115 fathoms (183 to 210 meters).

Watson's illustration of the type and the 2 specimens dredged by the *Albatross* show a considerable range of variation in coiling of the later part of the body whorl and in development of knob-bearing swellings below the shoulder of the body whorl. Owing to the variability in coiling, the posteriormost knob-bearing spiral below the shoulder is fully exposed on the penult whorl (Watson's illustration), or is barely exposed at the suture of the body whorl (pl. 9, fig. 4). It is exposed also on the specimen shown on plate 10, figures 3, 4, but on that specimen the swelling is very faint and bears no knobs on the later part of the penult whorl and the early part of the body whorl.

As remarked by Watson, in general features *Bathygalea wyvillei* is very similar to *B. coronadoi*. The two species may be distinguished, however, by the smaller number of initial spiral threads of *B. wyvillei* (3 instead of 6) and by its more closely spaced knobs on the swellings below the shoulder, as compared with the spacing of knobs on the shoulder. *B. wyvillei* is the only Recent species on which the periostracum is partly preserved.

Occurrence: Recent, Philippines.

Material examined: Two *Albatross* specimens: *Albatross* station 5535, between Cebú and Siquijor, depth 310 fathoms (567 meters) (USNM 238882); *Albatross* station 5519, off northwestern Mindanao, depth 182 fathoms (333 meters) (USNM 238838).

PHYLOGENY AND GEOLOGIC HISTORY

The localities at which *Bathygalea* has been found are plotted on plate 6 and the phylogeny, as deduced from the species now known, is shown in figure 1.

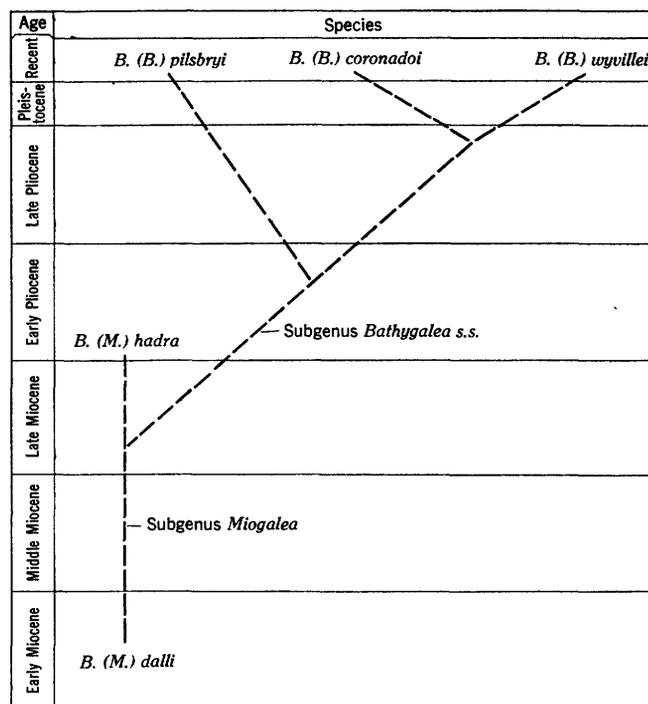


FIGURE 1.—Phylogeny of *Bathygalea*.

It is surmised that the unknown immediate predecessor of *Bathygalea* was an Oligocene cassid similar to "*Galeodea*" *trituberculata* (Weaver) (1943, p. 404, pl. 78, figs. 10–15, pl. 79, figs. 1–4, 8), a small late Eocene species from Washington. Durham (1942, p. 185) pointed out that "*Galeodea*" *trituberculata* has the deeply notched siphonal canal and swollen sharply limited siphonal fasciole of *Echinophoria* Sacco (1890, p. 39; type (logotype, Dall, 1909, p. 62): *Buccinum intermedium* Brocchi, Miocene and Pliocene, southwestern Europe), which is one of the close allies of *Phalium*. The strong ridges on the interior of the outer lip of *Bathygalea dalli* and the regularly arranged continuous ridges on its inner lip indicate that *Bathygalea dalli* and "*Galeodea*" *trituberculata* are not to be referred to the same genus. Durham assigned "*Galeodea*" *trituberculata* and much larger Oligocene and early Miocene species from Washington and Oregon—species sculptured with strap-like spirals—to *Echinophoria*. Though they are more closely related to *Echinophoria* than to *Galeodea* (to which they formerly were referred), it is doubtful whether any of these fossils represent *Echinophoria* in the restricted sense. Wrigley (1934, p. 109, 129) proposed to treat *Echinophoria* as a small, strongly knobbed, Oligocene to Pliocene subgenus of *Semicassis* and that seems to be a satisfactory arrangement. *Echinophoria* occurs in the upper Oligocene of the Canal Zone (USGS localities 6025, 18833, 18841) and in the middle Miocene of the Tehuantepec district,

