

THE NAUTILUS

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DEVOTED TO THE INTERESTS
OF CONCHOLOGISTS

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EDITORS AND PUBLISHERS

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The *new format* will consist of two columns of text and/or illustrations on a semi-gloss page, 8x10½ inches. Tables will be set in type. For a similar publication, see the recent Bulletin for 1971, vol. 37, of the American Malacological Union or the Proceedings of the National Shellfisheries Association.

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No. 1

HORACE BURRINGTON BAKER 1889 - 1971

By R. Tucker Abbott and Charles B. Wurtz

Horace Burrington Baker, former editor-in-chief of *The Nautilus* and Professor Emeritus of Zoology, University of Pennsylvania, was born January 25, 1889, in Sioux City, Iowa. He was one of America's outstanding land mollusk anatomists, and had a keen knowledge of systematics. For 40 years he gave unstintingly of his time as business manager and editor of *The Nautilus*.

His father was Robert Folin Baker, born in England, and his mother, Sophia Jane Burrington, was of English, Scotch and French Huguenot origin. Horace received his high school education in Flint, Michigan, and after working in a buggy factory for a year, he attended the University of Michigan in 1906. In his sophomore year he published his first paper on a "Key to the genera of Gastropoda of Michigan." The summer of his graduating year, 1910, was spent with Dr. A. G. Ruthven collecting mollusks in Mexico. He was an instructor of biology at Michigan's Douglas Lake biological station and, in 1913, an instructor at Colorado College, Colorado Springs.

World War I interrupted his education. He was commissioned a 2nd Lt., Field Artillery, in 1917, and spent eighteen months in France and Germany with the 18th Field Artillery, Third Division. Returning to the University of Michigan after the war, he participated in field work on mollusks in Venezuela, and received his doctorate in 1920.

An early disappointment to Dr. Baker was the total loss of his first doctoral dissertation after all the work was done, but before it was submitted to his graduate committee. That first dissertation was devoted to a study of midwestern grasshoppers, and it was lost in a fire at the University of Michigan. This entailed a new beginning for his doctoral research.

Most of Dr. Baker's professional life was spent as a professor of zoology at the University of Pennsylvania where he was appointed an instructor in 1920, assistant professor in 1926, associate

professor in 1928, and full professor in 1939. He became emeritus in 1959. He was an instructor in the invertebrate summer courses at Woods Hole, Massachusetts, in 1924 and 1925.

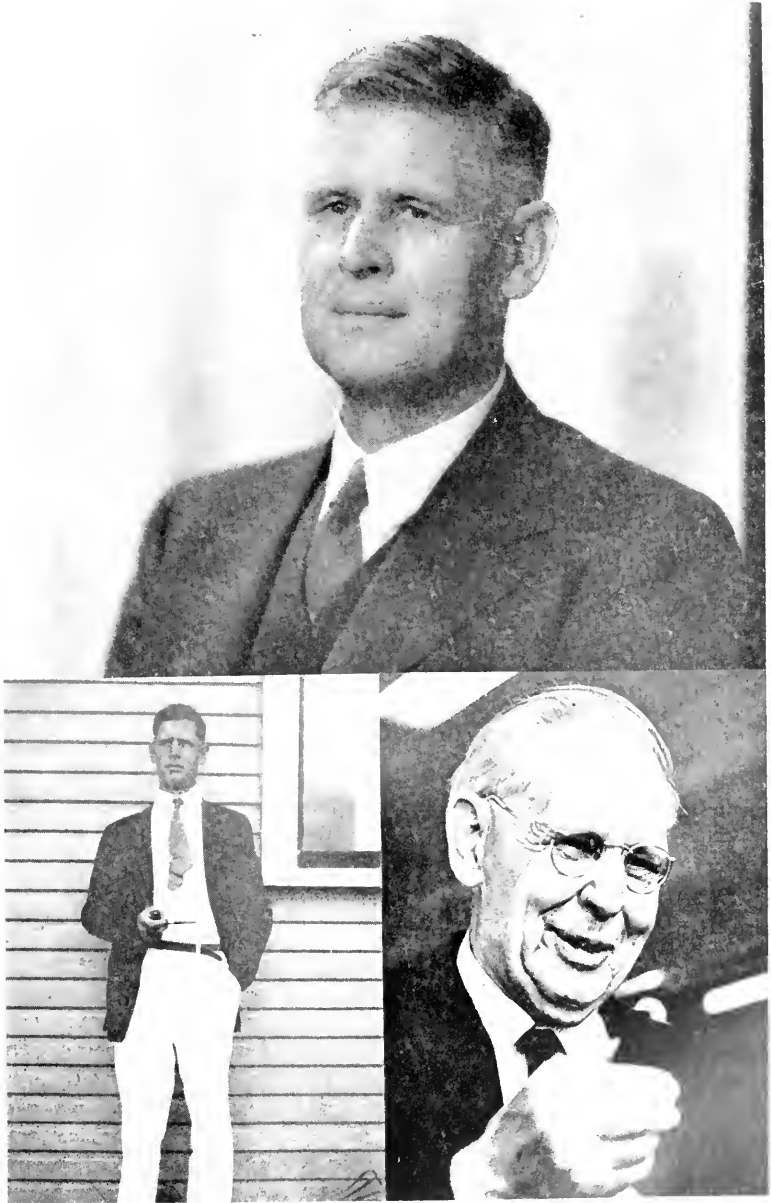
At the University of Pennsylvania Dr. Baker was best known as an anatomist. He taught vertebrate anatomy to a great many generations of aspiring medical students. He was also one of the early teachers of ecology. The junior author, C. B. Wurtz, studied ecology under him in 1947 and was one of his latest graduate students, taking his doctorate under Drs. Baker and Pilsbry as co-chairmen of his committee.

Dr. Baker was an excellent anatomical illustrator, as is evidenced by his beautiful drawings. He would sit in a large, leather-covered, reclining easy chair in his office and execute his drawing with a fine draughtman's pen on a large wooden board, not by moving his pen, but rather by moving the drawing paper. He made his drawings usually 5 or 6 times as large as the intended final published figure.

Dr. Baker was a quiet, pleasant, somewhat introverted, gentleman. He was particularly kindly and considerate of women. He enjoyed humorous stories and had an infectious quiet laugh. If anyone asked him a question, particularly a technical or historical one, he would promptly give a satisfactory answer, but after several minutes or even hours of contemplation, he would return to his interrogator with fuller, more detailed information. He was never jealous of his prerogatives or his position. When he asked the senior editor to handle *The Nautilus* after his first heart attack in 1968, he volunteered explicit permission to modify the journal in any way necessary.

When a course in systematics was first given at the Academy of Natural Sciences (about 1950), Dr. Baker conducted that part of the program devoted to the statistical analysis of data. He enjoyed statistics the way many enjoy crossword puzzles. He was also persistent in pointing out the errors that can occur through the incorrect application of statistical methods.

Dr. Baker was an avid collector of land and freshwater mollusks, and always kept meticulous locality data. His many field trips included those to Mexico (1910 and 1926), Venezuela (1919), Dutch Leeward Islands (1922), southern Appalachians (1928), Idaho (1929 and 1931), Jamaica (1933), Hawaii (1935), Puerto Rico (1939) and several occasions in Florida.



Horace Burrington Baker, 1889-1971. Formal portrait was taken about 1941. Lower left shows him as a graduate student about 1920. Lower right shows him in 1968 at age 79 (photo by R. Robertson).

In 1935, at the invitation of C. Montague Cooke, Jr., Dr. Baker was invited for an eight-month Yale-Bishop Museum Fellowship in Hawaii, where he worked on his monumental "Zonitid Snails from the Pacific Islands" (Bulletins 158, 165 and 166 of the Bernice P. Bishop Museum). He was an Honorary Research Associate in Malacology at the Bishop Museum from 1937 until his death in 1971. Altogether, he published 218 papers and notes, amounting to about 2,237 pages. All of his papers after 1941 were either published in *The Nautilus* or the *Proceedings of the Academy of Natural Sciences of Philadelphia*. At the latter, he was a Research Associate and Fellow from 1925 until his death. After his retirement from the University of Pennsylvania he gave his full volunteer time to renovating the land and freshwater collections and publishing a list of the holotype specimens at the Academy.

Upon the death of Charles W. Johnson in 1932, Dr. Baker took over the business managership of *The Nautilus* and served as an associate editor for 25 years. Upon Henry A. Pilsbry's death in 1957, he became editor-in-chief. He was editor of the mollusk section of the *Biological Abstracts* for many years, beginning in 1925. He was active in the American Malacological Union, becoming a charter member in 1932, the ninth President in 1940, and Honorary Life Member in 1958. He was a charter member of the Philadelphia Shell Club (1955), gave a series of formal course lectures to the members from 1963 to 1965, and was made the Honorary Life President in 1968. He was also for years a member of Sigma Xi, the American Society of Naturalists, the American Society of Zoologists, the American Ecological Society and the Pennsylvania Academy of Science.

Dr. Baker was married December 21, 1941, to Bernadine C. Barker of Massachusetts. She had been secretary for the Boston Malacological Club for many years and was a member of the American Malacological Union. "Bunny," as she is called, has served as business manager for *The Nautilus* since 1958. He was a devoted husband and theirs was a harmonious marriage for 30 years. They have two daughters, Elizabeth Coffin and Abigail Burrington (married Richard Woodhull Smith, March 15, 1965).

Dr. Baker suffered a mild heart attack in 1968, and again three years later when he died quietly early in the morning of March 11, 1971.

NEW RECORD FOR A RARE GALÁPAGOS LAND SNAIL

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Nacsiotus achatellinus (Forbes, 1850) has been collected only five times according to published records. The species is based on material discovered on the Galápagos Island of Chatham (Isla San Cristóbal) in 1846 by Kellett and Wood of the British surveying ship Pandora. However, there is an earlier collecting record. According to Stearns (1893:405), the British collector Hugh Cuming, whose mollusks from the Galápagos were obtained in the early 1830's, furnished Dr. Philip P. Carpenter with a list of his land shells including *N. achatellinus*, which the latter published (Carpenter, 1856:359). This record is confirmed by a single, brilliantly-colored, nearly adult, live-taken specimen deposited in the United States National Museum, Mollusk Division (no. 105150), with a label stating it was collected by Cuming and placed subsequently in the Isaac Lea Collection. Unfortunately, the island from which this shell came was not indicated.

The species was taken again in 1868, this time on Hood Island (Isla Española), by Dr. Simeon Habel, whose collection was reported upon by August Wimmer in 1879. The next record is that of Dr. Theodor Wolf, an Ecuadorian geologist, who collected on the Galápagos Islands in 1875, although an account of the land shells he obtained was not published until 1892 by Paul Reibisch. While Wolf's shells were limited in numbers and generally were of poor quality, apparently he did find a single specimen of *N. achatellinus* on "Chatham Island on mossy rocks at an elevation of 900 to 2000 feet . . ." The fifth collecting record is by Dr. George Baur, who made a collection in 1890 supported with important field notes, which formed the basis for a classic discussion of insular land shell faunas by William H. Dall in 1896. Evidently Baur found only one specimen on Chatham Island at about 1000 feet elevation on the undersides of the leaves of trees and bushes (USNM no. 107303), but this contained the soft parts from which Dall was able to extract and describe the jaw and the radula.

N. achatellinus was not found by Charles Darwin during the visit of the Beagle to the Galápagos in 1835; nor by Snodgrass and Heller during the Stanford-Hopkins Galápagos Expedition of

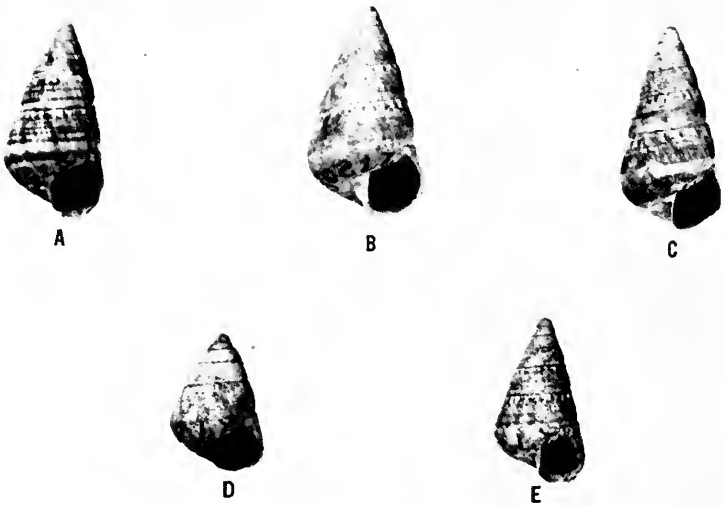


Fig. 1 A-E. *Naesiotus achatellinus* (Forbes). Freshwater Bay, Chatham Island, Galápagos. L.G. Hertlein, Coll. 31 Dec. 1931 (Calif. Acad. Sci. Geol. Dept. loc. no. 27208). Length of largest shell (1B), 16.6 mm.

1898-99; neither was it collected by W. H. Ochsner and the party of the California Academy of Sciences Expedition to the Galápagos in 1905-1906, which spent considerable time collecting land snails on Chatham and Hood Islands, among others. No specimens of it turned up during the Galápagos International Scientific Project in 1964. Thus it is with considerable satisfaction to be able to report a sixth collecting record accomplished by the well-known paleontologist and conchologist to whom a previous issue of *The Nautilus* was dedicated (vol. 84, no. 2) — Dr. Leo George Hertlein of the California Academy of Sciences.

Dr. Hertlein was a participant in the Allan Hancock Expedition to the Galápagos Islands in 1931-32 using the R/V Valero III. Among numerous other collecting activities while the members of the expedition were on Chatham Island, Dr. Hertlein tells me that he filled a sizeable sack with leaf mold and forest litter at an elevation of 300-400 meters from the sides of a small, permanent fresh-water stream flowing into Freshwater Bay. Subsequent sorting of this material produced five specimens of *N. achatellinus* as well as a rich haul of other land-snail species, as follows:

<i>Naesiotus canaliferus</i> (Reibisch, 1892)	50+
" <i>curtus</i> (Reibisch, 1892)	12+ juvs.
" <i>chemnitzoides</i> (Forbes, 1850)	1 subadult
<i>Gastrocopta</i> cf. <i>G. munita</i> (Reibisch, 1892)	100+
<i>Pupisoma dioscoricola</i> (C. B. Adams, 1845)	5
<i>Habroconus?</i> <i>galapaganus</i> (Dall, 1893)	25+
<i>Retinella?</i> <i>chathamensis</i> (Dall, 1893)	12
<i>Succinea</i> cf. <i>S. bettii</i> E. A. Smith, 1877	10+ juvs.
<i>Tornatellides chathamensis</i> (Dall, 1892)	100+
<i>Helicina nesiotica</i> Dall, 1892	100+

Unfortunately, as is often true in sortings of this kind, most of the snails were dead although many of the shells were still in fairly good condition.

The five shells of *N. achatellinus* consist of three adults and two sub-adults (figures 1 A-E). Along with others collected at the same time and place they have been accessioned into the California Academy of Sciences Geology Department Collection, locality no. 27208. Measurements (in mm) of Dr. Hertlein's five shells are as follows:

<i>Length</i>	<i>Max. Diam.</i>	<i>No. of Whorls</i>	<i>Remarks</i>
16.6	9.3	7 $\frac{3}{4}$	Bleached; no color pattern shows.
15.8	8.0	7 $\frac{3}{4}$	Somewhat bleached; color banding shows faintly.
15.1	8.0	7 $\frac{1}{2}$	Well preserved; shows color pattern of 2 narrow brown bands on a cream-colored background and 2 similar bands on the base.
12.8	7.3	7	Subadult; shows color pattern.
10.5	7.6	5 $\frac{3}{4}$	Bleached subadult; shorter and stouter than the other shells; lacks the well developed nodulous sutures.

There is no doubt that *N. achatellinus* is one of the rarer Galápagos land snails. It is of special interest because of its superficial resemblance to certain species of Hawaiian tree snails of the genus *Achatinella*. Also, its straight-sided, conical shape, its non-impressed, nodulose sutures, and its relatively bright color pattern set it apart from any other known species of *Naesiotus* from the Galápagos Islands or from the South American mainland. This led Pfeiffer to create a new subgeneric (or sectional) name *Raphiellus*

for it in 1855, a taxonomic step concurred in by Dall (1896:429; 1928:152), although Pilsbry (1897-98:94) did not agree, placing *Raphiellus* in the synonymy of the genus *Naesiotus* Albers, 1850. The very fine, closely-spaced, transverse riblets on the nuclear whorls, characteristic of *Naesiotus*, shows on one of Dr. Hertlein's specimens although they have been lost through age and wear, or both, on the other four shells.

The true systematic position of *N. achatellinus* with relation to other Galápagos Island species of *Naesiotus* can be established more firmly after collection of an adequate series of living snails for which the exact habitat and other ecological factors have been recorded accurately. It would be helpful to know, for example, whether the species lives in an aboreal habitat as Dall thought it might, or whether, in fact, it is more of a ground-loving species with only occasional sorties up into the lower branches of bushes and trees. The current interest in the Galápagos Islands and the easing of travel problems to and from them may provide more and better specimens than the few now available, together with more information on the conditions under which they live on both Chatham and Hood Islands.

I am indebted to Mr. Maurice Giles, scientific photographer of the California Academy of Sciences, for the illustrations accompanying this report.

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FAMILIAL AFFINITIES OF *HEMIDONAX* (BIVALVIA)

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The placement of the genus *Hemidonax* Mörch has long been controversial but the anatomical and conchological features of species in the genus show that it is allied to the family Cardiidae.

Recently Keen [*in*] Moore (1969: N629) considered *Hemidonax* as a member of the tellinacean family Donacidae. In the past, several authors have commented on the affinities of this genus and it has alternately been referred to the Cardiidae (Vest, 1875), the Tancrediidae (Fischer, 1887), the Crassatellidae (Hedley, 1906; 1909) as well as the Donacidae (Lamy, 1917). As subsequently shown, several conchological and anatomical features preclude its assignation to the tellinacean families Donacidae or Tancrediidae, and its hinge structures are totally unlike those found in the Crassatellidae or the related Astartidae and Carditidae. Iredale and McMichael (1962) have gone as far as considering *Hemidonax* the sole genus of a new family, the Hemidonacidae; however, they did not characterize the family or establish its systematic position in relation to other bivalves.

Early naturalists recognized the peculiar features of *Hemidonax*. Thus, Deshayes (1835) remarked on *Donax cardioides* Lamarck:

Il serait curieux de voir et d'étudier l'animal de cette espèce, car il est probable qu'elle n'appartient pas aux donaces; l'impression palléale n'est point échancrée postérieurement, et sa charnière se rapproche plus de celle du *cardium medium* que de celle des donaces.

Römer (1869) invited the description of a genus for *Cardium donaciforme* when he said:

Eine der seltsamsten Formen, die wahrscheinlich wenn das Thier bekannt sein wird, eine besondere Gattung bilden muss.

A response to this invitation was quickly received from Mörch (1870) who established *Hemidonax* and from Vest (1875) who produced a junior subjective synonym, *Donacocardium*.

Little more was said about the genus until Lamy (1917), in a paper on the Crassatellidae, discussed *Hemidonax* and concluded that it was referable to the Donacidae since its hinge line was similar to that of *Donax denticulatus*. Hedley (1923), who had earlier (1906; 1909) advocated that the genus be placed in the

Crassatellidae because it bore a great resemblance to *Cyamiomactra*, responded with:

Dr. Lamy rejects my suggestion that *Hemidonax* might enter the Crassatellitidae (*sic*) and restores it to the Donacidae. I feel more confident that the entire pallial margin should exclude it from the Donacidae than it should provide admission to the Crassatellitidae. It is not clear why Dr. Lamy disallowed Fischer's reference to Tancrediidae.

Thiele (1935) followed Lamy and made reference to Fischer (1887), who had placed *Hemidonax* in the Tancrediidae, as had Prashad (1932). Nearly all authors overlooked Pelseneer's (1911) paper which described the gross anatomy of *H. donaciforme*. From Pelseneer's figure (1911, pl. 13, fig. 4), the observations that *Hemidonax* lacks a pallial sinus made sense: the genus has neither retractable siphons nor the complex of retractor muscles that form the scar of a pallial sinus. Further, it lacks a cruciform muscle and the concomitant pallial scar of tellinaceans (Boss, 1966). The Tancrediidae is a Mesozoic family of tellinacean affinities which flourished from the Upper Triassic to the Upper Cretaceous (Cox [*in*] Moore, 1969). The Donacidae is also tellinacean (*i.e.* having a pallial sinus and cruciform muscle scars) and usually possesses shells with comparatively smooth sculpture. *Hemidonax* has relatively strong radial ribs and lacks both a pallial sinus and cruciform muscle scars; thus, it must be excluded from both the Tancrediidae and the Donacidae.

Pelseneer (1911) indicated that the laterally compressed foot of *Hemidonax* is unlike the elongate, geniculate foot of the cardiids and placed the genus in close proximity to *Crassatella*. However, the dentition of *Hemidonax* (Lamy, 1917, p. 269) differs from that found in either the Astartacea (Astartidae + Crassatellidae) or the Carditacea and closely resembles that found in the Cardiidae particularly *Hemicardium*. Thus, both conchological and anatomical features of *Hemidonax* show affinities with the family Cardiidae. Characteristics usually typical of the Cardiidae and exhibited by *Hemidonax* include: the lack of a pallial sinus, the concomitant lack of an elaboration of incurrent and excurrent siphons, the development of strong radial sculpture, and the configuration of the hinge and its dentition. Anatomically, *Hemidonax* compares favorably with cardiids: 1) gills plicate, with both inner and outer demibranchs; 2) siphons short, reduced, not markedly extensile or retractile and not provided with elaborate siphonal retractor

muscles; 3) adductor muscles subequal and mantle gape extensive, from the anterior adductor muscle to the incumbent aperture.

Thus *Hemidonax* can be considered a member of the Cardiidae as first suggested by Vest (1875). However, the genus does not have the elongate, geniculate foot, the pedal-byssal groove, the pallial eyes, or the dorso-ventrally skewed axis of the ctenidium of many cardiids and therefore forms a distinct taxon recognizable by its bilaterally compressed foot, blunted cardinal dentition and general donaciform shape. I think it merits nothing more than subfamilial rank, for which we can use the emended name Hemidonacinae, Iredale and McMichael, 1962, and it may possibly be related to the lineages which have radiated in the Pontian Basin (Davitashvili and Merklin, 1966).

The species which constitute this genus and respective subfamily are presently restricted in their distribution to the area of the Philippine Islands, Indonesia, and Australia. Although Lamy (1917) recognized a single species, several workers have augmented that number so that there are now seven available nomina:

Cardium donaciforme Schröter 1786, Einleit. Conch., 2: pl. 7, fig. 14; 3: 68 (type-locality, not known, subsequently given as the Philippine Islands, see Römer, 1869, p. 100).

Cardium donaceum Spengler 1798, Skrivt. Naturh. Selsk, 6: 37 (type-locality, Drontheim in Norwegen, in error).

Donax cardioides Lamarck 1818, Anim. sans Vert., 5: 550-551 (type-locality, mers de la Nouvelle-Hollande, à l'île Saint-Pierre-Saint François [Nuyts Archipelago, Great Australia Bight]; see Delessert, 1841, pl. 6, figs. 14a-c).

Cardium australiense Reeve 1844, Conch. Icon., vol. 2, *Cardium*, pl. 5, fig. 24 (type-locality, Port Lincoln, South Australia); 1845. Proc. Zool. Soc. London for 1844, p. 168.

Donax (Serrula) pictus Tryon 1871, Amer. J. Conch., 6: 23, pl. 1, fig. 1 (no locality given).

Hemidonax chapmani Gatliff and Gabriel 1923, Vict. Nat., 40: 10, pl. 11 (type-locality, San Remo, Ocean beach, Victoria).

Hemidonax dactylus Hedley 1923, Proc. Linn. Soc. New South Wales, 41: 303-304, pl. 31, fig. 13 (type-locality, Kiama, New South Wales).

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TWO NEW *STENOTREMA*, WITH NOTES ON *S. HIRSUTUM* AND *S. BARBATUM*

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Stenotrema simile, new species

Figure A

Shell imperforate, thin, subtranslucent to opaque, subglobose with a low conoid spire, a well rounded periphery and convex base. Color variable, ranging from deep cinnamon-brown to olive buff (of Ridgway). Embryonic whorl coarsely granulate with radially

elongate granules. Later whorls densely pilose, covered with moderately long, stiff, curved hairs with rounded bases. Parietal tooth slender, sinuous, not quite reaching the level of the basal lip, gently curved into the interdenticular sinus, then curving gently toward the outer lip tooth. Basal lip moderately wide, adnate to the body whorl on the outer margin for its entire length, the inner margin being conspicuously thickened around the lip notch. Lip notch deep, wide, U-shaped, with a thick, nob-like tooth on its peripheral edge. Interdenticular sinus deep and rounded. Outer lip tooth small. Fulcrum quite short, barely projecting beyond the basal lip callus, clearly visible through the shell, pointing radially from near the axis.

Height 6.7 mm. Diameter 9.3 mm. Whorls $5\frac{1}{4}$. Holotype.

Distribution.—**Maryland:** (*type locality*) Garrett Co.: leaf mould at base of steep slope near sharp bend of Bear Creek, 2.9 miles west of jct. U.S.-219 and Md.-42 (F. W. and G. F. Grimm, G. B. Morris, coll.), holotype 61543, paratypes 61544 National Museum of Canada; gorge of Bear Creek 2.8 miles east of Friendsville; leaf mould and logs near summit of Backbone Mountain, Roth Rock Fire Tower. **West Virginia:** Monongalia Co.: Cooper's Rock State Park. Nicholas Co.: wet sandstone talus 6.0 miles north of Richwood; cool wet woods along North Fork of Cherry River, 2-3 miles north of Richwood. Pocahontas Co.: damp maple hillside 5.3 miles west of Mill Point.

Stenotrema simile differs from *S. hirsutum* (Say) by being a bit larger, having coarser granulations on the embryonic whorl, a denser pile of longer hairs, a shorter fulcrum, a more distinct but thinner callus lining the lower lip, a deeper, more heavily callused lip notch which has a nob-like tooth on its peripheral margin, a deeper interdenticular sinus, and a more sinuous, thinner parietal tooth. *Stenotrema simile* is a rare, solitary species which inhabits cool, wet woods and ravines on the Appalachian Plateau. In the same region, *S. hirsutum* is a gregarious species which inhabits dry upland oak woods, cut over woods, and clearings.

Stenotrema simile differs from *S. barbatum* (Clapp) by having coarse granulations on the embryonic whorl (the embryonic whorl of *S. barbatum* is smooth to finely striate), smaller hairs on the surface of the shell, a much shorter, stouter fulcrum, a rounder outline with a proportionally higher spire and rounder base, a thicker callus on the lower lip, a deeper, more heavily callused lip

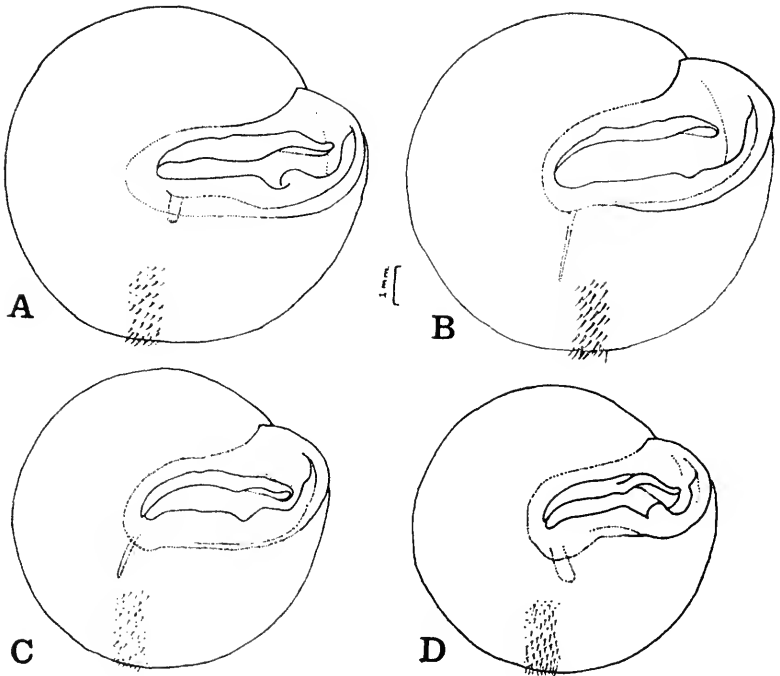


Figure 1. Shells of A. *Stenotrema simile* Grimm, holotype; B. *Stenotrema barbatum* (Clapp), Washington Co., Md.; C. *Stenotrema hirsutum* (Say), Howard Co., Md.; D. *Stenotrema burringtoni* Grimm, holotype.

notch with a nob-like tooth on its peripheral margin, a deeper interdenticular sinus, a higher parietal tooth and a narrower aperture. The inner half of the basal lip is adnate to the body whorl in *S. barbatum*; the entire basal lip is adnate in *S. simile* and *S. hirsutum*.

***Stenotrema burringtoni*, new species**

Figure D

Shell small, imperforate, subtranslucent, depressed globose with a low conoid spire, a well rounded periphery and convex base. Color pale cinnamon-brown (of Ridgway). Embryonic whorl coarsely granulate with rounded granules. Later whorls covered with moderately long, stiff, straight hairs with rounded bases. Parietal tooth comparatively stout, quite sinuous, reaching the level of the basal lip, strongly curved into the interdenticular sinus, its outer edge curved toward the outer lip tooth. Basal lip wide, sinuous, thickened on the inner edge. Lip notch deep, U-shaped, thickened at both edges, with a thick tooth at its peripheral edge.

Interdenticular sinus deep, forming a trough, rounded. Outer lip tooth quite distinct. Fulcrum short, very stout, projecting considerably beyond the basal lip callus, clearly visible through the shell, pointing tangentially from the axis and slanted toward the aperture.

Height 5.5 mm. Diameter 8.4 mm. Whorls 5. Holotype.

Type-locality.—**Virginia:** Highland Co.: limestone rubble 3.1 miles south-southwest of Mustoe on U.S.-220, holotype 61545, paratypes 61546 National Museum of Canada and Del. Mus. Nat. Hist. No. 41544.

Stenotrema burringtoni differs from *S. hirsutum* (Say) by averaging slightly smaller, having coarser, more rounded granulations on the embryonic whorl, a denser pile of longer hairs, a shorter, stouter fulcrum which is *slanted toward the aperture* (that of *S. hirsutum* is slanted away from the aperture), a thicker, more sinuous callus on the basal lip, a deeper, more heavily callused lip notch, a deeper, more rounded interdenticular sinus, and a higher, more sinuous parietal tooth which is turned into the interdenticular sinus, then swings upward toward the outer lip tooth. The parietal tooth of *S. hirsutum* points directly at the outer lip tooth.

Stenotrema burringtoni is named in honor of Horace Burrington Baker.

***Stenotrema hirsutum* (Say)**

Figure C

Because this species is likely to be confused with both of the preceding species, and frequently has been confused with *Stenotrema barbatum* (Clapp), a short discussion of it is presented here. Little can be added to the accurate description given by Pilsbry (1940, p. 662) except to state that despite its wide range, *S. hirsutum* is quite uniform in its appearance. After examining many lots of this species in the collections of the United States National Museum, the Academy of Natural Sciences of Philadelphia, the University of Michigan Museum of Zoology, and the National Museum of Canada, I noted no significant variation in sculpture or in the appearance of the aperture. The diameter varies from about 6.4 mm. to 8.8 mm., and the height from 4.5 mm. to nearly 6.0 mm. Extremes in size are rather rare. The fulcrum of *S. hirsutum* is moderately large, about $\frac{1}{4}$ to $\frac{1}{3}$ the width of the body whorl, and is slanted posteriad.

Stenotrema hirsutum ranges from Connecticut to northern Georgia in the Piedmont and Appalachians, west on unglaciated land to southern Indiana, south through central Kentucky and

Tennessee to northern Alabama and northeastern Mississippi. Throughout its range it occupies upland oak woods, mixed oak-pine woods, cut over woods, and dry clearings. Often it is most abundant in ecotonal situations such as roadsides and the edges of partially cleared upland woods.

Stenotrema barbatum (Clapp)

Figure B.

Polygyra (*Stenotrema*) *barbata* Clapp, 1904, *Nautilus* 18 (8): 85.

Polygyra hirsuta yarmouthensis F. C. Baker, 1927, *Nautilus* 40 (4): 115.

Stenotrema hirsutum form *yarmouthense* (F. C. Baker), Pilsbry, 1940, *Land Moll. N. Am.* 1 (2): 665.

Stenotrema hirsutum (Say) in part, Pilsbry, *op. cit.*: 662-665.

Stenotrema hirsutum barbatum (Clapp), Pilsbry, *op. cit.*: 665-666.

Stenotrema hirsutum (Say), Oughton, 1948, *Univ. of Toronto Biol. Ser.* 57: 10.

Stenotrema barbatum (Clapp), Hubricht, 1950, *Nautilus* 64 (1): 7. Listed, no discussion.

Stenotrema barbatum (Clapp), Hubricht, 1962, *Sterkiana* 8: 1. Discussion.

Stenotrema hirsutum (Say) in part, LaRocque, 1970, *Bull. Geol. Svy. Ohio* 62 (4): 566.

Stenotrema barbatum may be separated from *S. hirsutum* by its smooth to obsoletely ribbed embryonic whorl, by its larger, more widely spaced, stiffer hairs, by the weaker armature of its aperture, and by its longer, more slender fulcrum. The basal lip of *S. barbatum* is reflected, and does not become adnate to the body whorl until the lip notch is reached. The basal lip of *S. hirsutum* and the two species herein described is adnate to the body whorl for its entire length. The lip notch of *S. barbatum* is quite weak and shallow, nearly disappearing in some examples, and the aperture is wide because of the weakness of its teeth and thin basal lip.

Stenotrema barbatum is quite variable in size, ranging from 6.5 mm. to slightly over 11 mm. in diameter, and 4.1 mm. to 7 mm. in height. Usually it averages between 8.5 mm. and 10.5 mm. in diameter. Proportionally, its spire is lower than that of the other species discussed here. The largest examples are from floodplains near the Gulf Coast, the smallest are from loess and silt in the

northern Mississippi and Ohio valleys and from low ground in Michigan and southern Ontario.

This species ranges from Massachusetts to southern Minnesota (including the southern tip of Ontario), south in the west through Iowa to Kansas, in the east to Mississippi and Alabama, north on the Coastal Plain and Piedmont through the Carolinas to southern New England. Reports of *Stenotrema hirsutum* from northern Ohio, central and western New York, Michigan, Wisconsin, Iowa and Kansas are based upon *S. barbatum*.

Throughout most of its range *Stenotrema barbatum* is hygrophile, preferring shaded floodplains and marshes. It has been called the "lowland form" of *S. hirsutum*. It is most abundant where the calcium content of the soil is high, but it is found on acid soils as well. In scattered upland areas, usually near floodplains, it occupies ravines, clearings, and fields. I have found it with *S. hirsutum* several times in ravines at the bases of hills near floodplains on the Piedmont of Maryland, and have seen no intergradation.

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FLUORESCENCE IN ENDODONTID SNAILS

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A review of the literature related to fluorescence reveals little concerning the occurrence of this phenomenon in animals. Furreg and Querner (1929, 1930) described fluorescence of the shells of gastropods of the families Trochidae and Turbinidae. Latham (1953) reported the occurrence of fluorescence in the fur of the

least weasel, *Mustata frenata noveboracensis*. More recently, Zahl, (1963, 1968) presented popular accounts of this phenomenon in various kinds of animals, including certain coelenterates, arthropods and marine molluscs. Heretofore, it appears, fluorescence has not been observed in any of the land molluscs. We wish to report the discovery of this phenomenon in representatives of three of the genera of the family Endodontidae, and to suggest its probable occurrence in the remaining genera of the family.

Our first observation of this phenomenon occurred as we were attempting solution of a problem involving chromatographic study of mucus from snails of several families, including endodontids. Resorting to the use of ultraviolet light in an effort to visualize better a chromatogram of the mucus from *Anguispira alternata*, we found that a particularly brilliant, bluish fluorescence appeared under this illumination. With this observation as a clue, we turned to chromatograms of mucus from specimens of *Anguispira kochi* and discovered a similar fluorescence, but one which appeared to be distinctly different from that which we had previously observed. Our interest heightened, we prepared strip chromatograms of mucus from *Discus patulus* and were rewarded by the appearance of yet another seemingly distinctive fluorescence. The chromatograms were prepared on 1" x 8" strips of No. 4 Whatman paper. We used the solvent reported by Kirk, Main and Beyer (1954): 1-butanol, acetic acid, and water (100:22:50 v/v). The mucus was collected from snails by the use of standard blood capillary tubes which were inserted into the apertures of the shells; this technique provided a means of stimulating the snails to produce large quantities of mucus, as well as a means by which suitable volumes of mucus could be collected and delivered to the paper strips. Because of the viscosity, we found it necessary to expel the collected mucus samples onto the paper by gently blowing through the capillary tube. Three such applications were made on each strip and allowed to dry before hanging the strip from the solvent tray of the chromatographic jar. Solvent was allowed to descend for three hours, after which the strip was removed and air-dried. This technique gave a good distribution of the fluorescent material present in the mucus, and it provided a convenient source for that material for other aspects of a continuing study. We used a Mineralite-SL unit for our initial observations, but we found that the fluorescence which appeared was primarily in response to long-

wave ultraviolet illumination; weaker fluorescence was observed under short-wave light.

A somewhat natural progression of events led us to the observation that we could locate specimens of *Anguispira* and *Discus* in the dark, by simply playing the U-V light over the tray on which numerous snails had been spread; the mucus on the foot and body of each endodontid glowed brightly, as did the mucus trails left as these snails moved over the tray. Other specimens, all polygyrids, failed to exhibit any sign of the fluorescence, and we began to view the presence of fluorescence in the endodontids as something of a diagnostic characteristic.

Further investigation revealed that alcohol-preserved specimens of *Anguispira* and *Discus* could be identified readily by the fluorescence of the fluid in which the specimens had been kept. Later, we observed that snails of these genera could be recognized by simply holding the vials, containing the snails, under the U-V light and observing the characteristic fluorescence. We did find, however, that any endodontid contamination of alcohol used to preserve specimens of other families produced a degree of fluorescence which could be misleading. One vial of *Stenotrema*, for example, was observed to fluoresce even though all other specimens which we had of this genus did not; the data on this vial corresponded with data on several vials of *Anguispira*, and we concluded that specimens of both genera had been collected and preserved in common before being sorted.

Our experience with the preserved specimens of *Anguispira* and *Discus* led us to the further discovery that *Helicodiscus parallelus*, which we had available only in preserved form, exhibited still another apparently distinctive fluorescence. On the basis of our observations so far, we believe that *Punctum* and *Radiodiscus*, neither of which is represented in our preserved or live collections, will display a fluorescence similar to that exhibited by the genera which we have been able to investigate.

The fluorescence which we have observed in specimens of the three genera noted is extremely long-lived, being as bright and as distinctive in specimens preserved for twenty years and more as it is in living snails. Moreover, it is not simply a local phenomenon peculiar to snails of the central Illinois region. Mucus taken from specimens of *Anguispira* and *Discus* collected in several widely separated localities in Illinois responded to U-V illumination; and

alcohol-preserved specimens of all three genera mentioned, from numerous locations throughout their ranges, likewise exhibited the characteristic fluorescence.

Some animals fluoresce under U-V light because of the presence of specific minerals; others, because of the presence of certain organic compounds; still others fluoresce because of the presence of specific microorganisms. Certain evidence now available to us suggests that this phenomenon occurs in endodontids because of the presence of two or more as yet unidentified organic compounds in the mucus of these snails. Preliminary spectrophotometric work indicates a significant difference in the chemistry of the compounds; fluorescence peaks appear between 275 and 300 nm, and again between 350 and 400 nm, in mucus samples from all three genera investigated. We have also found, however, that the mucus of all living endodontids in our collection invariably contains bacteria of the genus *Pseudomonas*. We are testing the role, if any, that these bacteria play in the production of fluorescence in the snails. At the same time, several other avenues are being explored and we expect to report on these investigations in a subsequent paper.

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AROAPYRGUS COLOMBIENSIS N. SP. (GASTROPODA: HYDROBIIDAE), SNAIL INTERMEDIATE HOST OF PARAGONIMUS CALIENSIS IN COLOMBIA¹

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During investigations of paragonimiasis in Colombia (Little and Epler, unpublished report) a hydrobiid snail was found to be naturally infected with a new species of *Paragonimus*, *P. caliensis*

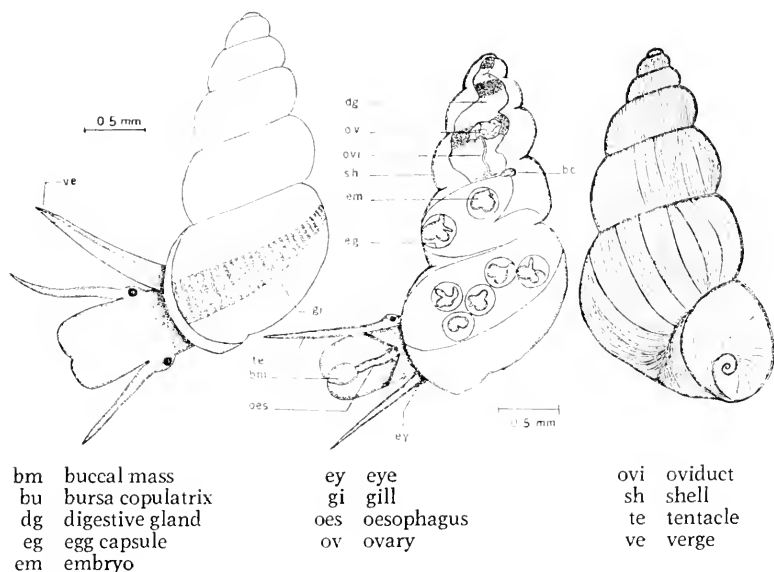


Fig. 1. *Aroapyrgus colombiensis*, showing shell and operculum. Fig. 2. Female specimen with the reproductive organs. Fig. 3. Male specimen showing the verge. The gill shows through the shell.

Little, 1968. The snails were collected from swift, shallow streams 2 to 6 feet wide, and with fairly steep banks. The snails were most readily collected in quiet pools on dead decaying leaves. Laboratory colonies were successfully established, with maple leaves being used as food. The availability of field and laboratory-reared snails permitted a study of the systematics of this new hydrobiid belonging to the genus *Aroapyrgus*, to which *A. colombiensis* is assigned.

Holotype: Delaware Museum No. 41542. Paratypes: Delaware Museum No. 41543; Field Mus. Nat. Hist. 168647; Acad. Nat. Sci. Phila. 321818. Type locality: Tributaries of Rio Pichinde, near Pichinde, Municipio de Cali, Departamento de Valle de Cauca, Colombia.

Methods

Specimens were relaxed with menthol before they were fixed in Bouin's or FAA. Morphological studies were carried out with some

¹ This study was supported by a U.S. Public Health Service Research Career Award K6-AI-18,424 to the senior author, and by the Tulane University International Center for Medical Research and Training Grant TW-00143, and grants AI-04919 and AI-00002 from the National Institutes of Health, U.S. Public Health Service. Acknowledgments are made to the Seamens Research Laboratory, USPHS Hospital for many facilities.

shells of these snails, while others were used for *in toto* mounts, after being stained with Semichon's carmine. Because of the small size of the snail it was found necessary to study its morphological details from serial paraffin sections, stained with Ehrlich's hematoxylin and eosin. The radula and operculum were studied in glycerin preparations.

Description of the snail

The Shell (Fig. 1)—Field collected specimens are covered with a dark brownish deposit. In laboratory-reared specimens, and a few field ones, however, the shell is smooth, light yellowish in color and translucent. Usually there is no size difference between the males and females. Very few females, however, are slightly broader than the males of the same age. The shell in the fully developed specimens has 5 to 6 evenly rounded whorls. The body whorl is rapidly increasing; some of the growth lines are raised in the form of very fine ridgelets. Fine microscopic ridgelets are also present on the body whorl, and on the penultimate whorl. The protoconch consists of one whorl only. The sutures are deeply impressed; the umbilicus is open, and relatively large. The aperture is ovoid and almost vertical; the peristome is simple and sharp, and is slightly flaring in the palatal region. The columellar margin is simple. The operculum is thin, corneous and paucispiral. Average shell measurements from 15 specimens in millimeters are as follows: height 3.1, width 1.6, aperture height 1, and aperture width 0.8.

The Animal (Figs 2 and 3)—The foot is spatulate, truncate anteriorly, and bluntly pointed posteriorly. The tentacles are slender on both sides of the moderately pigmented snout. The gill of *Aroapyrgus colombiensis* consists of about 30 lamellae and starts near the mantle collar, where it is wide, and narrows down posteriorly under the roof of the mantle, through which it shows very clearly.