Mexico (USGS localities 5886b, 10172) and the upper Miocene of Ecuador (Olsson collection). *Semicassis*, *Echinophoria* and *Bathygalea* generally lack varices other than the terminal varix, but an occasional specimen of all 3 has an earlier varix.

The early Miocene *Bathygalea dalli*, the oldest species of the genus, has the thickest shell and the strongest ridges on the interior of the outer lip. Though no middle or late Miocene species are now known (despite an apparently suitable depth facies in the late middle Miocene and late Miocene parts of the Gatun formation in the Canal Zone and Panamá), *B. hadra*, of early Pliocene age, evidently is in the direct lineage of *B. dalli*. The thinner shell and weaker ridges on the interior of the outer lip show that *B. hadra* is somewhat intermediate between *B. dalli* and the subgenus *Bathygalea* s.s., which is thin-shelled, or moderately thin-shelled, and the interior of its outer lip is weakly denticulate to practically smooth.

The Recent species are larger than the fossil species. The change in size, however, is not progressive, unless the 1 fairly complete specimen of *B. hadra* is immature. Moreover, the Recent species represent a wide range in size.

Bathygalea s.s. may have descended directly from *B. hadra*, but in view of the differentiation of that subgenus into 2 minor groups, it is more likely that it is an offshoot from the *B. dalli*-*B. hadra* lineage that diverged from the subgenus *Miogalea* not later than late Miocene time. *B. pilsbryi* is an offshoot from the stock leading to a common ancestor of *B. coronadoi* and *B. wyvillei*. If the distribution of those 2 very closely related species is as markedly discontinuous as it now appears to be, they are relicts. The geologic history of their immediate ancestor, however, is unknown, for Pliocene deep-water faunas are not common. Furthermore, the modern deep-water fauna of the Atlantic and Pacific Oceans is very inadequately sampled. The 1,200-kilometer gap

between the 2 localities where *B. coronadoi* has been found is interpreted as an indication of the sparse sampling, not as an indication that the species itself is a dwindling relict. Only 6 specimens of the three Recent species have thus far reached museums.

DEPTH ENVIRONMENT

The faunal association that includes *Bathygalea dalli* is thought to represent a depth environment of at least 100 meters and that of *B. hadra* about the same depth or a little less. The depth habitat of *B. pilsbryi* is unknown, but is surmised to be not less than 150 meters. The 1 depth record for *B. coronadoi* is 227 meters and the 3 for *B. wyvillei* range from 196 (the average for the type) to 567 meters. With the possible exception of *B. pilsbryi*, which has a thicker shell than the other 2 Recent species, the Recent species are adapted to deeper water than the fossil species.

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PLATES 7-10

PLATE 7

FIGURES 1-4. *Bathygalea (Miogalea) dalli* (Anderson) (p. 23).

Virtual topotypes. Socony Mobil Oil Company locality 30, near Puerto Colombia, Colombia, Las Perdices shale, early Miocene.

1, 2. Fragment of body whorl. Height 39 mm. USNM 562266.

3, 4. Height (incomplete) 44.3 mm, diameter (incomplete) 35.4 mm. USNM 562267.

PLATE 8

FIGURE 1, 2. *Bathygalea (Miogalea) hadra* Woodring and Olsson, n. sp. (p. 23).

Type. Height 43.7 mm, diameter 33.6 mm. USGS 8437, Caribbean coast at mouth of Río Indio, Panamá, Chagres sandstone, early Pliocene. USNM 562268.