The radula is similar to that of other hydrobiids (Baker 1930, Berry 1943, Thompson 1968). The central tooth has from 12 to 15 cusps on its reflected margin, and 3 basal cusps. The lateral has 9 to 13 cusps, the 6th from the inside (the mesocone) is twice as large as any of the others, and the tooth is attached by an elongate base which extends obliquely laterad and posteriad from its squarish body. The handle is elongate and narrow. The inner marginal tooth is spoon-shaped, its concave blade carries about 25 to 35 small cusps on the reflection. The outer marginal is thinner and

more slender than the inner, and has much smaller cusps which are numerous, and are not easily seen except in fresh preparations.

Description of the reproductive organs is based on reconstructions from serial paraffin sections. In the male the testis is located at the level of the third whorl, and is embedded among the tubules of the digestive gland. Seminal vesicles are located at the beginning of the vas deferens. The latter continues as a narrow duct until it opens into the verge. A large prostate gland extends transversely about the level of the penultimate whorl. The verge arises inside a circular fold to the right of the mid-dorsal line. As is characteristic of species belonging to this genus the verge (Fig. 3) is large, simple (devoid of any papillae and is unbranched); its terminal half is smaller in diameter than the base. The seminal duct runs along the outer margin of the verge.

In the female (Fig. 2) the ovary is located at the same level as is the testis in the male. The oviduct arises from the ovary as a narrow channel before it enlarges to form a "brood pouch," which is the equivalent of the pallial oviduct in other hydrobiids. A bursa copulatrix and a seminal receptacle open at about the junction of the two parts of the oviduct. Numerous embryos, up to 30, are found in the brood pouch. The active embryos, each with a shell of about one whorl, are located within the egg capsules from which they are apparently released at birth. The birth pore is found in the proximal end of the brood pouch at the mantle collar.

Discussion

Baker (1930) proposed *Aroa* as a subgenus of *Potamopyrgus*, with *P. (Aroa) ernesti vivens* as type. (The species *ernesti* was described as *Hydrobia ernesti* by von Martens 1873, as a subfossil from Lago de Valencia). The reasons Baker gave are that the verge is simpler than in *Potamopyrgus* and *Littoridina*, and still is not bifid, as in *Amnicola* or *Hydrobia (Paludestrina)*. Later, Baker (1931) renamed it *Aroapyrgus*, and Morrison (1946) used *Aroapyrgus* as genus with the genotype *Aroapyrgus ernesti vivens* H. B. Baker. According to Morrison (1946) the genus is known to occur from Panama to Cayenne in French Guiana. Some species described under *Amnicola* in the region from Mexico to Costa Rica might also belong to this genus but will remain uncertain until animal characteristics are better known.

Morrison (1946) named and described the species *Aroapyrgus alleei*, *A. chagresensis* and *A. joseana* from the Panama region.

A. alleei has faintly shouldered whorls, whereas *A. chagresensis* has evenly rounded whorls. *A. joseana* has axially shorter whorls, than the other two species, and can also be distinguished from them by its smaller aperture and narrower conical outline. *A. colombiensis* can be distinguished from the above 3 species by its somewhat turreted spire, by having more whorls (up to 6 rounded ones), and by a narrower aperture. Except for the genus characteristics of the copulatory organ Morrison (1946) did not mention any other anatomical features of his new species. Baker (1930) described *Aroapyrgus ernesti vivens* (= *Potamopyrgus (Aroa) ernesti vivens*) as a new subspecies from Venezuela. He noted that it was the commonest form in the small streams of central and western Venezuela. *A. colombiensis* differs from *A. ernesti vivens* in the fact that generally there is no sexual dimorphism in the Colombian species contrary to the case with the Venezuelan form. Pilsbry (1935) described *Potamopyrgus laciranus*, as a new species from La Cira formation near Zopffs, La Cira District, Colombia. The shells were found to be abundant in the La Cira hematitic sandstones. The description of the shell of *A. colombiensis* as given in the present paper agrees in the main with that described by Pilsbry.

A note on the nomenclatorial history of this hydrobiid group seems in order. Pilsbry (1891) regarded the two genera *Pyrgophorus* (Ancey) and *Potamopyrgus* (Stimpson) as synonymous. Morrison (1939), however, was of the opinion that *Potamopyrgus* is strictly a New Zealand genus, and that *Pyrgophorus* is found only in the Americas. He also thought that *Lyrodes* (Doering) is a synonym of *Pyrgophorus*. Species belonging to *Aroapyrgus* can be differentiated from species belonging to the latter genera by the characteristics of the verge. The verge is very simple in *Aroapyrgus* spp., whereas it is bifid, and is provided with very distinct papillae in *Pyrgophorus*.

Several hydrobiids have been described from South America under various genera. It is obvious from a review of the literature that further studies are still needed to clarify their taxonomic status. Weyrauch (1963) for example described, on the basis of the shell only, a new species of *Potamopyrgus* from Peru, *P. mirandoi*, and some new species of *Littoridina* from Argentina and Peru. Parodiz (1960) reported from Argentina, a new species of *Lyrodes*, *L. doellojuradoi* whose shells resemble those of *Aroapyrgus*

spp. However, their anatomy remains to be studied.

The morphology of various British and European prosobranchs, in particular *Potamopyrgus jenkinsi*, were dealt with in detail by Fretter and Graham (1962). The comparative morphology of the various organ systems of these mollusks were elucidated. The morphology of several hydrobiids was treated by various authors, viz. *Pomatiopsis* spp. by van der Schalie and Dundee (1956), Dundee (1957), van der Schalie and Getz (1962); *Oncomelania nosophora* by Roth and Wagner (1957); *Cochliopa texana* and *Lyrodes cheatumi* by Dundee and Dundee (1969); various hydrobiids from Florida by Thompson (1968). The above reports as well as the present report show the usual hydrobiid morphology and, indicate that generic and specific differences shown are based on details of the structure of certain parts of the genitalia, particularly the verge, and the oviduct. The pallial portion of the oviduct is considerably expanded in the viviparous forms to accommodate the fully developed embryos. Other features of diagnostic value are: the radula, shape of the gill and number of gill lamellae, size of the osphradium, branching of the ovary, and shape of the bursa copulatrix and prostrate gland.

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**VARIATION IN THE SHELL OF
MUDALIA POTOSIENSIS (LEA)
(PLEUROCERIDAE) FROM A SINGLE LOCALITY**

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A number of workers have attempted to correlate aquatic gastropod shell variation with environmental factors. Wiebe (1926), for example, reported a direct correlation between shell size and shape and exposure to wave action, reporting, however, that differences in obesity index arose via two main avenues: (1) because of apical erosion and (2) because of actual differences in shell size and shape. Several mechanisms underlying apical erosion have been suggested in the literature, from a combination of physical and chemical factors (Jones and Branson, 1964; Goodrich, 1936) to mechanical abrasion by water-borne silt (Bailey, Pearl, and Winsor, 1932, 1933 a). The latter investigators (1933 b) were not able to correlate shell characters with any features of the environment. However, Adams (1915) demonstrated headwaters-to-mouth variation in the shells of *Io*, and Cheatum and Mouzon (1934) found that shells of *Goniobasis comalensis* Pilsbry averaged longer and wider when secured from ponded areas as contrasted

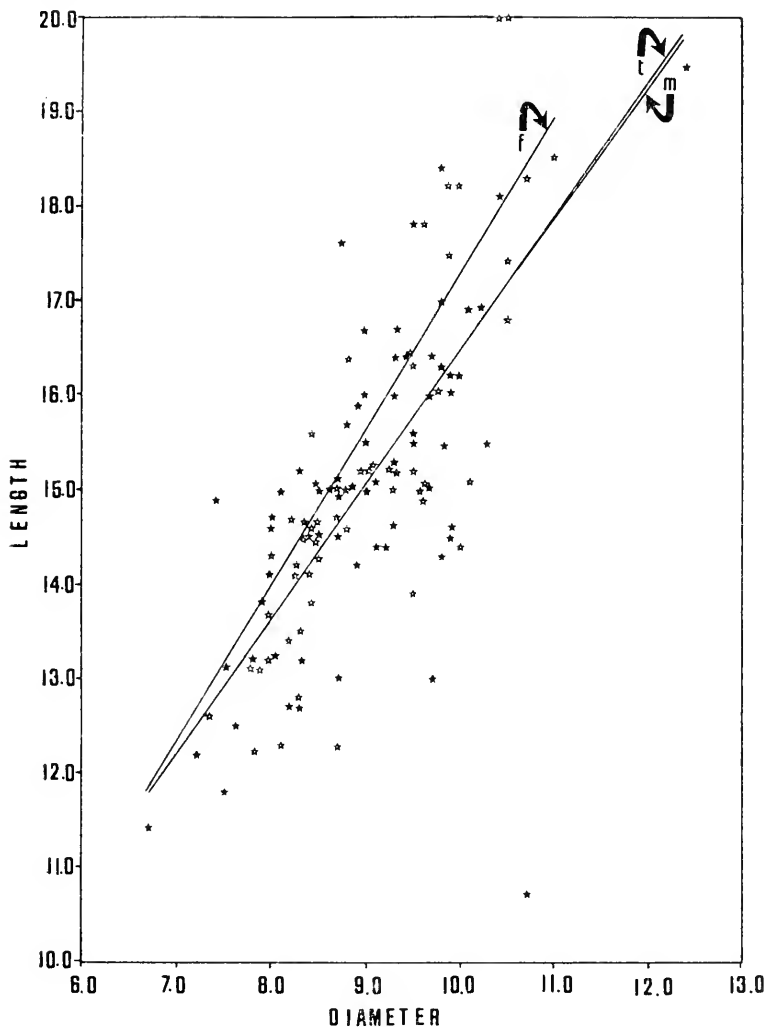


Figure 1. Regression of length on diameter in *Mudalia potosiensis*. F, female; m, male; t, total; $n=120$ (61 female; 59 male). Open stars, female; solid stars, male. Measurements in mm.

with ones from stream situations, and that the mean ratio diameter-to-length was greater in river shells than in ones from ponds, although these differences were not statistically significant.

Since none of the above authors investigated possible correlations between sex and shell variability, that question seems to be a natural avenue for investigation: are there measurable differences

between the shells of the two sexes? Since shell variation has been noted in specimens secured from different habitats and localities, all the specimens utilized in this study were secured from a single locality: the downstream side of a rock—approximately 2 feet by 1.5 feet in size—Shoal Creek, Redding's Mill, 2 miles south of Joplin, Jasper County, Missouri, 24 March 1962. From the 3,150 specimens collected at this site (deposited in the U.S. National Museum: USNM 262804), a random sample of 100 specimens was secured by means of blind-selection, one specimen at a time. The snails were killed by immersion in boiling water, the bodies removed from the shell, and the sex of each specimen determined following the technique of Jones and Branson (1964) and Stimpson (1864). Each shell was marked for later identification.

Although apical erosion was present in most of the shells, I do not believe this presents a serious problem as regards the analyses discussed below. I have assumed a normal distribution of the erosion in both sexes, and hence the quantitative results are probably valid and true. The measurements of greatest length and width (distance between the outermost point on the peristome and the opposite side of the body whorl) were made by means of a vernier caliper and are believed to be accurate within ± 0.05 mm. All computations were effected by means of Fortran programs.

Discussion—Utilizing Hubbs and Hubbs' (1953) method of graphical presentation, in which two standard errors are plotted on each side of the sample mean (no overlap indicates samples from different populations), demonstrates no significant differences between males and females as regards length and width (Figures 2 and 3). However, plotting these same measurements on a scatter-graph demonstrates some points of interest. The regression line for male specimens scarcely diverges from that for the whole population (Figure 1). The slope of the line for females does diverge somewhat from the other two. The reason for this divergence is obvious by inspection of the graph. As regards diameter, at levels below 8.5 mm there is a disparity of 12:7 in favor of females, and above 9.5 mm, a 19:15 ratio, again in favor of the females. In length, there is a similar degree of disparity in favor of females: 9:5 above 17.0 mm, and 3:1 below 13.0 mm.

These kind of data, of course, tend to smooth out some types of graphs (such as the Hubbs' type), and hence to obscure certain aspects of populations, in this example, a moderately developed

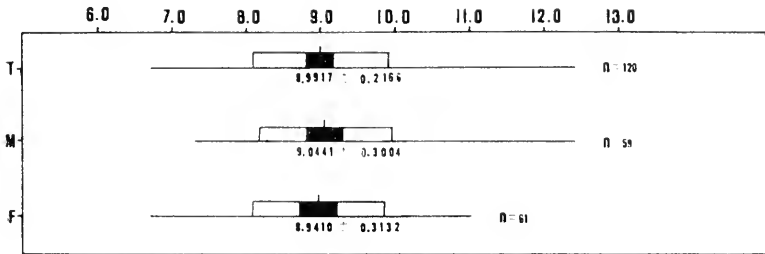


Figure 2. Shell diameter in *Mudalia potosiensis*. Horizontal line, range; vertical line, mean; open box, one standard deviation on each side of mean; closed box, two standard errors on each side of mean. Other symbols, abbreviations, numbers and measurements as in Figure 1. Confidence intervals set at 99% level.

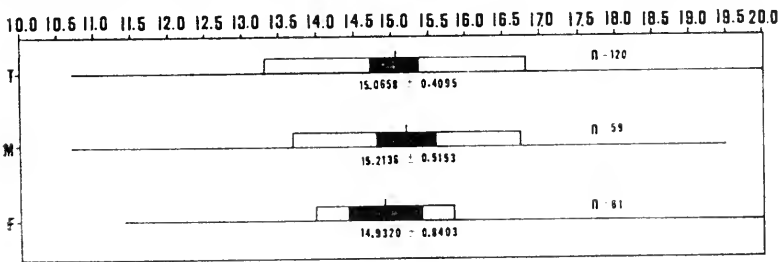


Figure 3. Shell length in *Mudalia potosiensis*. Data as in Figure 1 and 2.

trend toward sexual dimorphism in shell characteristics. The significance of these findings, although interesting, may be of minimal value to the researcher interested in separating specimens according to sex, although the odds would be 2:1 in his favor when lengths above 17.0 mm were used as the distinguishing criterion.

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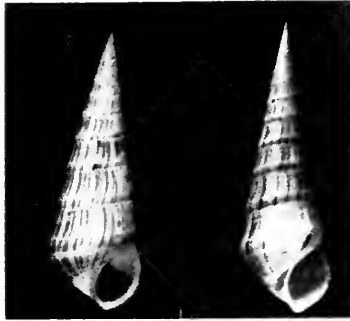
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NISO (NEOVOLUSIA) IMBRICATA
(SOWERBY, 1834) REDISCOVERED
(GASTROPODA: EULIMIDAE)

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At the time I reviewed the eastern Pacific representatives of the genus *Niso* (Emerson, 1965), the only Recent specimen known for *Niso imbricata* (Sowerby, 1834a) was the holotype, which was stated to have been dredged by Hugh Cuming off Santa Elena, Ecuador. Fossil specimens of this taxon, however, had been reported from a Pliocene deposit in Ecuador (Pilsbry and Olsson, 1941). As a result of collections made by Mesdames Carmen Angermeyer and Jacqueline DeRoy in the waters of the Galápagos Islands, additional specimens of this rare *Niso* have been recovered. This species is now known to occur also at Clarion Island, Revillagigedo Islands, Mexico, on the basis of specimens taken more than 35 years ago by the Allan Hancock Pacific Expeditions (Dr. James H. McLean, personal communication). These new records, together with notes on the holotype of Sowerby's taxon, form the foundation for this report.

The Angermeyers dredged one, well-preserved, specimen in 10 to 15 fathoms off Isla Rábida (here illustrated, left figure), and they found a fragmental specimen in the digestive tract of a fish that had been caught off Isla Santa Fe (AMNH No. 132795), in 1965. The DeRoys also obtained specimens by dredging in 5 to 6.5 fathoms in Academy Bay, Isla Santa Cruz, in November, 1965 and January, 1966. Two of these specimens, which measure 19.5 and 22 mm. in length, are now in the respective collections of Mr.



Niso (Neovolusia) imbricata (Sowerby, 1834)

Left fig. Off Isla Rábida [Jervis Island], Galápagos Islands, in 10-15 fathoms, Angermeyer coll.; 18.9 mm. in length.

Right fig. Holotype of *Eulima imbricata* Sowerby, 1834, off Santa Elena, Ecuador, in 6-8 fathoms, British Museum (Natural History) No. 1965226; 18.2 mm. in length.

Anthony D'Attilio of San Diego, California, and Dr. Donald R. Shasky of Redlands, California.

Three additional specimens came to light when the collection of gastropods of the Allan Hancock Foundation of the University of Southern California was transferred on loan to the Los Angeles County Museum of Natural History, in 1967. According to Dr. McLean, these are hermit crab specimens. They were collected intertidally at Sulphur Bay, Clarion Island, of the Revillagigedo Islands, on January 5, 1934 (Fraser, 1943, p. 280; AHF Sta. 141-34).

All of these specimens are without doubt referable to Sowerby's long-lost species, the holotype of which was examined by me during a recent visit to the British Museum (Natural History). The type specimen (here illustrated, right figure) is somewhat faded, but the characteristic color pattern of axially arranged, reddish brown lineations on a whitish surface is retained. The whorls are not as angulated as depicted in the illustrations of Sowerby (1834b, fig. 4; Adams, 1854, pl. 70, fig. 10; Reeve, 1866, fig. 3). The axial lines also are not weakly varicose, as the drawings suggest, but they have this appearance to the naked eye. The recently obtained Galapagan specimens, however, have slightly more inflated whorls and the suture is not as strongly developed as that of the holotype (see figures).

Neovolusia Emerson (1965, p. 8) was proposed to replace the homonym *Volusia* A. Adams, 1861, and it was afforded subgeneric

status to include *Niso imbricata*, which, on the basis of the illustrations of the type specimen, I wrongly concluded was weakly varicose. Dr. McLean has kindly pointed out to me that *Niso imbricata*, together with the Panamic *Niso excolpa* Bartsch, 1917, form a distinctive group in which the periphery projects beyond the whorl below. Therefore, I have retained *Neovolusia* as a subgeneric unit to include the species of *Niso* with this morphological character.

Acknowledgements: In addition to Mesdames Angermeyer and DeRoy, and Dr. McLean, I am also indebted to Mr. S. Peter Dance, formerly of the British Museum (Natural History), for providing a photograph of the holotype of *Niso imbricata*.

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PLEISTOCENE LAND SNAILS ON THE CHANNEL ISLANDS, CALIFORNIA: A CALL FOR RESEARCH

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In the course of soil and geomorphological studies carried out

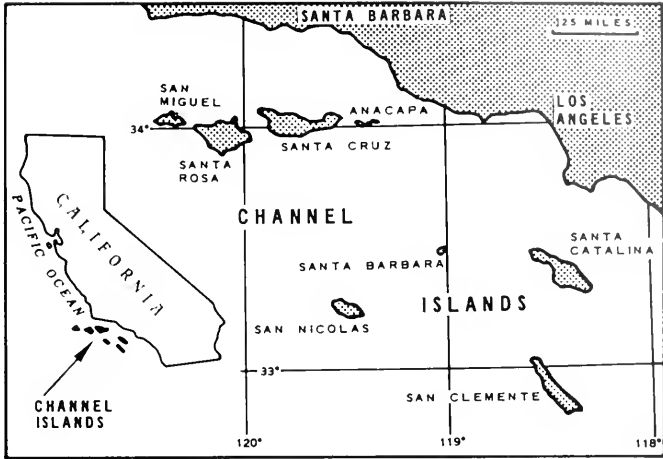


Figure 1. Location map of the California Channel Islands.

over a number of years on the Channel Islands of California the writer has been increasingly impressed with the malacological research potentials offered by the islands. The location of the islands is shown in Figure 1.

While each of the four outermost islands¹ of San Clemente, San Nicolas, Santa Rosa, and San Miguel offer more than casual interest for the malacologist concerned with possibly tracing evolutionary changes of characters of a species, the latter island, San Miguel, is by far most interesting and potentially most scientifically rewarding. On this island, Pleistocene mollusks number literally in the millions and appear to the writer, who is untrained in malacology, to be primarily of the single species *Helminthoglypta ayresiana* (Newcomb), although a specialist's eye might discriminate others. The mollusks occur at many places over the island in some of the oldest as well as very recent Quaternary deposits (Figure 2), and are still extant.²

The modern shells are noticeably smaller than their Pleistocene counterparts, an observation earlier made by Cockerell (1937) but not emphasized by him. Although Cockerell was of the opinion

¹ Santa Rosa Island is privately owned and, as experience has shown, is difficult of access. San Clemente and San Nicolas are both owned and administered by the U. S. Navy; permission to do scientific research is usually granted by writing directly to the base commanders, respectively. San Miguel Island is also owned by the U. S. Navy, but is administered by the National Park Service; permission to work on the island must come from the Channel Islands National Monument, Oxnard, California.



Figure 2. Typical scene on San Miguel Island, California. Subfossil *Helminthoglypta ayresiana* shells weathering out of a paleosol and over-lying sediments.

“I do not see that it is possible to distinguish the fossil shells from the recent . . .” his view was based on two brief visits to the island in July, 1937 (Cockerell 1938) and in May 1938 (Cockerell 1939) before any detailed stratigraphic studies had been carried out, and before the profusion and age of the shells established. Whether linear relationship between time and shell size exists remains to be determined.

² Cockerell (1938) described a fossil subspecies *H. ayresiana lesteri* from San Miguel Island, but since shells occur ubiquitously from oldest through youngest nonmarine sediments we have no way of knowing where his specimens fit temporally, or morphologically, in the chronologic column. Additionally, probably it is premature to assign a subspecific rank based on non-quantitative parameters, especially when the shells occur in quantities sufficient for statistical analysis.

The late Quaternary subaerial (nonmarine) sedimentary record on San Miguel Island is probably more complete than anywhere else on the west coast of North America. For example, in one particular exposure which consists of a complex of paleosols (fossil soils) and eolian sand deposits, the entire span of radiocarbon time is represented, and the age of the lower zones of the sedimentary unit is well beyond radiocarbon range. Land snails occur throughout the deposit. Similar exposures abound on the island, and are contributing to a Quaternary chronology.

The large number of snail shells present in the Quaternary deposits should easily lend themselves to quantitative analyses of shell morphological characters, such as size, banding, and so on. Additionally, the proven association of snail shells with vertebrate remains, fossil plants, and archaeological sites on the island attests to their cross-disciplinary importance, and as Taylor points out "Pleistocene history will be most advanced by combined researches on stratigraphy, soils, fauna, and flora; through such investigations research on fossil mollusks will not only yield more but receive more from neighboring sciences" (Taylor 1965).

In summary, the Channel Islands of southern California, especially San Miguel, offer a fund of untapped malacological research possibilities. The nonmarine Quaternary deposits on San Miguel Island contain a virtually continuous record of subfossil land snails from late Pleistocene times to the present, presumably of a single species which occurs in great numbers. To the writer's knowledge no detailed malacological studies of these subfossil snails have been made. This vacuum of research activity should be filled.

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NOTES

NEW RECORDS OF *CORBICULA MANILENSIS* (PHILIPPI) IN TEXAS
— The spread of the "Asiatic clam," *Corbicula manilensis*, in the United States is well documented in the literature by various authors. Since the reports by Dundee and Harman (1963, *Nautilus* 77:30) of *C. manilensis* from Louisiana and by Metcalf (1966, *Nautilus* 80:16-20) with the first records of the species from west-

ern Texas near El Paso, *C. manilensis* has been expected in eastern and southeastern Texas. Mrs. Constance Boone, Houston, Texas, forwarded to me specimens of *C. manilensis* obtained in February, 1969, from the Mexican side of Falcon Lake which borders United States and Mexico. This suggested that the species occurred on the U.S. side of the lake.

On April 18, 1969, Kery Hummel, a Trinity student, collected *C. manilensis* from Monte Alto Reservoir (locally called Delta Lake) in Hidalgo County, Texas. This reservoir has a sand and mud bottom, and the water is used for irrigation of vegetable and fruit farming in the extreme southeastern part of Texas. Monte Alto Reservoir is approximately 150 miles east of Falcon Dam and over 750 miles east of the first Texas recorded by Metcalf. Kery Hummel recovered additional specimens of *C. manilensis* on May 3, 1969 from an irrigation canal beside U. S. Highway 281 near Relampago, Hidalgo County. Specimens from Monte Alto Reservoir are judged to be 3-4 years old, and specimens from near Relampago are 1-2 years old which indicates a more recent introduction to the Relampago area. Since Metcalf suggested his specimens were approximately four years old in 1964, establishment of *C. manilensis* probably occurred first in western Texas and secondly in southeastern Texas.

In August, 1969, Mrs. Boone forwarded to me a single specimen of *C. manilensis* collected from Lake Mathis, 25 miles northwest of Corpus Christi, Texas. Persons attending the 1968 American Malacological Union in Corpus Christi will recall the visit to this lake which at that time yielded no *C. manilensis*. Lake Mathis is on the Nueces River approximately 170 miles north of the populations in the Lower Rio Grande drainage in Hidalgo County.

C. manilensis is now established in southeast Texas and appears to be moving in a northern direction. The next few years will probably see additional Texas records as this species spreads into eastern Texas areas where irrigation for cotton and rice farming is common. — Harold D. Murray, Trinity University, San Antonio, Texas 78212.

PROTECTION OF THE TYPE LOCALITY OF *CLAPPIELLA SALUDENSIS* (MORRISON) — *Clappiella saludensis* (Morrison) is listed as a rare and endangered eastern land snail by Dundee (Malacologia, Vol. 10, No. 1, May, 1970). The type locality in Greenville County, S. C., as described by Morrison (Proc. Biol. Soc. Wash., Vol. 50,

p. 59, 1937), is now included within the watershed area of a reservoir maintained by the Greenville (S. C.) Waterworks. The area is maintained in a natural state and all public access is denied. This type locality is probably effectively and permanently protected against most adverse factors. —George F. Townes, P. O. Box 10128 F. S., Greenville, S. C. 29603.

SPHAERIUM SIMILE (SAY) IN TENNESSEE.—In the summer of 1962, I collected *S. simile* Say 1816 (*S. sulcatum* Lamarck 1818 is a synonym) from Grassy Cove, Cumberland County, a large sink-hole measuring nearly four miles across and with a bottom elevation of about 1560 feet above sea level. The surrounding mountains of the Cumberland Plateau range up to 2900 feet in elevation. This is the first record from the Tennessee River drainage. The species does not extend through the underground streams of Grassy Cove drainage into the Tennessee Valley proper. Davenport Spring, from which these specimens were taken, is located about 35 yards west of Highway 68 and one mile north of Grassy Cove Church. Other mollusks found in this spring and its sluggish outlet were: *Goniobasis teres* Lea, *G. laqueata castanea* Lea, *Helisoma trivolvis* Say, *Physa microstoma* Haldeman, *Pisidium compressum* Prime and *P. casertanum* Poli. —Herbert D. Athearn, R-5, Box 376, Cleveland, Tennessee 37311.

DATES OF THE NAUTILUS.—Vol. 84, no. 1 mailed July 16, 1970. No. 2, Oct. 5, 1970. No. 3, Jan. 25, 1971. No. 4, April 26, 1971.

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No. 2

THE FEEDING HABITS OF APLYSIID OPISTHOBRANCHS IN FLORIDA

BY JANET M. KRAKAUER

Department of Biology, Hollins College, Virginia 24020

While collecting data on the ecology of *Aplysia willcoxi* for a Master's thesis at the University of Florida, some incidental observations were made on the other two aplysiids, *Bursatella leachi plei* and *Phyllaplysia engeli*, which are known to occur in the Cedar Key area. The question arose as to whether or not the food preferences of these animals, all purported to be herbivores (Hyman, 1967), overlapped.

A survey was made of the macroscopic algae found in the Cedar Keys and the crop contents of 47 *A. willcoxi* were analyzed. The crop contents and fecal material from two *B. leachi* were also examined. Observations were made with a dissecting microscope on two living *P. engeli* while they were feeding.

Analysis of the crop contents indicate that *A. willcoxi* eats chiefly macroscopic red algae. Less than 5% of the crops contained fragments of green and brown algae. Fragments of the smaller sea grasses, *Diplanthera* and *Syringodium*, were also found in some of the sea hares' crops. The only animal matter present was attached or slow moving organisms such as bryozoans and some unidentified gastropods. In aquaria, *A. willcoxi* fed on both red and green algae, but refused brown algae. Captive sea hares were never observed to feed on animal matter.

The crop contents of *B. leachi* include a variety of materials of both plant and animal origin. There was an assortment of diatoms, sand grains, ostracod exoskeletons, some very small fragments of the red alga *Spyridia*, and some other unrecognizable detritus. The fecal material contained chiefly sand grains and some living diatoms. *B. leachi*, in aquaria, was observed to feed on bits of shrimp, and appeared to be more adept at feeding from the bottom of the aquarium than was *A. willcoxi*.

Although no crop contents were examined in the case of *P. engeli*, observations were made on some living animals while they fed.

P. engeli is much smaller than the other two species, and is well camouflaged to blend in with the turtle grass, *Thalassia*, to which it clings while feeding. *P. engeli* feeds on the microscopic epiphytes of the turtle grass.

The three aplysiids differ appreciably in their food preferences and do not compete with each other. *A. willcoxi* is restricted to the red algae in the Cedar Keys, probably because the green algae, although palatable to the sea hares, are chiefly intertidal and are not generally available to subtidal organisms. The animal matter in the sea hares' crops appears to have been ingested by accident.

B. leachi shows the food preferences of a bottom feeding organism. It apparently ingests a variety of food. Whether or not diatoms are a part of *B. leachi*'s diet is open to question since living diatoms were found in the fecal material.

P. engeli appears to restrict its feeding activities to the epiphytes of the turtle grass. In this it resembles *P. taylori* which Beeman (1969) reports feeds on the diatoms on eel grass.

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DISTRIBUTION PATTERNS OF FIVE SELECTED GASTROPOD SPECIES FROM McCARGO LAKE

BY THOMAS J. HORST AND R. R. COSTA

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Introduction—Selected gastropod species were studied with reference to their distribution in McCargo Lake, Orleans County, New York. The lake is located on the Fancher Campus of SUNY College at Brockport. It has a surface area of 31,948 m.² and a maximum depth of 5.75 m.

The results of investigations conducted during July and August 1970 are contained in this report. The species studied were *Amnicola limnosa*, *Valvata tricarinata*, *Physa sayii*, *Gyraulus parvus* and *Promenetus exacuus*. Other gastropods present in the lake but not

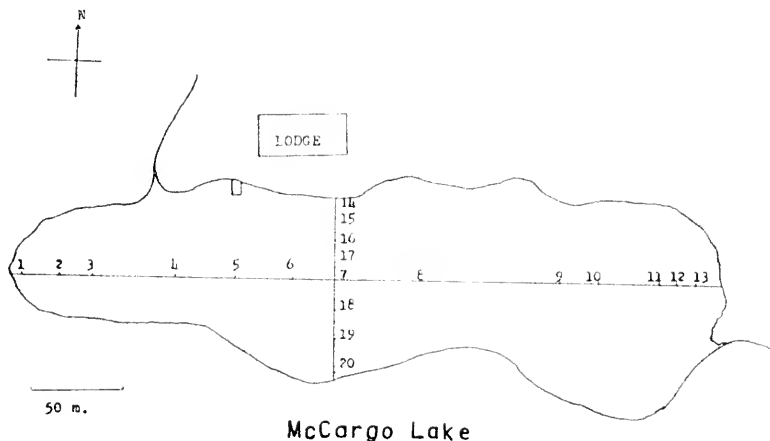


Fig. 1. Location of stations along the North-South and East-West transects.

included in this study are *Helisoma trivolvis*, *Viviparus georgianus* and *Ferrissia* sp.

The habitats and ranges of water temperature associated with these gastropods are discussed by Baker (1928) and Harman (1968). Boycott (1936) considers the most important features of molluscan habitats to be clean water, "absence of disturbance" and the presence of lime.

Methods and Materials—Two transects were sampled during the summer of 1970. Three Ekmann (6 in. by 6 in.) bottom samples and a Kemmerer water sample were taken from the hydrosol layer at each of the twenty stations (Fig. 1).

Water samples were analyzed for temperature, dissolved oxygen, alkalinity, carbon dioxide, hydrogen sulfide, turbidity and color. Water analyses were performed according to Standard Methods (APHA, 1965). Hydrogen sulfide, turbidity and color were monitored using the HACH colorimeter.

Analysis of bottom samples was performed according to the techniques of Duncan (1955). Gastropod counts obtained from replicate samples were analyzed and for all stations were found to be acceptable at a 95% confidence limit.

Results—Twenty stations which varied in depth from 0.75 m. to 5.75 m. were sampled along two transects.

Temperature profiles indicated that the epilimnion extended to a depth of 2.0 m. during the sampling period. Photometric read-

Table 1. Physical and chemical analysis of Kemmerer water samples

STATION	DEPTH (m.)	WATER TEMP. (C°)	DISSOLVED OXYGEN (ppm)	CARBON DIOXIDE (ppm)	PHENOL- PHTHALEIN (ppm)	TOTAL (ppm)	HYDROGEN SULFIDE (ppm)	TURB- IDITY (jtu)	COLOR APHA*
1	1.00	20.5	2.6	6.0	0.0	286.0	0.07	18.0	100.0
2	1.75	21.0	3.4	2.0	0.0	286.0	0.08	20.0	120.0
3	3.00	17.5	3.2	2.0	0.0	276.0	0.08	18.0	120.0
4	4.00	11.5	2.1	4.0	0.0	264.0	0.10	28.0	130.0
5	5.00	08.5	0.0	6.0	0.0	278.0	5.00	60.0	240.0
6	5.25	09.0	0.0	56.0	0.0	282.0	5.00	80.0	310.0
7	5.75	17.0	0.0	52.0	0.0	260.0	5.00	89.0	300.0
8	5.50	15.0	0.0	14.0	0.0	284.0	5.00	80.0	300.0
9	4.50	16.5	0.0	4.0	0.0	258.0	1.00	40.0	175.0
10	4.00	17.0	0.0	4.0	0.0	262.0	0.12	35.0	140.0
11	3.00	19.5	5.4	0.0	12.0	244.0	---	25.0	130.0
12	2.00	23.5	6.1	0.0	16.0	258.0	---	25.0	130.0
13	1.00	24.0	7.2	0.0	12.0	256.0	---	25.0	120.0
14	0.75	27.5	8.1	0.0	20.0	248.0	---	20.0	140.0
15	1.25	25.5	7.0	0.0	18.0	252.0	---	15.0	130.0
16	2.50	21.0	6.0	0.0	32.0	262.0	---	12.0	105.0
17	4.50	10.5	3.9	4.0	0.0	232.0	---	18.0	170.0
18	5.00	09.5	2.0	12.0	0.0	228.0	---	12.0	110.0
19	4.50	12.0	2.2	1.0	0.0	242.0	---	35.0	150.0
20	2.00	24.0	5.8	0.0	12.0	252.0	---	25.0	120.0

*APHA Color Standard Platinum

Table 2. Two way analysis of variance, North-South and East-West transects

NORTH-SOUTH TRANSECTS, STATIONS 14-20				
SOURCE	NDF	SS	MEAN SQ	F
STATIONS	3	2080.00	693.33	5.0968*
SPECIES	4	11083.07	2770.76	20.3683*
INTERACTION	12	15651.33	1304.28	9.5879
WITHIN	40	5441.33	136.03	
TOTAL	59	34255.73		

EAST-WEST TRANSECT, STATIONS 1-13				
SOURCE	NDF	SS	MEAN SQ	F
STATIONS	3	86.85	28.95	.7562
SPECIES	4	2549.23	637.31	16.6471*
INTERACTION	12	557.57	46.46	1.2137
WITHIN	40	1531.33	38.28	
TOTAL	59	4724.98		

*significant at 0.05 level

ings revealed only 5% light transmittance at the 2.0 m. zone. Secchi disk determinations ranged from 1.25 m. to 1.75 m.

Dissolved oxygen concentration at stations where live gastropods were collected ranged from 2.6 ppm to 8.1 ppm. A 0.70 correlation coefficient between gastropod density and dissolved oxygen was found. A negative correlation (-0.64) was found to exist between hydrogen sulfide and dissolved oxygen.

Phenolphthalein alkalinity was present at stations on the north and south shores while carbon dioxide was detected at all other stations. Total alkalinity values ranged from 228.0 ppm to 286.0 ppm.

A summary of chemical and physical data is presented in Table 1.

Live gastropods were collected at eight of the twenty stations (Figs. 2-3). These stations ranged in depth from 0.75 m. to 2.50 m.

Discussion—Water samples taken in the profundal zone, below 2.5 m. were found to have chemical and physical properties different from those of the littoral zone. Water color and turbidity were most pronounced in the profundal zone. Water samples taken below 3.0 m. were found to have low dissolved oxygen and high hydrogen sulfide concentrations. Alkalinity and carbon dioxide concentrations reflected lower pH values for the deeper stations.

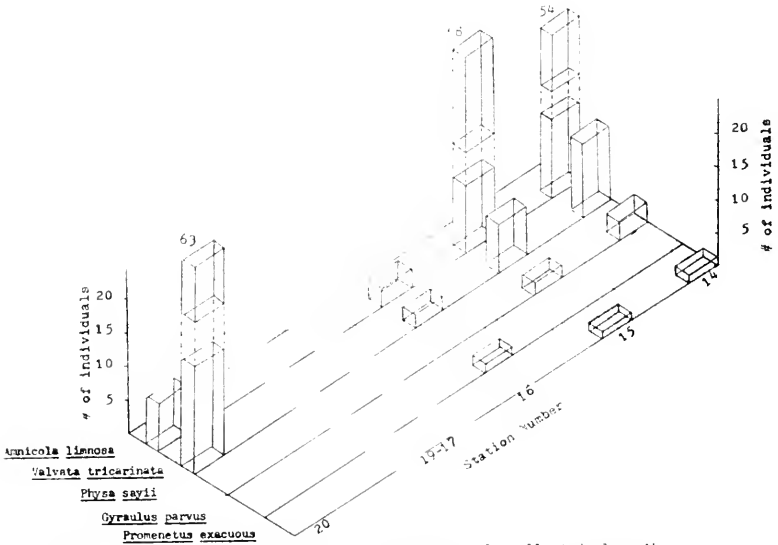


fig. 3. Mean number of gastropods per Skmann sample collected along the North-South transect.

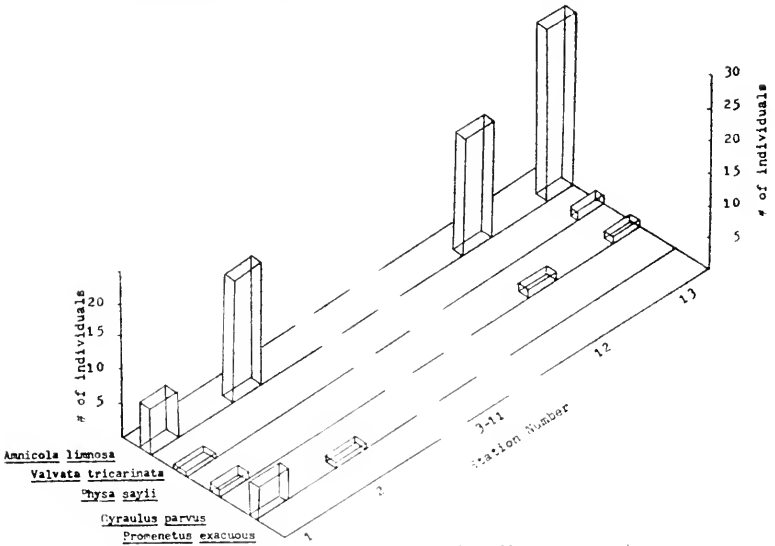


Fig. 2. Mean number of gastropods per Skmann sample collected at stations along the East-West transect.

Limited light penetration and its apparent effect upon the composition of the algal community were factors associated with the absence of gastropods. Samples collected below 1.5 m. contained *Oscillatoria* sp. and were associated with lower gastropod density.

Sediments of the littoral zone were lighter in color and contained more detrital matter than those of the deeper layers. The only sediments containing gravel were collected on the south shore. This is the only shore of the lake with high relief.

Results of analysis of variance indicated that the south shore gastropod community was significantly different than that of the north shore (Table 2). There was no significant difference, however, at the east and west shores. *A. limnosa* was the most abundant species at all shores except the south. *V. tricarinata* was most abundant there.

Summary and Conclusions—A study of the distribution of the gastropods of McCargo Lake was conducted during the summer of 1970.

Water of the littoral and profundal regions was found to have different chemical and physical properties. Low oxygen tension, high hydrogen sulfide concentration and low pH probably accounted for the absence of gastropods in the profundal zone. Limited light penetration in the lake and its effect upon the algal community appeared to be related to gastropod distribution.

Additional work is needed to relate sediment composition and algal communities to gastropod distribution.

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THE INFLUENCE OF LIGHT CONDITIONS UPON THE EGG-LAYING OF THE PLANORBID SNAIL, *BIOMPHALARIA GLABRATA*

BY JAMES E. JOY
College of Veterinary Medicine
Department of Veterinary Parasitology
Texas A&M University
College Station, Texas 77843

The influence of light on the behavior of snails has been given little attention. Pesigan et al (1958) showed that the reaction of

Oncomelania quadrasi: to light was one of avoidance as the snails invariably crawled away from a high intensity light source, the speed of their movement increasing as the intensity of the light increased. That *Oncomelania* avoids direct sunlight or strong direct light rays has also been documented by Abbott (1948), Kawamoto (1952), Komiya et al (1959), and Moose and Williams (1961-62). In an attempt to correlate the distribution of *B. glabrata* with environmental factors in Puerto Rico, Harry and Aldrich (1958) stated that, "*A. glabratus* seems little affected by the amount of light which reaches its habitat. It is often found exposed to direct sunlight, and in habits partially or well shaded." On the other hand, Deschiens (1957) maintained that *glabrata* withdrew into its shell immediately when subjected to a strong direct light. Deschiens' belief that *B. glabrata* favored darkness and light of a low intensity, led he and Bijan to study the behavior of this snail under conditions of total darkness for a period of 90 days. Deschiens and Bijan (1956) noted that, "que ce mollusque conserve, dans ces conditions, son comportement et son activité normaux: le rythme des pontes, leur nombre, la croissance des embryons, des larves et des formes juvéniles ne sont pas entravées par l'absence de lumière." Although reproductive activity appeared normal the authors gave no specific numbers of clutches, eggs, or percent hatchability.

The data presented here show differences in egg-laying of *B. glabrata* with relation to light energy and day length.

Materials and Methods—All snails used in this study were maintained individually in 250 ml of dechlorinated tap water at a temperature of 23 to 25 C. Plaster of Paris was added at the rate of 2.5 mg per liter of water. The water, not being aerated, was changed every third day. Romaine lettuce was always available for the snails. A sodium alginate food supplement was given the snails one day per week.

Five groups of snails were maintained under the following conditions of light period and energy.

- 1) continuous darkness (the changing of water, feeding and counting of eggs required a certain amount of light. These light periods were of short duration, usually less than 10 minutes each day, and at a very low—but unmeasured—light energy level).
- 2) continuous light at 355 $\mu\text{W cm}^2$

3) continuous light at $890 \mu\text{w}/\text{cm}^2$

4) 12-hour dark period 12-hour light period at $355 \mu\text{w}/\text{cm}^2$

5) 12-hour dark period 12-hour light period at $890 \mu\text{w}/\text{cm}^2$

Light energy levels were attained through the combination of four 8-foot, 40-watt cool white fluorescent lamps and twelve 25-watt incandescent bulbs. The light energy of this source three feet above the snails was calculated at $890 \mu\text{w}/\text{cm}^2$ with $617 \mu\text{w}/\text{cm}^2$ in the visible spectrum and $273 \mu\text{w}/\text{cm}^2$ in the infra red spectrum.

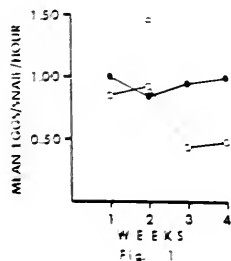
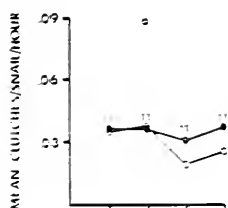


Fig. 1

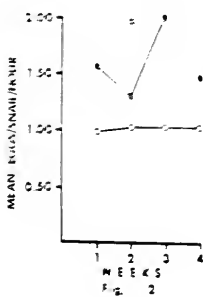
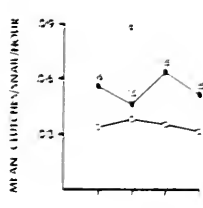


Fig. 2

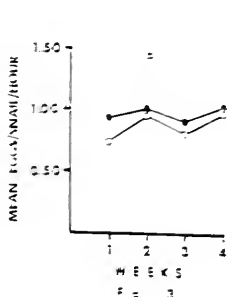
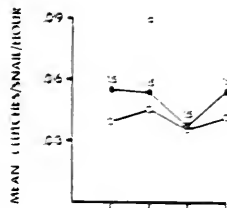


Fig. 3

Figure 1. Mean clutches per snail per hour (a) and mean eggs per snail per hour (b) laid by *B. glabrata* maintained under continuous darkness. Closed circles represent clutches and eggs laid during the nighttime (3 P.M. to 3 A.M.); open circles represent clutches and eggs laid during the daytime (3 A.M. to 3 P.M.). Numbers above closed circles in (a) represent ovipositing snails.