3, 4. *Bathygalea (Miogalea) dalli* (Anderson) (p. 23).

Virtual topotype. Height (practically complete) 49.5 mm, diameter 39.5 mm. Olsson locality 294, near Puerto Colombia, Las Perdices shale, early Miocene. USNM 562265.

PLATE 9

FIGURE 1, 4. *Bathygalea (Bathygalea) wyvillei* (Watson) (p. 24).

Height 62.7 mm, diameter 47.5 mm. *Albatross* station 5519, off northwestern Mindanao, Philippines.
USNM 238838.

2, 3. *Bathygalea (Bathygalea) coronadoi* (Crosse) (p. 24).

Height 117 mm, diameter 82 mm. *Blake* station 2603, off Cape Fear, N. C. USNM 83215.



MIOCENE SPECIES OF *BATHYGALEA*



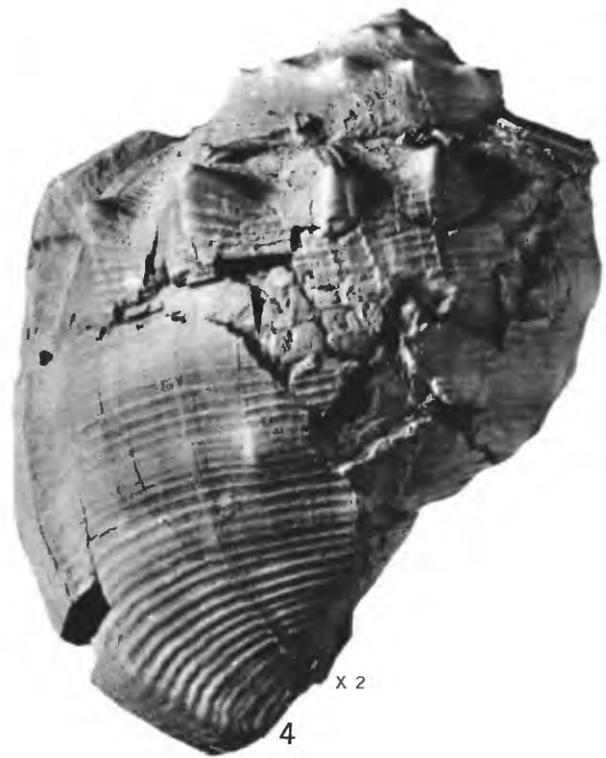
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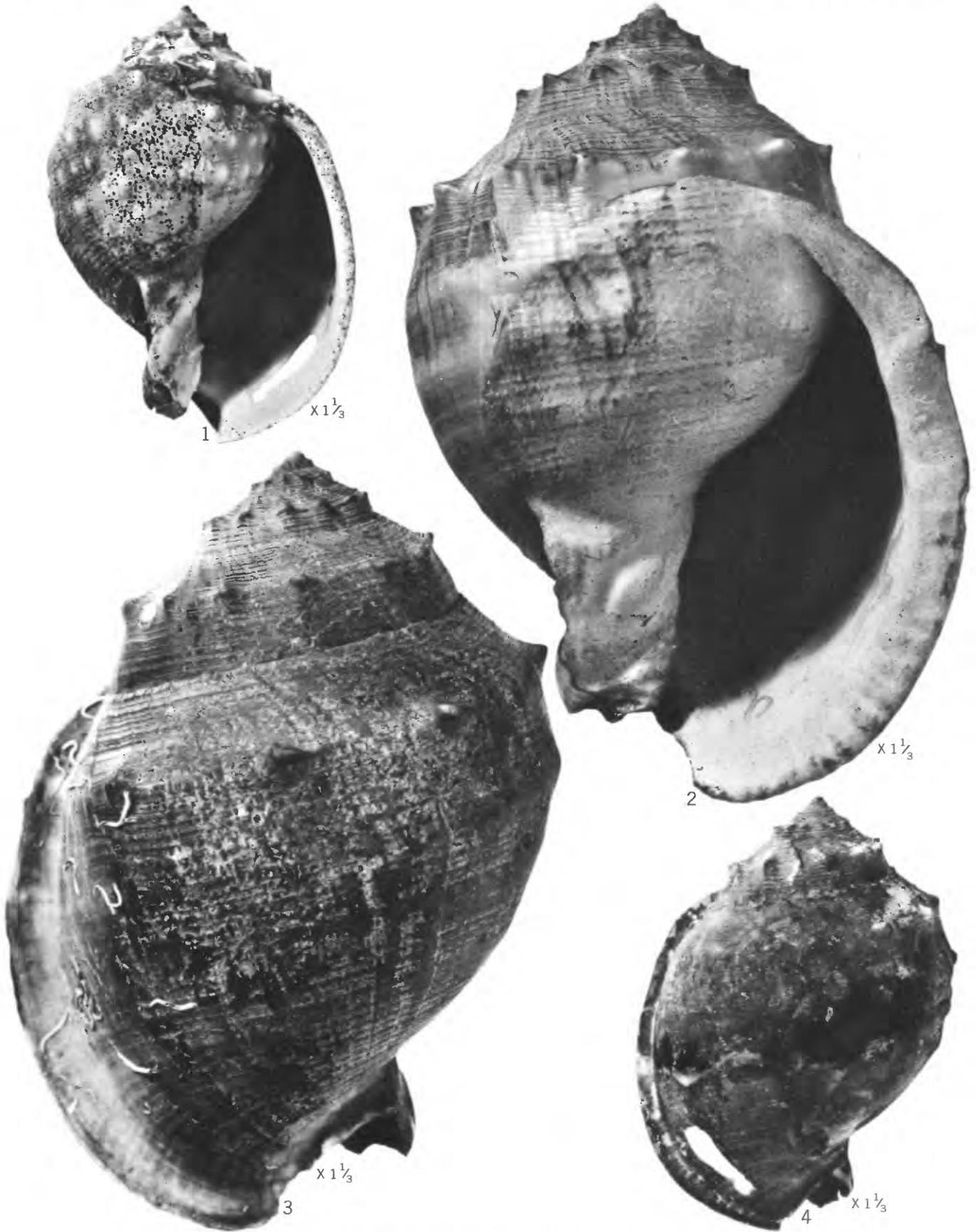