Figure 2. Mean clutches per snail per hour (a) and mean eggs per snail per hour (b) laid by *B. glabrata* maintained under continuous light at an energy level of $355 \mu\text{w}/\text{cm}^2$. Closed circles represent clutches and eggs laid during the nighttime (3 P.M. to 3 A.M.); open circles represent clutches and eggs laid during the daytime (3 A.M. to 3 P.M.). Numbers above closed circles in (a) represent ovipositing snails.

Figure 3. Mean clutches per snail per hour (a) and mean eggs per snail per hour (b) laid by *B. glabrata* maintained under continuous light at an energy level of $890 \mu\text{w}/\text{cm}^2$. Closed circles represent clutches and eggs laid during the nighttime (3 P.M. to 3 A.M.); open circles represent clutches and eggs laid during the daytime (3 A.M. to 3 P.M.). Numbers above closed circles in (a) represent ovipositing snails.

To obtain a lower light energy level with the same spectral distribution, three layers of aluminum screening were placed ten inches above the snails. This procedure reduced the original energy of $890 \mu\text{w}/\text{cm}^2$ to a total energy of $355 \mu\text{w}/\text{cm}^2$ with $250 \mu\text{w}/\text{cm}^2$ in the visible spectrum and $105 \mu\text{w}/\text{cm}^2$ in the infra red spectrum. Measurement of the light source was done with an ISCO Model SR Spectroradiometer having a wave length range of 380 to 1050 μm .

Approximately three weeks after the onset of oviposition, clutches and eggs of all snails were counted at 8 A.M. (to ascertain night-

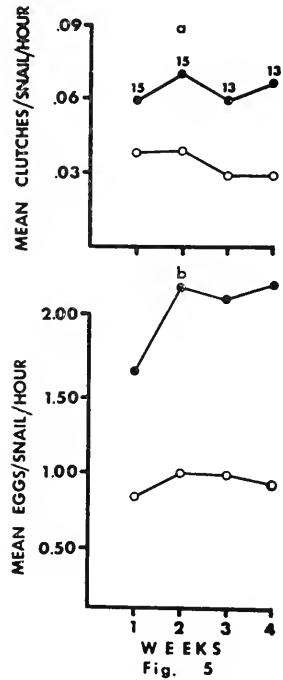
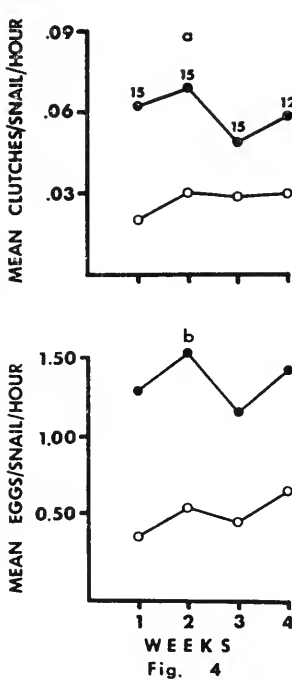


Figure 4. Mean clutches per snail per hour (a) and mean eggs per snail per hour (b) laid by *B. glabrata* maintained under a 12-hour/12-hour day. The light period was at an energy level of $355 \mu\text{w}/\text{cm}^2$. Closed circles represent clutches and eggs laid during the nighttime (8 P.M. to 8 A.M.); open circles represent clutches and eggs laid during the daytime (8 A.M. to 8 P.M.). Numbers above closed circles in (a) represent ovipositing snails.

Figure 5. Mean clutches per snail per hour (a) and mean eggs per snail per hour (b) laid by *B. glabrata* maintained under a 12-hour/12-hour day. The light period was at an energy level of $890 \mu\text{w}/\text{cm}^2$. Closed circles represent clutches and eggs laid during the nighttime (8 P.M. to 8 A.M.); open circles represent clutches and eggs laid during the daytime (8 A.M. to 8 P.M.). Numbers above closed circles in (a) represent ovipositing snails.

time egg-laying activity regardless of whether the snails were in darkness or light) and at 8 P.M. to determine the number of clutches and eggs laid during the daytime (again disregarding light conditions).

Results—There is no evidence to suggest a strict correlation of egg-laying with light conditions. Although a predisposition to nocturnal egg-laying existed in all groups, the disparity between nighttime and daytime oviposition was lessened in those groups maintained under continuous conditions of darkness and light (Figs. 1 thru 5; Table 1). Mean egg-laying rates for the entire experimental period, along with the rate of nighttime egg-laying over that of the daytime, are shown in Table 1.

Discussion—That *B. glabrata* "prefers" the nighttime for oviposition has been demonstrated. They retain this ability, although to a lesser degree, even when maintained in continuous darkness or light for extended periods of time. The same phenomenon has been observed in other snails. Pesigan et al (1958), in working with 200 female snails on 12-hour/12-hour days for a period of 5 days, noted that *Oncomelania quadrasi* favors the nighttime over daytime for oviposition by a ratio of nearly 3 to 1. Clapp (1921) in working with the river limpet, *Ancylus fuscus*, Cole (1925) in studying *Planorbarius corneus* and *Helisoma trivolvis*, and Krull (1931) in working with *Gyraulus parvus*, all observed that egg-laying occurred at night. Cole even had groups of snails in continuous darkness and continuous light which deposited their eggs at night. These experiments were, however, of short duration (96 hours). In additional experiments Cole reversed the day and found that "Under

TABLE 1.

LIGHT CONDITIONS	MEAN EGGS/SNAIL/HOUR		RATE OF NIGHTTIME EGG-LAYING OVER DAYTIME
	NIGHTTIME	DAYTIME	
Continuous Darkness	0.926	0.666	1.4
Continuous Light (355 $\mu\text{w}/\text{cm}^2$)	1.584	1.019	1.6
Continuous Light (890 $\mu\text{w}/\text{cm}^2$)	1.008	0.683	1.4
12-hour/12 $\frac{1}{2}$ -hour (355 $\mu\text{w}/\text{cm}^2$)	1.336	0.517	2.6
12-hour/12 $\frac{1}{2}$ -hour (890 $\mu\text{w}/\text{cm}^2$)	1.992	0.935	2.1

these conditions 14 masses were deposited, all of them during the night, even though the normal environmental conditions of day and night had been reversed."

Another point of interest concerns the snails maintained under continuous light at $355 \mu\text{w}/\text{cm}^2$. The snails in this group had the highest rate of egg-laying in the daytime and second highest during the nighttime (Table 1). This is not too surprising, however, since increased oviposition in continuous light has been noted before. Wagner (1954-55) reported a definite trend toward increased production of young by snails in continuous light. Van der Schalie and Davis (1968) reported the same was true of *Oncomelania hupensis formosana*, as more young were produced when 5 males and 5 females were kept in continuous light of 70-100 footcandles. On the other hand, while Deschiens and Bijan (1956) believed the reproductive activity of *B. glabrata* under continuous darkness to be normal, this study reveals that of the five groups tested the continuous darkness group had the poorest oviposition rates as determined by eggs/snail/hour.

Clutch patterns (Figs. 1a thru 5a) have been included to emphasize a minor point. They paralleled the egg patterns (Figs. 1b thru 5b) quite well, indicating that by the fourth week of oviposition the number of eggs/clutch had stabilized.

Acknowledgments—I would like to thank Dr. R. D. Powell and Mr. Bobbie McMichael of the Department of Plant Sciences, Texas A&M University, for use of laboratory equipment and providing assistance in calculating light energy levels.

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CONUS PATAE, A NEW CARIBBEAN GASTROPOD

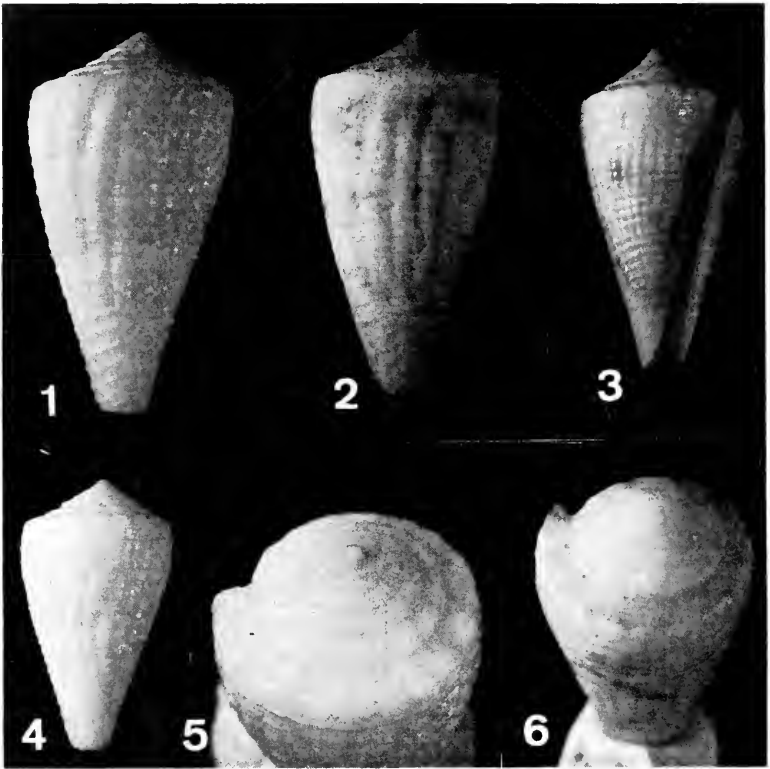
BY R. TUCKER ABBOTT
Delaware Museum of Natural History

Through the kindness of Mrs. Patricia Nelson Ware, Miss Elizabeth K. Stapleton, J. M. Humfrey and Thomas L. McGinty, a new species of *Conus* from Florida and Jamaica has been submitted for description. I take pleasure in naming it for the original discoverer, Mrs. Patricia N. Ware of Florida. This new species somewhat resembles *Conus mus* Hwass, 1792, and *C. cardinalis* Hwass, 1792.

Conus patae, new species

Figs. 1-6

Description—Shell 21 to 25 mm. in length, moderately heavy, spirally sculptured and weakly and axially ridged. Whorls $7\frac{1}{2}$ or $8\frac{1}{2}$, almost straight-sided. Shoulder carinate and smooth, although in some specimens it may be weakly undulating. Color of shell ivory-white with a blush of lavender at the base and a band of tincture of rose at the shoulder. Over this are a few irregular, small blotches of light brown. In Florida specimens which have been buried in offshore sands, the lavender color has faded and the brown blotches are yellow. Spire fairly low, straight to slightly concave and with an angle of about 100° . Top of whorls concave in the spire and have about 6 raised spiral threads crossed by microscopic axial scratches. The thin, brown periostracum in live specimens is similarly sculptured. Top of whorls with 6 to 8 color blotches per whorl. Sides of whorls with long, axial, conspicuous, rounded plaits, crossed by about two dozen spiral threads. Interior of aperture pinkish in fresh specimens, white in dead ones. Soft parts and operculum unknown.



Figs. 1-6. *Conus patae* Abbott, new species. 1, holotype, 24.4 mm. 2, paratype from Jamaica, 24.0 mm. 3 and 6, paratype from Jamaica, 20.8 mm. 4 and 5, paratype from off Lauderdale-by-the-Sea, 24.5 mm. (Del. Mus. Nat. Hist. no. 40595).

Measurements—

length	width	no. whorls	
24.4	13.8	8.5	Holotype
24.5	13.6	8.0	Paratype; Lauderdale
25.0	14.2	8.0	Paratype; Lauderdale
24.9	14.0	8.0	Paratype; Lauderdale
24.0	13.0	8.0	Paratype; Jamaica
20.8	10.6	8.5	Paratype; Jamaica
17.5	10.3	7.0	Paratype; Finlay Coll'n

Types—The type locality is 10 fathoms, from pipe dredgings, off Pompano Beach, Broward County, Florida. Patricia N. Ware, coll. 1970. The holotype is in the Delaware Museum of Natural His-

tory, No. 44097. Paratype from the same locality, DMNH 44096; 3 paratypes (DMNH 40595) from dredgings, 50 to 100 feet depth, 1/2 mile off Lauderdale-by-the-Sea, Elizabeth K. Stapleton, coll. 1970. Two paratypes (DMNH No. 44095) from Ocho Rios, north central coast of Jamaica. J. M. Humfrey, coll. 1970, in 45 feet of water near coral reefs; 3 paratypes from 80 feet, off Pompano Beach from the John Finlay collection.

Range—From southeast Florida to Jamaica.

Remarks—*Conus patae* has the same general shape as *Conus daucus* Hwass, 1792, and *C. juliae* Clench, 1942, but differs in having strong axial and spiral sculpturing and lacking any color in the nuclear whorls. *C. patae* has a non-coronate shoulder, unlike *C. mus* Hwass, 1792, *C. cardinalis* Hwass, 1792, and the various varicose forms of *jaspideus* Gmelin, 1791, such as *verrucosus* Hwass, 1792, and *havanensis* Aguayo and Farfante, 1947. The most outstanding feature of this new species is the series of fine axial folds that extend the length of the last whorl. Fresh specimens from Jamaica have a pink to lavender blush that is more pronounced at the base.

REVIEW OF *PARODOSTOMIA*, *TELLODA*, *GONIODOSTOMIA* AND *EULIMASTOMA* (GASTROPODA: PYRAMIDELLACEA)

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Clarkesville, Tennessee 37040

In 1959, Laseron (p. 200) concluded that the generic name *Scalenostoma* Deshayes, 1863, had been incorrectly applied in studies of the Australian fauna. All well-known Australian "*Scalenostoma*" are pyramidellacean gastropods of the odostomiid stock. They have heterostrophic protoconchs, prominent parietal plications, and convex or flat-sided whorl profiles. *Scalenostoma carinatum* Deshayes, 1863, the type species of *Scalenostoma*, is poorly known but it lacks a parietal plication and has a concave whorl profile. Laseron doubted that *Scalenostoma* Deshayes belonged in the Pyramidellacea.

Parodostomia Laseron, 1959, was proposed for Pacific pyramidellacean gastropods that had been incorrectly assigned to the genus *Scalenostoma* Deshayes. The type species, *Odostomia compta* Brazier, 1877, and two other Australian species were unequivocally

referred to *Parodostomia*. A North American species, *Odostomia* (*Scalenostoma*) *dotella* Dall and Bartsch, 1909, was referred to *Parodostomia* with query and Laseron suggested that a New Zealandic species might also belong in his new genus. Laseron's concept of *Scalenostoma* Deshayes has won wide acceptance and *Parodostomia* Laseron is a commonly used name (e.g.: Iredale and McMichael, 1962).

Laseron was not the first person to note pronounced differences between *Scalenostoma* Deshayes and Pacific species referred to *Scalenostoma*. *Telloda* Hertlein and Strong (1951, p. 104) was proposed for an Eastern Pacific pyramidellacean species that had been placed in the eulimacean genus *Scalenostoma* Deshayes. Though no general review of *Scalenostoma* was attempted, Hertlein and Strong clearly meant *Telloda* to include species like those Laseron placed in *Parodostomia*.

By original designation, the type species of *Telloda* Hertlein and Strong is *Odostomia* (*Scalenostoma*) *dotella* Dall and Bartsch, 1909. Yet, according to Laseron (1959, p. 200), “. . . *S. dotella* Dall and Bartsch is apparently a *Parodostomia*.” The type species of *Telloda* and the type species of *Parodostomia* are very similar. They differ in a single character. Species assigned to *Parodostomia* have spiral sculpture on the interior of the outer lip while such sculpture is absent in species assigned to *Telloda*. Traditionally, great taxonomic significance is assigned to the presence of spiral sculpture on the interior of the outer lip of pyramidellids (e.g.: Dall and Bartsch, 1909; Laws, 1940). In *Parodostomia* and *Telloda* all morphologic features except internal lirations are virtually identical. Species assigned to *Parodostomia* are, thus, regarded as congeneric with those assigned to *Telloda*. Since species assigned to *Parodostomia* and those placed in *Telloda* do differ in one important shell character and have distinctly different geographic distributions, they are here regarded as subgenerically distinct.

Both *Telloda* and *Parodostomia* were established for pyramidellacean gastropods previously placed in the eulimacean genus *Scalenostoma*. Prior to the establishment of either *Parodostomia* or *Telloda*, Bartsch (1916) had concluded that *Scalenostoma* Deshayes should be placed in the eulimacean family Eulimidae. He also reviewed American and African species of *Scalenostoma*. For *Odostomia* (*Scalenostoma*) *dotella* Dall and Bartsch, 1909, a new

taxon was proposed: *Eulimastoma* Bartsch, 1916. Since type species are the same, *Eulimastoma* Bartsch, 1916, is a senior objective synonym of *Telloda* Hertlein and Strong, 1951. It is also a senior subjective synonym of *Parodostomia* Laseron, 1959, and *Parodostomia* should be ranked as a subgenus of *Eulimastoma*. *Eulimastoma* appears to be the oldest valid name for gastropods congeneric with *Odostomia* (*Scalenostoma*) *dotella* Dall and Bartsch, 1909.

Some indication of a possible synonymy between *Parodostomia*, *Telloda*, and *Eulimastoma* is implicit in the original descriptions. Each nominal genus involves both *Scalenostoma* Deshayes and *Odostomia dotella* Dall and Bartsch. *Goniodostomia* Pilsbry and Johnson (1917, p. 181) is here interpreted as another synonym of *Eulimastoma* Bartsch, 1916, but the basis for this synonymy is considerably more complex. The name *Goniodostomia* should never have been proposed. It was introduced as the result of a series of errors.

Eulimastoma Bartsch, 1916, was proposed to rectify an erroneous interpretation of *Scalenostoma* Deshayes made by Dall and Bartsch (e.g.: 1909). The one species referred to *Eulimastoma* by Bartsch (1916) had been described as a *Scalenostoma* by Dall and Bartsch (1909). The species was not redescribed and *Eulimastoma* was not formally characterized by Bartsch (1916). In Dall and Bartsch (1909, p. 229), *Scalenostoma* Deshayes is diagnosed as "Smooth *Odostomias* having a peripheral keel." Unfortunately, the first species described under *Scalenostoma* in Dall and Bartsch (1909) has an abundance of microscopic spiral striations and lacks a keel, though the periphery is angular. Since it is neither smooth nor keeled, this species bears no relationship to the genus-level diagnosis under which it was described. This is the species, *Odostomia dotella* Dall and Bartsch, that became the type species of *Eulimastoma* Bartsch. Thus, *Eulimastoma* must include species with spiral microsculpture. Pilsbry and Johnson (1917) apparently took the diagnosis of *Scalenostoma* by Dall and Bartsch (1909) at face value. They placed *Eulimastoma*-like species from the Oligocene of Hispanola in two groups. Smooth species were placed in *Eulimastoma*, in accordance with the Dall and Bartsch (1909) diagnosis of *Scalenostoma*. For species with spiral microsculpture, like the type species of *Eulimastoma*, they created a new taxon, *Goniodostomia* Pilsbry and Johnson (1917, p. 181).

Clearly, *Goniodostomia* Pilsbry and Johnson, 1917, must be ranked as a junior subjective synonym of *Eulimastoma* Bartsch, 1916. Species that Pilsbry and Johnson placed in *Eulimastoma* pose a more significant taxonomic problem. They do lack spiral microsculpture and are, thus, morphologically distinct from the type species of *Eulimastoma*. In odostomiids, and in other pyramidel-
lacean families, great taxonomic significance has been assigned to the presence, or absence, of faint spiral striations (e.g.: Dall and Bartsch, 1909). Recent research suggests that the mere presence or absence of spiral microsculpture may not be taxonomically significant. One recent study (Corgan, 1969) shows that similar microscopic ornamentation can be produced by two different morphologic features, superficial sculpture and internal structural differences within the shell wall. Spiral micro-ornamentation is, thus, a difficult character to use as a taxobasis. Personal experience shows that odostomiids may have spiral microsculpture at one ontogenetic stage and lack it at another. In studies of monospecific populations of adult odostomiids, both Willett (1937) and Abbott (1958, p. 102) concluded that presence, or absence, of spiral microsculpture alone was not a taxonomically significant character at the species level. All data suggest that faint spiral striations can not be reasonably cited as evidence of genus-level distinction. Species Pilsbry and Johnson placed in *Eulimastoma* are properly referred to that genus.

The equivalence, or near equivalence, of the names *Eulimastoma*, *Goniodostomia*, *Telloda*, *Parodostomia*, and "*Scalenostoma*" has passed unnoted and, in the literature of the last few decades, new congeneric species have been proposed under different generic names. In addition, *Telloda*, *Eulimastoma*, *Goniodostomia*, and "*Scalenostoma*" are, at least occasionally, ranked as subgenera of *Odostomia* Fleming, 1813. Thus, six genus-level names are currently used for congeneric species. To clarify the contest, characteristics, and distribution of *Eulimastoma* Bartsch, 1916, the genus is briefly reviewed below.

Superfamily PYRAMIDELLACEA

Family ODOSTOMIIDAE

Genus *EULIMASTOMA* Bartsch, 1916

Eulimastoma BARTSCH (1916, p. 73).

Goniodostomia PILSBRY AND JOHNSON (1917, p. 181). Type species by original designation *Odostomia* (*Goniodostomia*) *superans* Pilsbry and Johnson.

Telloda HERTLEIN AND STRONG (1951, p. 104). Type species by original designation *Odostomia (Scalenostoma) dotella* Dall and Bartsch.

Parodostomia LASERON (1959, p. 200). Type species by original designation *Odostomia compta* Brazier.

Type Species—By original designation, *Odostomia (Scalenostoma) dotella* Dall and Bartsch.

Diagnosis—Small to minute, high spired marine gastropods with a single columellar plication that is generally expressed as a prominent parietal tooth; with a pronounced angulation at the periphery; with or without faint spiral striations; late teleoconch whorls generally attached low on the base of earlier whorls, exposing part of the earlier whorl base; protoconch heterostrophic, low-spired, generally about two whorls, unornamented, usually deeply and sometimes completely immersed in the first teleoconch whorl; teleoconch whorls slightly convex to flat-sided; aperture generally oval, with or without faint spiral sculpture inside the outer lip; with or without umbilicus; known adult size range from about 1.2 to 5.5 mm, average adult size about 2.5 mm.

Status—Many authors rank *Eulimastoma*, or a synonym, as a subgenus of *Odostomia* Fleming, 1813 (e.g.: Hertlein and Strong, 1951). Others rank *Eulimastoma*, or a synonym, as a genus and place it near the genus *Eulimella*, which is usually attributed to Forbes, 1846 (e.g.: Cossmann, 1921). Most modern workers treat *Eulimastoma*, or a synonym, as a genus and place it near *Odostomia* (e.g.: Bartsch, 1955).

An immersed, to partly immersed, heterostrophic protoconch, presence of a columellar plication, and a dearth of sculpture suggest that *Eulimastoma* does belong to the odostomid stock. Slightly convex to flat-sided whorls and a high spired growth form make *Eulimastoma* quite distinct from *Odostomia*. Morphologic distinctions, wide geographic distribution, and a significant duration in time combine to suggest that *Eulimastoma* Bartsch, 1916, should be ranked as a genus of the Odostomiidae.

Ecology—Odostomiids are external parasites of mollusks and/or worms (e.g.: Fretter and Graham, 1962). Dietary preferences of *Eulimastoma* have not been described. Dredged specimens have been recovered between 24 to 162 feet. The exact depth range of living specimens is unknown but data suggest that the genus is restricted to the inner Continental Shelf. Laseron (1959, p. 201)

associates *E. compta* (Brazier) with a grass substrate. It may well occur on a variety of substrates and it may, or may not, be typical of the genus.

Subgenera—Two subgenera are recognized: *Eulimastoma* (*Eulimastoma*) and *Eulimastoma* (*Parodostomia*):

Eulimastoma (*Eulimastoma*)

Diagnosis—*Eulimastoma* without spiral striations on the inner surface of the outer lip.

Geologic Range—Oligocene to modern.

Content—One species is known from the Oligocene of New Zealand: *Scalenostoma southlandica* Laws (1940, p. 158, pl. 13, fig. 5). Six nominal species, first illustrated by Pilsbry (1922), have been collected from the Oligocene of Hispanola. Two of these species, with faint columellar plications, have not previously been placed in *Eulimastoma*. They are *Odostomia* (*Evalea*?) *vexator* Pilsbry and Johnson (1917, p. 180) and *O. santodomingensis* Pilsbry and Johnson (1917, p. 179). These seem to be meaningful species. The name *O. santodomingensis* originated as a replacement for *Aclis polita* Gabb (1881, p. 226). Though the grounds offered for replacement are no longer valid, there is an *Aclis polita* Verrill (1872, p. 282) and the replacement, thus, is necessary.

Odostomia (*Goniodostomia*) *superans* Pilsbry and Johnson (1917, p. 180) and *O. (G.) circumvincta* Pilsbry and Johnson (1917, p. 181) are rather similar species but, apparently, distinct. It seems best to rank *Odostomia* (*Eulimastoma*) *pyrgulopsis* Pilsbry and Johnson (1917, p. 179) as a senior synonym of *O. (E.) bathyraphe* Pilsbry and Johnson (1917, p. 180). It has page priority and *O. bathyraphe* seems to be an unusually broad individual of the same species.

With seven nominal species of *Eulimastoma* known from the Oligocene, it is surprising that Miocene species seem to be unrecorded. One Pliocene species from Florida has been described under two names: *Eulimastoma harbisonae* Bartsch (1955, p. 82, pl. 16, fig. 1) and *E. olssoni* Bartsch (1955, p. 83, pl. 16, fig. 5). These nominal species occur together and differ only in the presence, or absence, of an umbilicus. Personal experience with *Eulimastoma* and the observations of Laseron (1959, p. 200-201) show that both umbilicate and non-umbilicate individuals occur in monospecific populations of *Eulimastoma*. Since it has page priority,

Eulimastoma harbisonae Bartsch, 1955, is here selected as the senior synonym.

An unpublished dissertation (Corgan, 1967) describes and illustrates two new species of *Eulimastoma* from Quarternary sediments of the Mississippi River Delta. New species are part of a cool water fauna that inhabited the area some 15,500 years ago. It seems probable that these species are still part of the Carolinian fauna of the Gulf of Mexico. Since the dissertation was prepared, I have seen two additional new species of *Eulimastoma* in modern faunal collections made by Miss Jean Andrews on the Texas Coast.

Described modern species of *Eulimastoma* (*Eulimastoma*) are known only from the tropical coasts of western North America. The two known species are *Odostomia* (*Scalenostoma*) *dotella* Dall and Bartsch (1909, p. 230, pl. 30, fig. 5) and *Odostomia* (*Telloda*) *subdotella* Hertlein and Strong (1951, p. 104, pl. 8, fig. 5). Both seem to be meaningful taxa.

Eulimastoma (*Parodostomia*)

Diagnosis—*Eulimastoma* with spiral striations on the inner surface of the outer lip.

Geologic Range—Known only from modern faunas.

Content—*Eulimastoma* (*Parodostomia*) is known only from the Pacific. Two species occur in the fauna of New South Wales: *Scalenostoma subcarina* Laseron (1951, p. 308, fig. 21) and *S. pyramidata* Laseron (1951, p. 308, fig. 24). One species occurs in northern Australia: *Odostomia compta* Brazier (1877, p. 259). Laseron (1959, p. 200, figs. 46-48) provides illustrations and a synonymy. He correctly treats *O. affinis* Brazier (1877, p. 259), *O. parvula* Brazier (1877, p. 260), and *O. polita* Brazier (1877, p. 260) as junior synonyms of *O. compta* Brazier. The only other known species of *Eulimastoma* (*Parodostomia*) is *Odostomia eutropia* Melvill (1899, p. 94, pl. 1, fig. 14) from Pakistan.

Eulimastoma ?

A fairly detailed review of the world odostomiid fauna suggests that no other described species can be unequivocally referred to *Eulimastoma*. A few briefly described and/or unillustrated species can not be adequately evaluated. *Odostomia yaquica* Maury (1917, p. 151, pl. 25, fig. 22) may be a *Eulimastoma*. It is, apparently, known only from the holotype which came from Hispanola and is probably of Oligocene age.

Odostomia engonia Bush (1885, p. 466) and *O. engonia* var. *teres* Bush (1885, p. 467, pl. 45, fig. 9) resemble *Eulimastoma* in growth form and sutural characteristics. Protoconch-teleoconch relationships are not adequately described for either nominal taxon and from published records they can not be identified with certainty. Garcia-Cubas (1963, p. 45, pl. 4, fig. 9) has recorded *Pyramidella engonia* var. *teres* (Bush) from southeastern Mexico. Like Bush, Garcia-Cubas does not provide a detailed description but his illustration is good and the species is apparently a *Eulimastoma*. If the identification is correct, Bush's taxon is very widespread.

SUMMARY

Eulimastoma Bartsch, 1916, must be regarded as a common and widespread genus. It ranges from roughly 35° north, in the Atlantic, to about 35° south, in the Pacific, and extends back in time to the Oligocene. *Eulimastoma* and its subgenus *Parodostomia* Laseron, 1959, include, or may include, the 22 nominal species listed below. Species that, to the best of my knowledge, have not previously been placed in *Eulimastoma* s.l. are indicated by an asterisk. Each species listed is cited and discussed in the text.

Eulimastoma (*Eulimastoma*)

circumvineta (Pilsbry and Johnson); *dotella* (Dall and Bartsch); *harbisonae* Bartsch (syn.: *olssoni* Bartsch); *pyrgulopsis* (Pilsbry and Johnson) (syn.: *bathyraphe* (P. and J.)); **santodomingensis* (Pilsbry and Johnson) (syn.: *polita* (Gabb)); *southlandica* (Laws); *subdotella* (Hertlein and Strong); *superans* (Pilsbry and Johnson); **vexator* (Pilsbry and Johnson).

Eulimastoma (*Parodostomia*)

compta (Brazier) (syn.: *affinis* (Brazier), *parvula* (Brazier) and *polita* (Brazier)); **eutropria* (Melvill); *pyramidata* (Laseron); *subcarina* (Laseron).

Eulimastoma ?

engonia (Bush); *teres* (Bush); *yaquica* (Maury).

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NOTES ON *ALASMIDONTA FABULA* (LEA) IN KENTUCKY (UNIONIDAE)

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The mollusk fauna of Kentucky is fairly well-known by collected material but more publications are needed (Bickel, 1967). This paper will discuss the status of *Alasmidonta (Pegias) fabula* (Lea), a small bivalve characteristic of the Cumberlandian fauna (Wilson and Clark, 1914; Ortmann, 1924, 1925, 1926). Simpson (1914) and Clench (1959) gave the distribution of *A. fabula* as the Cumberland and Tennessee rivers. Williamson (1905) reported *A. fabula* in the Rockcastle River, a major tributary of the Cumberland. However, no data were given as to ecology or abundance. Wilson and Clark (1914) listed the species as rare after collecting only two living specimens from the Cumberland Drainage. Again, the col-

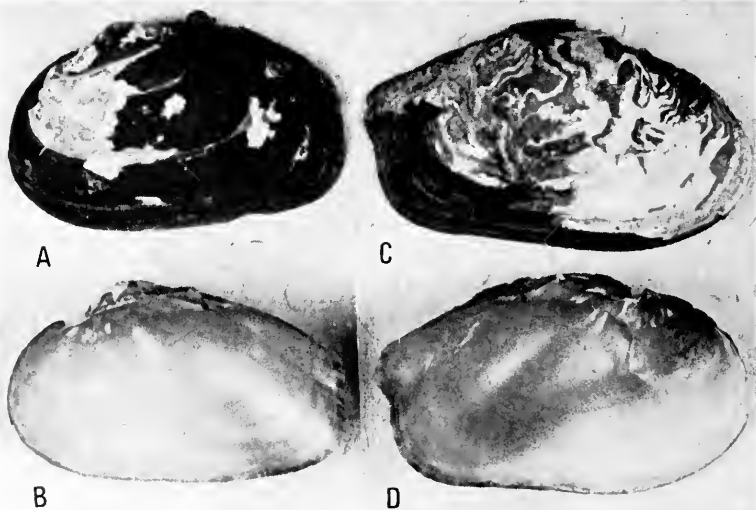


Figure 1. *Alasmidonta (Pegias) fabula* (Lea) from Horse Lick Creek, Rockcastle-Laurel County line, Kentucky: (A) left valve, male; (B) right valve, male; (C) right valve, female (note highly corroded condition of specimen, making age determination impossible; and (D) left valve, female.

lection was secured from the Rockcastle River at Livingston, Kentucky. An intensive search was made by Neel and Allen (1964), but no specimens of *A. fabula* were obtained and thought to be extinct.

On October 2, 1970, an empty shell was found near the mouth of Horse Lick Creek, Rockcastle-Laurel County line, a tributary of the Rockcastle River. One week later living specimens were located about two miles upstream from the first collecting station. One of each sex was taken for the initial study. Selected measurements are: 5-year-old male (dead), length: 25.5 mm., height: 16.0 mm. 4-year-old male, length: 21.5 mm., height: 13.0 mm. Female (age unknown), length: 25.0 mm., height: 13.5 mm.

As illustrated by the photograph, all specimens were badly corroded. Not one specimen was found to be "dug in," but all were free to be moved by the churning water causing additional wear.

It is hoped that this report will stimulate additional study as to ecology and distribution of this unusual mussel.

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THE REPRODUCTIVE ANATOMY OF *TRYONIGENS REMONDI* (TRYON, 1863): HELMINTHOGLYPTIDAE

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Two shells of *Tryonigens remondi* (Tryon) were collected by Auguste Rémond, a French geologist, in the vicinity of Mazatlan,

Sinaloa, Mexico, and sent to George W. Tryon, Jr., who described it as *Helix Rémondi* Tryon (1863). The synonymy and distribution of *T. remondi* has been reviewed by Solem (1959).

A single living specimen from Manzanillo, Colima, was mailed to Pilsbry (1905, p. 256) but unfortunately by the time it arrived, it had been crushed, partly decayed, and the remains had dried hard. Nevertheless, Pilsbry was able to make out certain details of the lower genitalia as well as the serrated keel of the tail and an *Epiphragmophora*-like radula. Based on these studies, he established the genus *Tryonigens* Pilsbry (1927: 189-191).

The author and his son, Walter B. Miller III, collected several specimens of *Tryonigens remondi* in December, 1962, and again in December, 1963, in the vicinity of Mazatlan, Sinaloa. The locality is a wooded, tropical ravine along the Mazatlan-Durango highway at an elevation of about 2,600 feet. At that time of the year, the snails were all hibernating. By diligent digging, however, the

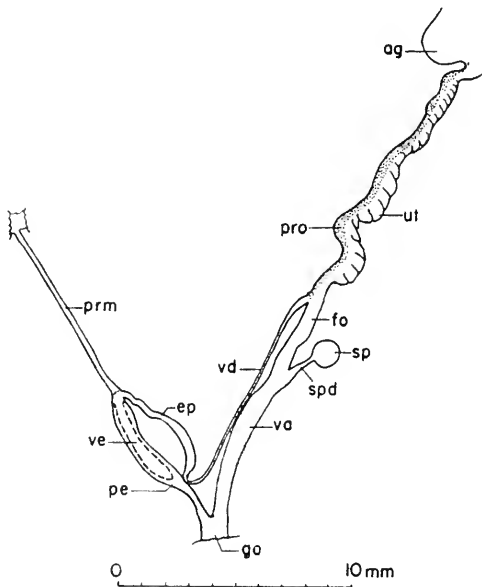


Figure 1. Lower genitalia, *Tryonigens remondi* (Tryon), No. 4556-A: ag, albumin gland; ep, epiphallus; fo, free oviduct; go, genital orifice; pe, penis; prm, penial retractor muscle; pro, prostate; sp, spermatheca; spd, spermathecal duct; ut, uterus; va, vagina; vd, vas deferens; ve, verge. Drawing to scale indicated, from stained whole mount.

author's son found a single live adult during each of the two visits. In each case the animal had buried itself in loose dirt among the rockslide and had developed a very thick and firm epiphragm. Dead shells were relatively common on top of the ground or in shallow crevices among the rocks, indicating that during its active season, it is probably an active surface dweller rather than a deep rockslide inhabitant.

The two animals (WBM Cat. 4397-A and 4556-A) were dissected by the author and stained whole mounts of the genitalia were prepared. The lower genitalia of No. 4556-A are shown in Fig. 1; the details of the verges and epiphalli of both specimens are shown in Fig. 2. Pilsbry's description of the lower genitalia is verified, specifically the absence of a dart apparatus, the presence of a large verge, the mode of insertion of the penial retractor, and the absence of a visible epiphallic cecum (flagellum). Other striking characteristics stand out as follows:

1. The spermathecal duct is extremely short, measuring approximately 2 mm. or $2/5$ of the length of the free oviduct.
2. There is no spermathecal diverticulum.

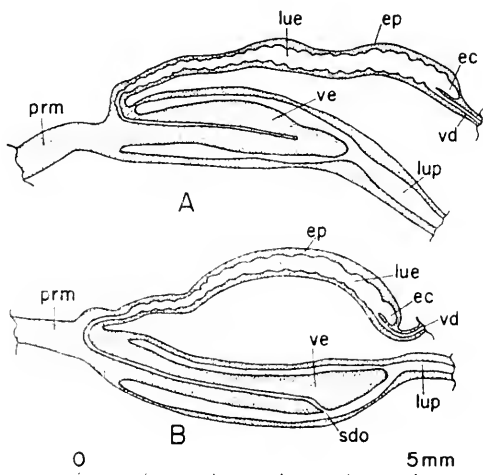


Figure 2. Details of penis and epiphallus, *Tryonigens remondi* (Tryon). A, No. 4397-A; B, No. 4556-A. ec, epiphallic cecum; ep, epiphallus; lue, lumen of epiphallus; lup, lumen of penis; prm, penial retractor muscle; sdo, seminal duct orifice; vd, vas deferens; ve, verge. Drawings to scale indicated, from stained whole mounts.

3. The mantle has a light greyish-white color, with no other color markings or spots of any kind.

Additional details of interest are: (1) the subterminal orifice of the sperm duct in the verge, (2) the absence of a penial sheath, (3) the variability in length and shape of the verge in the two dissected specimens, and (4) the very short internal cecum on the epiphallic duct (Fig. 3) at its junction with the vas deferens. This latter cecum is not visible externally but is very probably a vestige of an ancestral, larger epiphallic cecum (flagellum).

Pilsbry's question of the affinity or parallelism of *Tryonigens* with *Sonorella* must remain in abeyance, at least as far as the comparative anatomy of the genitalia is concerned. Like *Sonorella*, *Tryonigens* has a verge, no dart apparatus, and no spermathecal diverticulum. In *Sonorella*, the epiphallic cecum (flagellum) is minute or absent; in *Tryonigens* it is absent. In *Sonorella*, the spermathecal duct is relatively long, while in *Tryonigens* it is extremely short. Pilsbry considered that the serrated keel of the tail showed a decided resemblance to *Leptarionta* and *Lysinoe*, while the radula was similar to that of *Epiphragmophora*. It can now be stated that the spermathecal duct is also like that of *Epiphragmophora*.

Solem (1959) lists the range of *Tryonigens remondi* from Guerrero to Sonora at Guaymas, and to Chihuahua at Guasaremos, Rio Mayo. The range of *Tryonigens* nowhere overlaps or comes in contact with the range of *Sonorella*. An investigation of the southern limits of *Sonorella* (Miller, 1967a) reveals a large area south of latitude 29°N in Sonora where neither *Sonorella* nor *Tryonigens* are found.

The evidence at hand does not support a close relationship between *Sonorella* and *Tryonigens*. *Sonorella* probably arose from a marginal population of *Sonorelix* or *Eremarionta* (Miller, 1967b) while *Tryonigens* probably arose from *Leptarionta* or a common *Leptarionta*-like ancestor. This would represent an additional instance of convergent evolution, with secondary simplification of structures, as noted in the case of *Mohavelix* and other helminthoglyptid genera (Miller, 1970: 278).

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FLUORESCENCE IN *MESODON CLAUSUS* (SAY)

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A recent paper (Rawls and Yates, 1971) reported the discovery of fluorescence in the mucus of specimens of three genera of endodontid snails exposed to long-wave ultraviolet light, and suggested that it possibly would be found to occur in the remaining genera of that family. We now wish to report the discovery of fluorescence in the mucus of specimens of *Mesodon clausus* (Say), apparently the only polygyrid to exhibit this phenomenon.

As part of a study of the role played by bacteria in the production of fluorescence in land snails, we had been conducting a survey of the flora of mucus samples from various representatives when we observed fluorescence in specimens of *Mesodon clausus*. Such an observation was intriguing to us because we had not expected any polygyrid to exhibit this phenomenon. Our preliminary work with various members of this family had led us to the assumption that fluorescence would not be demonstrated in polygyrids, and we had therefore intended to use mucus samples from members of this family as controls against which to compare mucus samples from fluorescent snails. Our assumption, obviously, was wrong, and the discovery of fluorescence in *Mesodon clausus* quickly caused us to revise our thinking with regard to the occurrence of this phenomenon in the representatives of any given family. We now suggest that fluorescence, whenever observed in land snails, will be found to occur in all representatives of a given species but not necessarily in all members of any higher group.

The discovery of fluorescent members in a family in which we had not expected the phenomenon to be exhibited led us to carry out a careful study of the response to ultraviolet light by specimens of all available polygrids. We collected living representatives from several widely separated localities in Illinois, and we utilized preserved specimens from numerous points throughout the range of the family. Of all the polygrids which we subjected to ultraviolet light, only *Mesodon clausus* displayed any fluorescence. The phenomenon was observed to be uniformly characteristic in all representatives of this species, the fluorescence being as bright and as distinctive in preserved snails as in living specimens. The color of the fluorescence is a greenish blue which is recognizably different from that observed in endodontids. Spectrophotometric investigation of mucus samples from living specimens reveals fluorescence peaks at 275 nm. and at 330nm., suggesting the presence of two fluorescent compounds in the mucus.

The nature of the fluorescent compounds present in the mucus of *Mesodon clausus* is still being investigated, as is true also of the compounds in the mucus of fluorescent members of the Endodontidae. We are not prepared now to present definitive data concerning these compounds, but we do wish to comment on the presence of certain bacteria in mucus samples from these and other snails, because a relationship between these bacteria and the phenomenon of fluorescence seems possible.

Of the several kinds of microorganisms which we have found in mucus samples from land snails of various species, representatives of the genus *Pseudomonas* are consistently present. These bacteria are common in soil and water, and include representatives which can produce fluorescent pigments ranging in color from green through blue and violet to shades of red and yellow, according to Breed and others (1957). For example, we have found that bacterial isolates from the mucus of *Mesodon clausus*, *Mesodon thyroidus*, *Anguispira kochi* and *Anguispira alternata* all produce pigments which fluoresce under ultraviolet light. The association of such bacteria with the phenomenon of fluorescence in land snails of certain species would therefore seem to be entirely logical. Further, the bacteria in the isolates prove to be members of the genus *Pseudomonas*. *Mesodon thyroidus*, however, does not fluoresce, whereas the others do. We are thus faced with a relationship

which at first seems valid, but which later does not appear to hold true.

If pseudomonads are either directly or indirectly responsible for the fluorescent properties of certain land snails, one thing seems certain and that is that something in the physiology of these snails permits the phenomenon to occur, whereas some factor of the physiology of nonfluorescent snails prevents it. On the other hand, if bacteria are not related to the phenomenon as it occurs in fluorescent snails, something in the physiology of these snails produces the fluorescence. We are continuing investigations along several lines in an attempt to resolve this problem, and we plan to report on our findings in a subsequent paper.

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UNITED STATES RESEARCH TRENDS IN MALACOLOGY

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A recent survey was made by me of the types of molluscan topics appearing in 10 U.S. journals beginning in 1900. They were broken into three periods: 1900-1920, 1921-1950, 1951-1969. It was necessary to make arbitrary assignments of many papers, since their categories were mixed or not clear-cut. The following journals were analyzed and tabulated in figure 1.

Evolution	Amer. Microscopical Soc. Trans.
Quarterly Review of Biology	Comp. Biochemistry & Physiology
Ecology	Jour. Experimental Zoology
Ecological Monographs	Nautilus
American Midland Naturalist	Malacologia

In addition, a similar analysis was made of the types of molluscan research projects funded by the National Institutes of Health from 1960 through 1969 (see fig. 2).

From this search it was found that research was being done over the last ten years by less than 100 workers, a remarkable few in view of the fact that mollusks represent the second largest group of living animals. Until recent years, most papers dealt solely with taxonomy and distribution. In recent years the emphasis has veered toward ecology, behavior, cytology, and reproductive biology.