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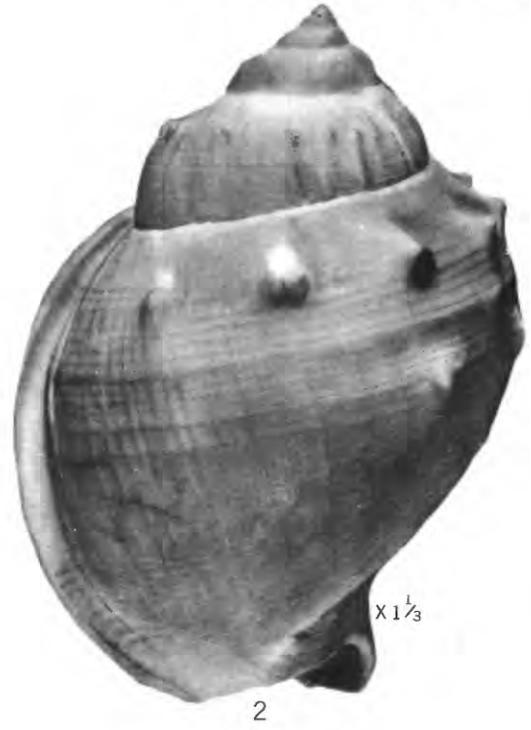


4

MIOCENE AND PLOCIENE SPECIES OF *BATHYGALEA*



RECENT SPECIES OF *BATHYGALEA*



RECENT SPECIES OF *BATHYGALEA*

PLATE 10

FIGURE 1, 2. *Bathygalea (Bathygalea) pilsbryi* Woodring and Olsson, n. sp. (p. 24).

Type. Height 66.3 mm, diameter 47 mm. Seymour Bay, Indefatigable Island (Isla de Santa Cruz), Galápagos.
Acad. Nat. Sci. Phila. 153618.

3, 4. *Bathygalea (Bathygalea) wyvillei* (Watson) (p. 24).

Height 75.6 mm, diameter 52.8 mm. Albatross station 5535, between Cebú and Siquijor, Philippines. USNM
238882.