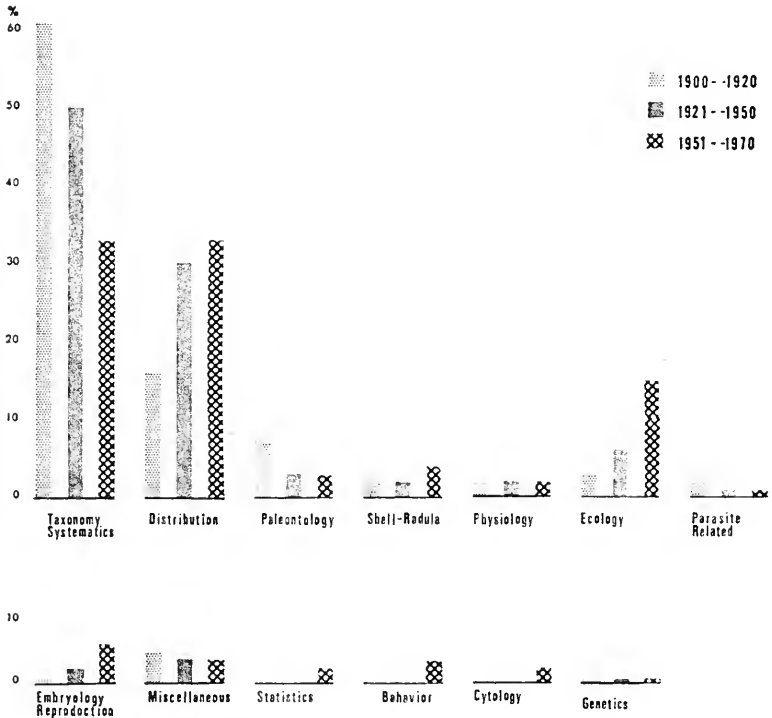


Figure 1. Percent of papers published on various aspects of malacology from 1900-1970. Based upon a survey of ten U. S. journals.

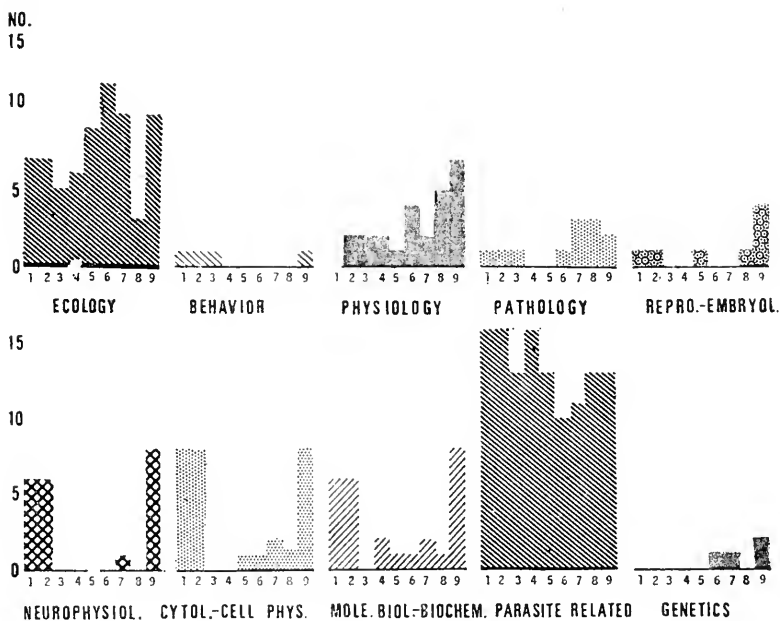


Figure 2. Generalized types of malacology funded from 1961 through 1969 by National Institutes of Health.

NOTES

ADDITIONS TO THE CAYMAN ISLANDS LAND MOLLUSKS.—During Nov. 1970, Lt. Col. Corinne Edwards of Coconut Grove, Florida collected a few land shells on the western end of Grand Cayman Island. Two of the few species collected are worthy of record.

These notes are an addition to a paper which was published for these islands in 1964. (Clench, W. J. Occasional Papers on Mollusks, Howard Univ. 2: 345-384, pl. 61-63).

SUCCINEIDAE

Succinea latior C. B. Adams

Succinea latior C. B. Adams 1845, Contributions to Conchology pt. 3, p. 38 (Montego Bay, Jamaica); Clench 1964, Occ. Papers on Mollusks, Harvard Univ. 2: 359, pl. 62, fig. 2.

Remarks: I had not seen this species from the Cayman Islands at

the time the Cayman Island report was published but listed it on the authority of H. A. Pilsbry.

Specimens examined: Georgetown, Grand Cayman.

POLYGYRIDAE

Praticolella griseola (Pfeiffer)

Helix griseola Pfeiffer 1841, *Symbolae Historiam Heliceorum 1*: 41 (Veracruz, Mexico).

Praticolella griseola (Pfeiffer). Pilsbry 1940, *Monograph No. 3, Acad. Nat. Sci. Philadelphia 1*: pt. 2, p. 690, fig. 425.

Remarks: This is the first Cayman Islands record of this introduced species. It has been introduced also at Key West, Florida, Habana Province, Cuba, and San Pedro de Macoris, Hispaniola. It is endemic to Mexico.

Specimens examined: Georgetown, Grand Cayman.—William J. Clench, *Museum Comp. Zool., Cambridge, Mass.* 02138.

MOLLUSKS OF OTSEGO LAKE, NEW YORK—Ecological and limnological studies are being undertaken on Otsego Lake, Otsego Co., N. Y. by researchers at the Stephen C. Clark Biological Field Station at Cooperstown. The molluscan species, and their distributions throughout the lake, have been determined:

Bivalvia

Unionidae

- Lampsilis radiata* (Gmelin)
- Elliptio complanata* (Lightfoot)
- Anodonta cataraeta* (Say)
- Anodontoides ferussacianus* (Lea)
- Strophitus undulatus* (Say)
- Alasmidonta undulata* (Say)

Sphaeriidae

- Pisidium compressum* (Prime)
- Pisidium subtruncatum* (Malm)
- Sphaerium sulcatum* (Lamark)

Gastropoda

Lymnaeidae

- Lymnaea humilis* (Say)
- Lymnaea palustris* (Müller)
- Lymnaea emarginata* (Say)
- Lymnaea columella* (Say)

Planorbidae

- Helisoma trivolvis* (Say)
- Helisoma anceps* (Menke)
- Helisoma campanulata* (Say)
- Gyraulus parvus* (Say)
- Promenetus exacuus* (Say)

Physidae

- Physa heterostropha* (Say)

Viviparidae

- Viviparus georgianus* (Lea)

Pleuroceridae

- Spirodon carinata* (Bruguière)

Valvatidae

- Valvata tricarinata* (Say)
- Valvata sincera* (Say)

Hydrobiidae

- Annicola limosa* (Say)
- Annicola lustrica* (Pilsbry)

A new state park has recently been completed at the northern end of this body of water. Siltation from the creation of artificial sand beaches has resulted in chronically turbid waters in that part of the lake. I feel that this list will provide a valuable baseline for future reference if radical changes in the fauna take place. Collec-

tions were made over a 2 year period at more than 200 sites in from 0 to 50m of water.—Willard N. Harman, New York State University College, Oneonta, New York 13820.

SPHAERIUM LACUSTRE IN OKLAHOMA—On June 10, 1970 I collected *Sphaerium lacustre* (Müller) in the "Tin Horn" region of Pennington Creek about 2.5 miles south of Tishomingo, Johnston County, Oklahoma. Specimens were numerous in shallow side channels but lacking elsewhere. The identification was verified by Rev. H. B. Herrington, Westbrook, Ontario. This species has not been reported before in Oklahoma.

PISIDIUM COMPRESSUM IN MISSISSIPPI—On April 23, 1970 I collected *Pisidium compressum* Prime in a small tributary of the Strong River five miles northeast of the junction of highways 13 and 49 near Mendenhall, in Simpson County, Mississippi. The clams were abundant in a small sand-bottomed pool about 75 feet east of the point where the stream passes under highway 13. The specimens were identified by Rev. H. B. Herrington, Westbrook, Ontario. This species has not been reported previously in Mississippi. Both notes by William F. Gale, Ichthyological Associates, RD 1, Box 306A, Berwick, Pa. 18603.

THE APPEARANCE OF PSEUDOSUCCINEA COLUMELLA (SAY) IN ARIZONA—In Tucson, Arizona, this lymnaeid snail was collected in November of 1970 on water hyacinth, *Eichhornia crassipes* (Mart.) Solms, in a nursery which imported the plants from Florida. Of 18 specimens examined, the largest measured 12.5 mm. in length, whereas the mean of all specimens was 10.5 mm. The relatively small size, dark color, and heavy shell compare closely with these characters in specimens from Florida (Baker, 1911, Special Publ. 3, Chicago Acad. Sci., p. 170-171, discusses this small form from the southern United States). At this point, this snail is not known to have become established in the Tucson area, and it remains to be seen if this species will spread from its initial introduction into Arizona, or even if the initial colony will maintain itself.—Richard H. Russell, Department of Biological Sciences, University of Arizona, Tucson, 85721.

VERONICELLIDS STILL ON THE MOVE IN THE GULF COAST—

Since 1960 the only Veronicellid slug found in the New Orleans area *in nature* has been *Veronicella ameghini* Gambetta (Dundee, Stutts, Hermann, 1965). From time to time *Veronicella floridana* (Leidy) has been seen in nurseries in the area; it was only a matter of time until they became introduced in nature. These nurseries at which *V. floridana* were found demonstrated to us, by collecting from incoming plant materials, that they were coming in on plants from Florida!

Within the past 3 months reports of *V. floridana* living in the city have been reaching me. They are now definitely established in two areas in the city with the possibility of others existing at the present. Up to now the distribution of *V. floridana* in nature in the U.S. has been: various localities in south Florida, and Hodges Gardens in western Louisiana.

Veronicella ameghini, which has been in the New Orleans and Mobile areas for ten years is also spreading. The latest finding of it was in Lafayette, Louisiana (100 miles west) in a greenhouse and immediately outside of it! Within the last ten years it has spread from New Orleans and Mobile northward to about the middle of the states of Alabama, Mississippi, and Louisiana, and now it is very likely to become established westward also.—Dee S. Dundee, Louisiana State Univ., New Orleans, La. 70122.

REFERENCE CITED

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STROMBUS RANGE EXTENSIONS—A juvenile, 120.9 mm.-long specimen of *S. raninus* Gmelin was obtained in 1970 in 23 meters, about 69 miles east of Wilmington, N. C. (34°20'N., 76°52.3'W.) and a juvenile, 80 mm.-long specimen of *S. gigas* Linné was obtained in 25 meters, about 38 miles east of Georgetown, S. C. (32°58.2'N., 78°45.5'W.). Cruise No. E-28-70 of the R/V *Eastward* was supported by NSF grant No. GB 8189 to Duke University, under the direction of Dr. F. John Vernberg. I wish to thank Dr. Robert Robertson for identifying these specimens.—Alan H. Shoemaker, Baruch Institute, University of South Carolina, Columbia, S. C. 29208.

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GASTROCOPTA ARMIFERA (SAY)

BY LESLIE HUBRIGHT
4026—35th Street
Meridian, Miss. 39301

Gastrocopta armifera (Say) which has been considered one variable species, is in fact five distinct and easily recognized species, once the distinguishing characters are understood. These species can be readily divided into two groups by the size and shape of the shell. The first group contains only *G. armifera*, and is distinguished by its larger, ovoid shell. The other group contains *G. abbreviata*, *G. similis*, *G. ruidosensis*, and *G. clappi*. These four species all have smaller, more cylindrical shells with more dome-shaped spires and finer sculpture. All four species have been found associated with *G. armifera*, and can be readily sorted by the difference in size and shape of the shell.

The graphs (figs. 1-4) show the relative height and diameter in mm. of *G. armifera* and each of the four other species with which it was found associated. Fig. 3 shows the size difference between *G. armifera* and *G. abbreviata* where they were found living together, showing clearly that there are two species. While the differences in the teeth would have made it possible to sort most of the specimens, there were some in both species which were intermediate in one or more characters. In the other species there are differences in the teeth which are adequate to separate them from *G. armifera* and from each other.

I am indebted to Dr. Juan J. Parodiz of the Carnegie Museum, Pittsburgh, for the loan of material from the Sterki collection.

Key to the Species

1. Columellar lamella with a forward lobe 2
Columellar lamella without a forward lobe 3
2. Shell large, ovoid, columellar lamella usually with a distinct vertical lobe;
basal tooth usually small *G. armifera*
Shell smaller, more cylindrical, columellar lamella with vertical lobe weak
or wanting; basal tooth usually well developed *G. abbreviata*
3. Columellar lamella with a distinct angle near its center *G. similis*
Columellar lamella a flat projecting plate 4
4. Columellar lamella sloping backward *G. ruidosensis*
Columellar lamella sloping forward *G. clappi*

Gastrocopta armifera (Say)

Pupa armifera Say. 1821. Jour. Acad. Nat. Sci. Philadelphia, 2: 162.

Gastrocopta armifera (Say). Pilsbry. 1948. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci. Philadelphia, Mono. 3, vol. 2, pp. 874-877, figs. 472: 1-4.

G. armifera varies in length from 3.7 to 5.0 mm., and in diameter from 2.0 to 2.6 mm. The shell is usually ovoid, but may be cylindrical in elongate individuals. Such elongate shells are too large to be confused with the other species of the complex. Angular and parietal lamellae not always completely fused, as there is often a shallow furrow separating them, and the angular lamella projects a little beyond its junction with the parietal lamella. The columellar lamella is shaped somewhat like an inverted 'Y', being branched below. The lower palatal fold is rather thin, entering; the upper palatal fold is similar but smaller. Supra-palatal tubercle small. Basal fold usually very small.

G. armifera is found in calcareous areas over most of eastern United States, ranging west to Colorado and New Mexico. It is absent from the Piedmont and southern Atlantic Coastal Plain, and from peninsular Florida. Its northern limits are not well understood because of confusion with *G. similis*.

Gastrocopta abbreviata (Sterki)

Bifidaria armifera abbreviata Sterki. 1909. The Nautilus 23: 53.

Bifidaria armifera interpres Sterki. 1909. The Nautilus 23: 52.

Gastrocopta armifera abbreviata (Sterki). Pilsbry. 1948. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci. Philadelphia, Mono. 3, vol. 2, p. 877, figs. 474: 1-3.

G. abbreviata varies in length from 3.3 to 4.2 mm., and in diameter from 1.8 to 2.2 mm. The shell is more slender and generally smaller than that of *G. armifera*. The angular and parietal lamellae are more completely fused, the angular lamella does not project beyond the junction with the parietal lamella. The vertical lobe of the columellar lamella is quite short or wanting, the lamella being shaped like an inverted 'U', or may be reduced to a horizontal fold. The basal fold is well developed. *G. abbreviata* can not always be distinguished from *G. armifera* by the teeth. The difference between these two species is much like the difference between *G. tappaniana* (C. B. Adams) and *G. pentodon* (Say), where differences in size

and shape of the shell must be used to distinguish them.

G. abbreviata ranges from Illinois and Mississippi west to Colorado and New Mexico, and from North Dakota south to Texas. It has been found associated with *G. armifera* at the following localities: Missouri: St. Louis Co.: Prospect Hill. Mississippi: Oktibbaha Co.: cedar glade, 1 mile southwest of Osborn (fig. 3). Oklahoma: Haskell Co.: drift, South Canadian River, Whitefield. Texas: Comel Co.: loess, near Guadalupe River, 1.5 miles north of Sattler (fig. 4). Kerr Co.: loess just west of Ingram. The two lots labeled *interpres* Sterki in the Sterki collection, Carnegie Museum, from Fort Gibson, Oklahoma, and Wichita, Kansas, are mixtures of *G. abbreviata* and *G. armifera*.

Gastrocopta similis (Sterki)

Bifidaria armifera similis Sterki. 1909. The Nautilus 23: 53.

Bifidaria armifera affinis Sterki. 1909. The Nautilus 23: 53.

Gastrocopta armifera (Say) form *similis* Sterki. Pilsbry. 1948. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci. Philadelphia, Mono., 3, vol. 2, p. 877, fig. 472: 6.

Gastrocopta armifera (Say) form *affinis* Sterki. Pilsbry. *ibid.* p. 877, fig. 472: 5.

G. similis varies in length from 3.2 to 4.3 mm., and in diameter from 1.7 to 2.0 mm. The shell is smaller and more slender than that of *G. armifera*. The angular and parietal lamellae are completely fused. The columellar lamella lacks the forward lobe. The vertical and backward lobes are higher and thinner than in *G. armifera*. The lower palatal fold is usually very short, being tubercular, often distinctly wider and more deeply immersed than in *G. armifera*. The upper palatal fold is similar but smaller. The basal fold is very small or wanting.

G. similis is a northern species, ranging from northern New York and southern Canada, west to Minnesota and Kansas. It has been found associated with *G. armifera* at the following localities: Missouri: St. Charles Co.: loess, 2.5 miles northwest of St. Charles. St. Louis Co.: talus, Cliff Cave; talus, Fox Creek Gap, 1 mile west of Allenton; talus, Fern Glen (fig. 1). Illinois: Madison Co.: talus, 2 miles northwest of Alton.

Gastrocopta ruidosensis (Cockerell)

Bifidaria armifera var. *ruidosensis* Cockerell. 1899. The Nautilus 13: 36.

Columella tridentata Leonard. 1946. The Nautilus 60: 20, pl. 3, figs. 1, 2.

Gastrocopta proarmifera Leonard. 1946. The Nautilus 60: 21, pl. 3, figs. 3-5. Pilsbry. 1948. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci. Philadelphia, Mono. 3, vol. 2, pp. 878-880, figs. 473: 3-4.

Gastrocopta tridentata (Leonard). Pilsbry. 1948. *ibid.* p. 880, figs. 473: 1-2.

G. ruidosensis varies in length from 3.5 to 4.2 mm., and in diameter from 1.8 to 2.0 mm. The shell is smaller and more slender than that of *G. armifera*. The angular and parietal lamellae are completely fused. The columellar lamella lacks the forward and vertical lobes and the backward lobe is expanded into a broad plate. The lower palatal fold is short and broad, the upper palatal fold is similar but smaller. The basal fold is very small or wanting. The columellar lamella and the lower palatal fold are deeply immersed.

G. ruidosensis is found living in a small area in central New Mexico, but occurs as a Pleistocene fossil from western Kansas to central Texas. It has been found associated with both *G. armifera* and *G. abbreviata* at the following localities: Texas: Comel Co.: loess, near Guadalupe River, 1.5 miles north of Sattler (fig. 4). Kerr Co.: loess, just west of Ingram.

On a wooded hillside, 7 miles east of Pryor, Mayes Co., Oklahoma, associated with *G. armifera*, I found a single living shell that agrees with the holotype of *Columella tridentata* Leonard in all essential details. This is a rare aberration which might occur in any species of the group.

Gastrocopta clappi (Sterki)

Bifidaria clappi Sterki. 1909. The Nautilus 22: 108, pl. 8, fig. 4.

Gastrocopta armifera clappi (Sterki). Pilsbry. 1948. Land Mollusca of North America (north of Mexico). Acad. Nat. Sci. Philadelphia, Mono. 3, vol. 2, p. 878, figs. 472: 7-8, 472a.

Gastrocopta clappi (Sterki). Hubricht. 1962. *Sterkiana* 7: 1.

G. clappi varies in length from 3.5 to 4.3 mm., and in diameter from 1.8 to 2.0 mm. The shell is smaller and more slender than that of *G. armifera*. The angular and parietal lamellae are completely fused. The columellar lamella lacks the forward and backward lobes. The vertical lobe is expanded into a thin, forward sloping plate, and is placed low on the pillar. The lower palatal

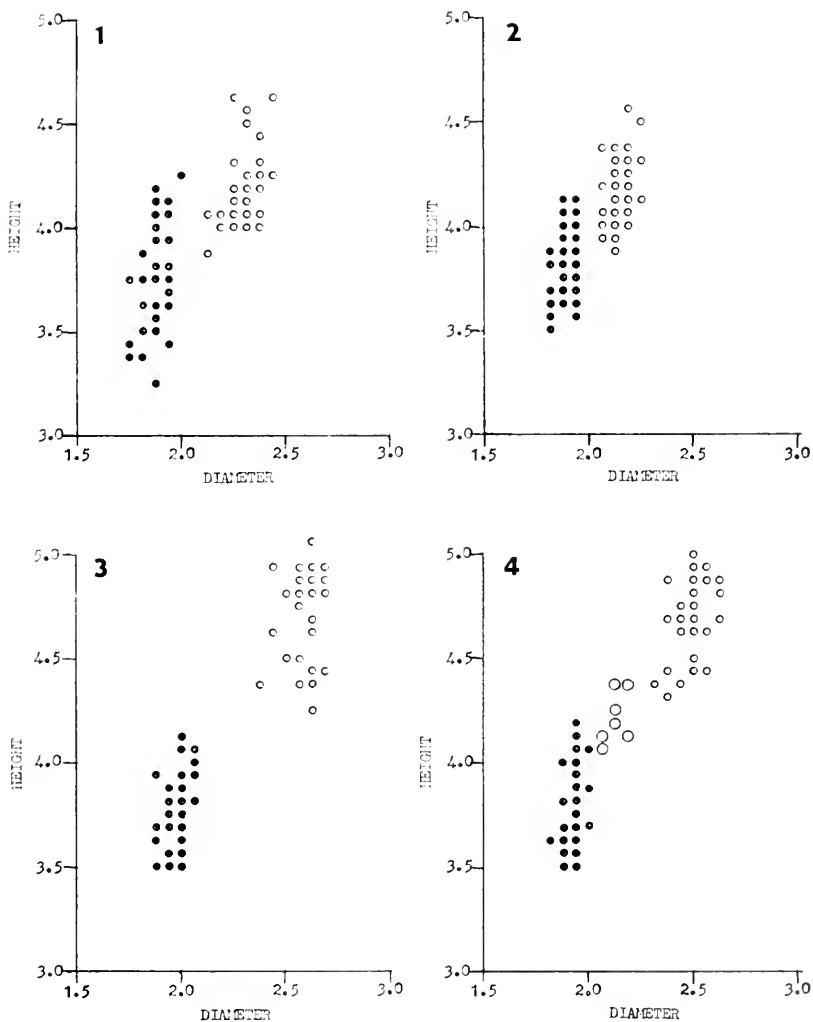


Fig. 1, solid circles = *G. similis*, open circles = *G. armifera*, from Pleistocene talus, Fern Glen, St. Louis Co., Missouri. Fig. 2, solid circles = *G. clappi*, open circles = *G. armifera*, from cedar woods, Turnhole Sink, Mammoth Cave National Park, Edmonson Co., Kentucky. Fig. 3, solid circles = *G. abbreviata*, open circles = *G. armifera*, from a cedar glade, 1 mile southwest of Osborn, Oktibbaha Co., Mississippi. Fig. 4, solid circles = *G. ruidosensis*, large open circles = *G. abbreviata*, small open circles = *G. armifera*, from Pleistocene loess, near Guadalupe River, 1.5 miles north of Sattler, Comel Co., Texas.

fold is short, the upper palatal fold is similar but smaller. The basal fold is very small or wanting.

G. clappi ranges from southwestern Virginia to central Kentucky, south to northern Alabama and Georgia. It has been found associated with *G. armifera* at the following localities: Kentucky: Edmonson Co.: cedar woods, Turnhole Sink, Mammoth Cave National Park (fig. 2). Tennessee: Moore Co.: cedar woods, 2.5 miles southwest of Lynchburg. Georgia: Dade Co.: roadside, 3 miles southwest of Wildwood.

NEW GASTROPODS FROM THE PLEISTOCENE OF ILLINOIS

BY A. BYRON LEONARD
The Illinois State Geological Survey
Urbana, Illinois 61801

In the course of studies of the molluscan faunas recovered from sediments of Kansan age at eight localities and from more than 25 fossiliferous outcrops of Illinoian age in the Pleistocene rocks of Illinois, six kinds of apparently undescribed gastropods were encountered. Formal descriptions of these mollusks follow.

Types and paratypes of these gastropods are catalogued in the Palaeontological Collections of the Illinois State Geological Survey, except for suites of paratypes deposited with the Academy of Natural Sciences of Philadelphia.

***Vertigo occulta*, new species**

Fig. 8

Diagnosis: A small species of *Vertigo*, ovate-cylindrical in shape, similar to *Vertigo nylanderi* and to *V. briarensis* from both of which it differs in important details, principally with respect to the placement of the lower palatal fold.

Type locality: Long Lake Section, Banner Formation, in humic-stained silts of Kansan age, situated in the Cen. NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 18, T.2 N, R 2 E, Schuyler County, Illinois.

Description of holotype: An ovate-cylindrical shell of five obliquely striate whorls; suture deeply impressed; aperture small, occupying less than one-third the total length of shell; peristome slightly everted and somewhat thickened, with furrow behind; outer lip of peristome sharply indented at middle, forming clearly marked sinulus; denticles six: a small, low, elongate angular, about one-third the length of parietal, the latter elongate, heavy, deeply

entering, and inclined above toward angular; small, nodular, columellar lamella, not ascending inwardly; basal fold small, nodular, subcolumellar in position; palatal folds elongate, elevated and thin, the upper fold deeply entering from the angle of the sinulus, and marked by a deeply impressed furrow without; lower palatal thin, elevated, almost membranous, arising at columella and extending almost at right angles to long axis of shell toward the inner end of the upper palatal fold, where it bends slightly outward. This relation of the two palatals is evident also from their external impressions. Total length of shell, 7.8 mm.; diameter, 1.0 mm.; diameter of aperture, 0.6 mm., height, 0.5 mm.

Variations and comparisons: The large series of shells obtained from seven Kansan and four early Illinoian localities vary little except that the lower palatal fold is in some examples higher and more membranous than in the holotype.

Vertigo occulta differs from *V. nylanderi* in that it is more robust; the angular lamella is less deeply entering; the columellar lamella does not ascend inwardly; and conspicuously by the placement of the lower palatal fold, that is deeply situated within the aperture, almost at right angles to the upper palatal. In *V. briarensis* the angular lamella is wanting, the basal fold is extremely reduced or wanting; and the lower palatal fold is more rugged, less deeply immersed within the aperture, and subparallel to the upper palatal fold.

***Vertigo briarensis*, new species**

Fig. 9

Diagnosis: *Vertigo briarensis* is small, the ovate-cylindrical shell being always less than two millimeters in length, and having five well-rounded whorls. It is similar to *V. occulta*, from which it seems to have been derived.

Type locality: Briar Bluff South Section, in Petersburg Silts of Illinoian age, in the SW corner NW $\frac{1}{4}$ sec. 21, T 1 N, R 1 E, Henry County, Illinois.

Description of holotype: Shell ovate-cylindrical, having five obliquely and finely striate whorls; suture deeply impressed; aperture less than one-third total length of shell; peristome only slightly everted, not thickened, and only vaguely indented, forming an indistinctly outlined sinulus; denticles: an elongate elevated parietal fold, deeply entering the aperture; a nodulose columella lamella; and two palatal folds, deeply situated within the aperture, the lower

more so, and sub-parallel to the upper. Total length of shell, 1.75 mm.; diameter, 1.0 mm.; diameter of aperture, 0.5 mm., height of aperture, 0.5 mm.

Variations and comparisons: Unlike *V. occulta*, *V. briarensis* has not been recovered from Pleistocene deposits of Kansan age, but it is widely distributed both geographically and stratigraphically in deposits within the various substages of the Illinoian Stage. Shells from eight localities are remarkably uniform, although there is slight variation in size. None of the examples seems to intergrade with *V. occulta* although they overlap stratigraphically, and *V. briarensis* replaces *V. occulta* in deposits younger than early Illinoian.

Vertigo briarensis differs from *V. occulta* in that the angular lamella is wanting and the basal almost so; the sinulus is poorly defined; the palatal folds are both less developed and the lower is subparallel to the upper, rather than being almost at right angles to it.

Gastrocopta venusta, *new species*

Fig. 7

Diagnosis: Shell small, less than two millimeters in length, having five moderately inflated whorls, suture well-impressed; surface sculpture granulate, except last two whorls both granulate and obscurely striate; shell somewhat similar to *Gastrocopta holzingeri* (Pilsbry and Vanatta) and *G. falcis* Leonard, but differing from both in important details.

Type locality: Wildcat Creek Section, Petersburg Silt Formation of Illinoian age, in the NE¹/₄ NE¹/₄ NE¹/₄ sec. 19, T 13 N, R 4 W, Mercer County, Illinois.

Description of holotype: Shell small for the genus, having five moderately inflated whorls; structure deeply impressed; first three whorls having granulate sculpture; the last two whorls having granulate surface overlain with faint striae; aperture small, narrowly ovate, less than one third height of shell; peristome thin and sharp, but with heavy crest behind; denticles 7: A fused anguloparietal as in the *immersidens* group, the two forked in front; the angular the more conspicuous in front, extending to the peristome, the fused denticle is high, strong, sinuous and deeply entering; the columellar lamella arises deeply within the aperture on the columella, rapidly increases in height, and extending almost to the parietal before decreasing in height and extending to the outer edge of the peristome; the basal fold is broad in front and situated on the

callus that bears the palatal folds, it narrows and increases in height inwardly; the lower palatal fold is broad where it arises from the callus but it narrows inwardly; the upper palatal fold is much smaller, narrower and shorter than the lower; a small granular suprapalatal fold is invariably present. Total length of shell, 1.75 mm.; diameter, 0.95 mm.; diameter of aperture, 0.55 mm.; height of aperture, 0.5 mm.

Variations and comparisons: *Gastrocopta venusta* was recovered from three localities, one in the Kansan and two Illinoian deposits; in all the three localities yielded only a dozen specimens, among which the only observed variation was a few tenths of millimeters in length. *G. venusta* differs from *G. holzingeri agna* in that: the angular lamella is more conspicuous; the columellar lamella extends to the outer edge of the peristome; the basal and palatal folds are broad below and narrow within; and the aperture is narrower and more triangular.

In *G. falcis* the angulo-parietal fold is broadly forked in front, the columellar lamella does not extend to the outer lip of the peristome, and the suprapalatal fold is high and entering rather than tubercular.

***Armiger exigua*, new species**

Figs. 2, 3

Diagnosis: A minute species of *Armiger*, having two and one-half to three depressed, carinate whorls, that slowly increase in diameter toward the aperture. The nuclear whorl has finely granular sculpture, while the remaining whorls exhibit irregular, subvertical striations and less numerous carinae. There are no spiral striations. The last whorl does not descend toward the aperture, which is roundly ovate in form.

Type locality: Briar Bluff South Section in Petersburg Silts of early Illinoian age, in the SW corner of NW $\frac{1}{4}$ sec. 21, T 17 N, R 1 E, Henry County, Illinois.

Description of holotype: Shell plano-spiral with two and one-half whorls that are flattened somewhat above, rounded below; the periphery is somewhat above the middle of the last whorl which is roundly angular; last whorl not descending toward the aperture; aperture rounded-oval, and narrowly appressed to preceding whorl; spire depressed but not below level of general dorsal surface; umbilicus impressed but revealing all the whorls; nuclear whorl having granular sculpture that extends on to succeeding whorls where they

are overlain by coarse diagonal growth lines which on the last whorl are interspersed with costae, of which there are about 18 on the last whorl; there is no hint of spiral striae. Lip of peristome thin and simple. Greater diameter of shell, 1.95 mm.; lesser diameter, 1.67 mm.; height of aperture, 0.7 mm.; width of aperture, 0.6 mm.

Variations and comparisons: Shells vary but little among the 53 paratypes available. The largest shell observed had two and three-fourths whorls, and its greater diameter measured 2.2 mm.

Armiger exigua differs from *A. crista* (Linné) in that it is much smaller, although having the same number of whorls; the nuclear whorl is granulate rather than striate; there is no indication of spiral striae; the last whorl does not descend toward the aperture; and the aperture is roundly oval in shape.

***Succinea exile*, new species**

Fig. 1

Diagnosis: Shell similar in form to *Succinea gelida* Baker but uniformly smaller (total length always less than 5 mm.) more slender in form, and having the aperture narrowly ovate above.

Type locality: Briar Bluff South Section, Petersburg Silts of Illinoian age, in the SW corner NW $\frac{1}{4}$ sec. 21, T 1 N, R 1 E, Henry County, Illinois.

Description of holotype: Shell small for the genus; the three and one-half whorls rounded, the last proportionately small, separated by deeply incised suture; nuclear whorl swollen but smaller (diameter 0.5 mm) with granular sculpture, the remaining whorls having delicate but rather irregular vertical striae; aperture pear-shaped, rounded below, narrowed above; outer lip of peristome not greatly curved inward above; columellar lip rounded below, angled above toward the short callus spread against the parietal wall; aperture length about one half that of shell. Total length of shell, 4.9 mm.; diameter, 2.4 mm.; height of aperture, 2.4 mm., diameter, 1.7 mm.

Variations and comparisons: Among the 42 shells from three Kansan and 4 Illinoian localities there is little variation except that due to difference in age. *Succinea exile* differs from *S. gelida* which it resembles in general form, in being uniformly smaller, and the shell having a more slender form; the aperture is narrower above, and the outer lip does not turn inward above as sharply as it does in *gelida*.

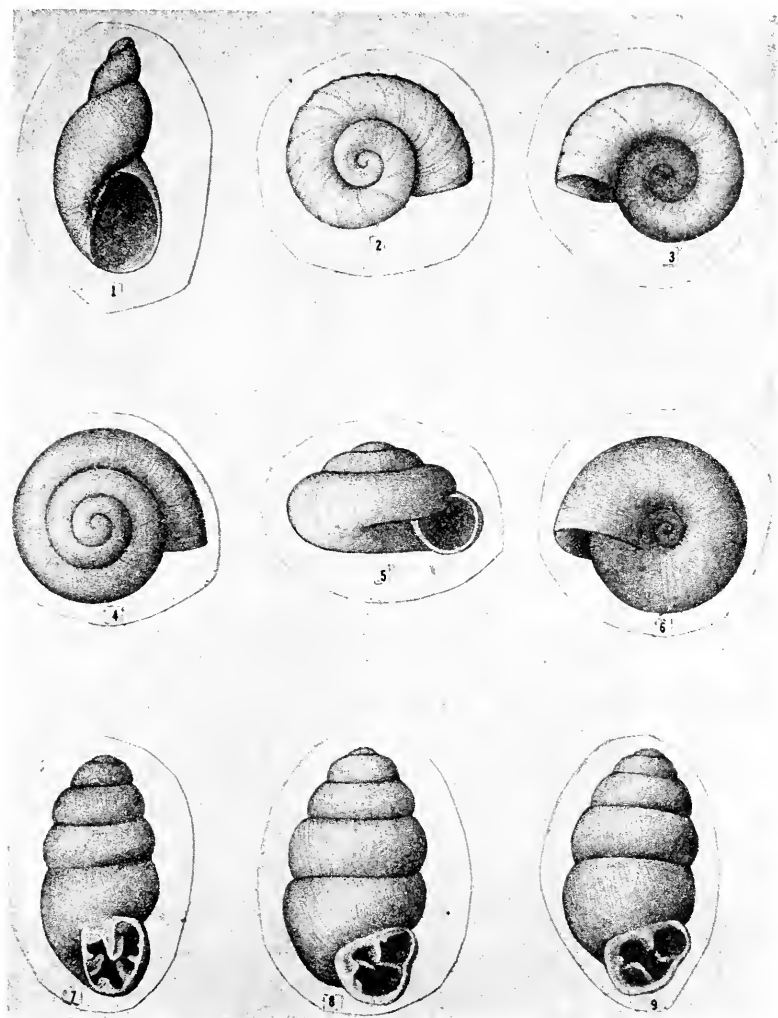


Fig. 1. *Succinea exile* Leonard, holotype; X 6.5. Figs. 2, 3. *Armiger exigua* Leonard, holotype; X 12.5. Spiral and umbilical views, respectively. Figs. 4, 5, 6. *Punctum parvulum* Leonard, holotype; X 18.8. Spiral, apertural and umbilical views, respectively. Fig. 7. *Gastrocopta venusta* Leonard, holotype; X 18. Fig. 8. *Vertigo occulta* Leonard, holotype; X 19. Fig. 9. *Vertigo briarensis* Leonard, holotype; X 19.

***Punctum parvulum*, new species**

Figs. 4, 5, 6

Diagnosis: A minute, depressed, conoid, spiral shell, similar to *Punctum minutissimum* (Lea) which it most resembles, but differing in being smaller in size and having a lesser number of whorls, lacking spiral striae, and having a much narrower umbilicus.

Type locality: Long Lake Section, in silts of the Banner Formation of Kansan age, situated in the center of NW¹/₄ NW¹/₄ sec 18, T 2 N, R 2 E, Schuyler County, Illinois.

Description of holotype: Shell small, depressed, conoid, whorls three and one-half, rounded; suture moderately impressed; aperture lunate, peristome thin, simple; nuclear one and one-third whorls granular, the granular sculpture extending onto the remaining whorls where it is overlain by extremely delicate vertical striae, not apparent without strong magnification; no indication of spiral lines either above or below; umbilicus very narrow, its diameter no more than one-sixth that of the shell. Diameter of shell, 1.3 mm.; height, 0.7 mm.; height of aperture, 0.5 mm., diameter, 0.5 mm.; diameter of umbilicus, 0.22 mm.

Variations and comparisons: The 95 shells from seven Kansan and two Illinoian localities are remarkably uniform except for age variations. *P. parvulum* differs from *P. minutissimum* in that it is slightly smaller and with fewer whorls; the nucleus is granular rather than smooth; the striae are more delicate; spiral striae are lacking, and the umbilicus is much narrower.

**OBSERVATIONS ON THE GASTROPOD,
CHARONIA VARIEGATA, IN TRINIDAD AND TOBAGO**

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When the author came to Trinidad in 1958, underwater observations soon revealed that *Charonia variegata* was fairly common in these waters. Many specimens have since been observed underwater in their habitat, and observation on their feeding habits reveals that they are voracious predators.

FORMS AND HABITAT

Like the shells of many other species of tropical gastropods, *Charonia variegata* presents two separate morphological forms. The shallow water, coral reef form is characterized by the denser calcar-

eous shell, the lighter colouration of the shell pattern and the tendency for the shell to be overgrown with algae, and the early whorls to be badly pitted by the boring sponge *Cliona* sp. The deep water form, which is found in 15 to 45 metres of water, lives on a grit and muddy silt bottom with occasional rock outcrops, under the eaves of which the mollusc finds shelter while resting. G. Warmke and R. Tucker Abbott reported in "Caribbean Seashells," that divers in Puerto Rico found *Charonia variegata* in underwater caves.

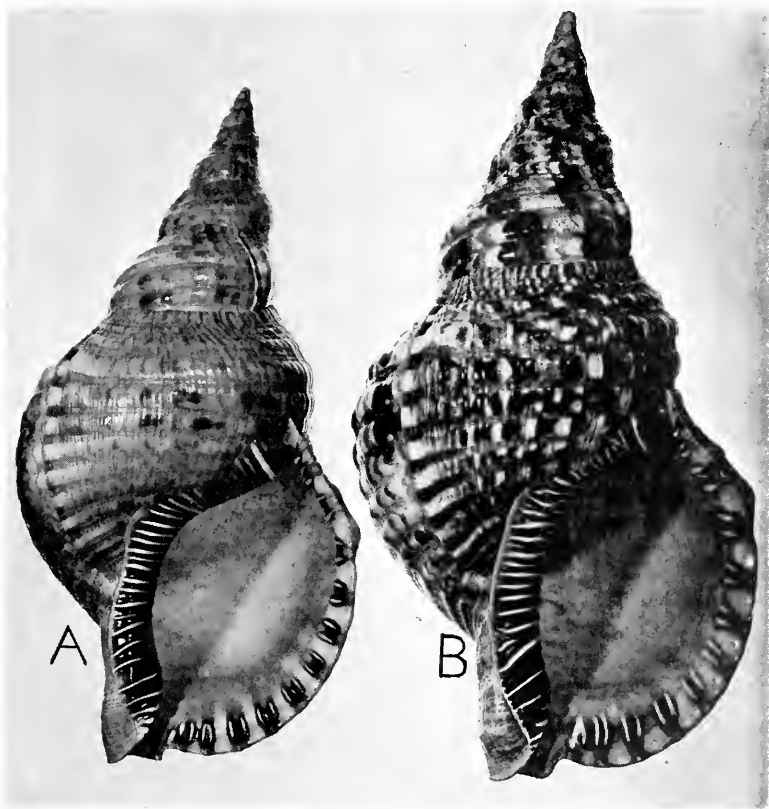


Fig. 1A. Specimen of *Charonia variegata* which was observed on many occasions feeding on echinoids, mainly *Eucidaris tribuloides*. Fig. 1B. Specimen tagged and observed over an extended period, feeding mainly on asteroids, *Echinaster sentus*, and bivalve molluscs, *Laevicardium laevigatum* and *Chione cancellata*.

Not one specimen has ever been found in a true marine cave in Trinidad. However, most of the specimens observed have been found under the eaves of large rocks or coral reefs, or out on the open mud substrate at the foot of a reef or rocky outcrop. While searching for a place to rest, even large specimens of *Charonia variegata* manage to creep under rocks and wedge themselves into the silt substrate.

The shallow water form appears to be fairly dormant during the

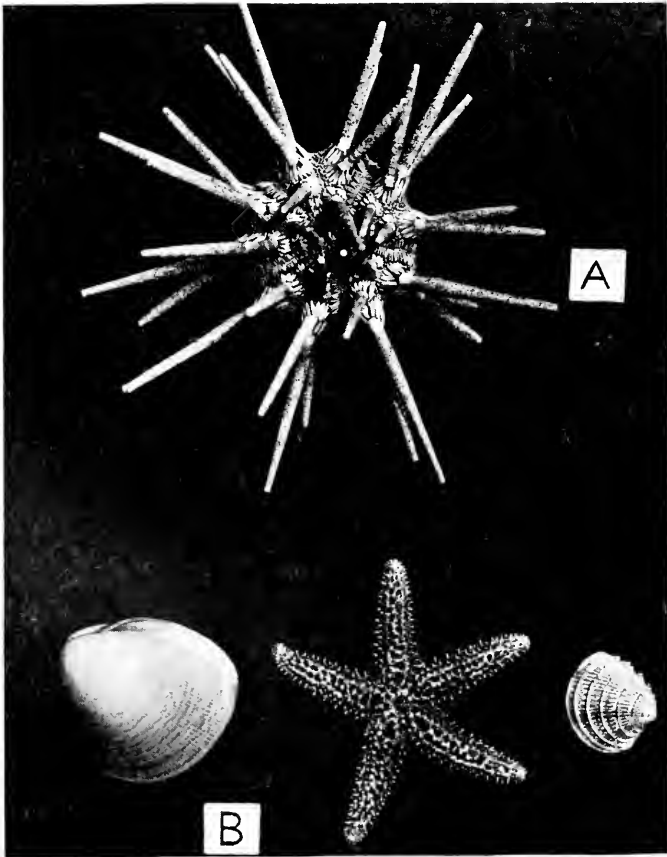


Fig. 2A. Specimen of *Eucidaris tribuloides* taken away from the light-coloured *Charonia* in fig. 1A. Fig. 2B. Specimens upon which the dark-coloured *Charonia* was feeding (*Laevicardium laevigatum*, *Echinaster sentus* and *Chione cancellata*).

daytime, especially if there is strong sunlight and clear water. The deeper water form is characterized by the much lighter construction of the shell, strongly reminiscent of the thin but strong shells of *Tonna galea* Linné 1758. It is significant that both these two species belong to the same super family, the *Tonnacea* and possess in some ways similar feeding habits, especially in the use of highly acid saliva jetted at their prey in order to subdue same. The shell pattern of the deep water form is also more colourful, being more vivid yellow and orange. (See Feeding Habits).

The protoconch and the early whorls, of the deep water form are more likely to be found in good condition and without pitting and shell damage by fouling growth, etc. The deep form, quite often avails itself of shelter in discarded man-made objects whilst extending the shell, between varices. The author has observed specimens in the process of shell extension, sheltering in an old bucket, truck tyres, paint or grease drums and sections of steel pipe.

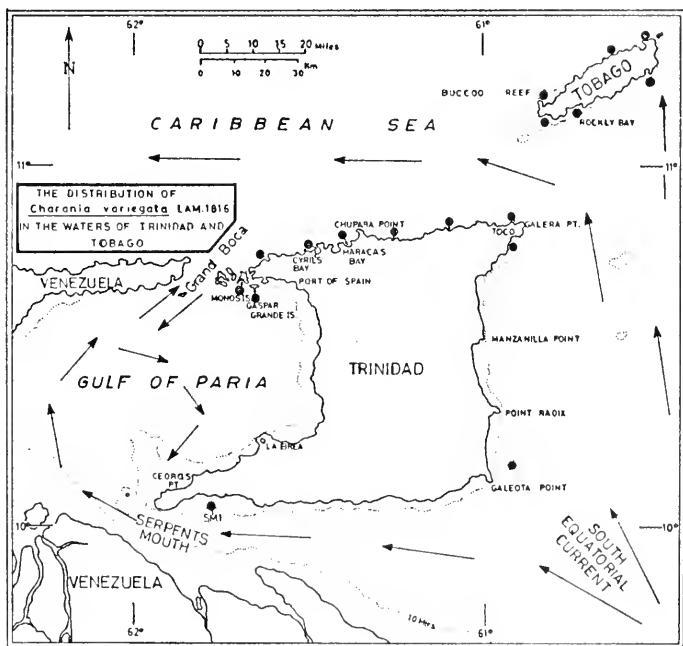


Fig. 3. Map of locality records of *Charonia variegata* found by the author.

The shallow water form has not been observed in these strange habitats, although in certain reef areas these objects are regrettably very common. In shallow water, *Charonia variegata* seeks shelter far inside holes in the coral and in rock reefs, specimens are often found, wedged tightly in the crevices below large fallen rocks. The finding and observation of these specimens often requires the use of a powerful underwater light even in daylight hours.

FEEDING HABITS

After over fifty observations of feeding behaviour, it is considered that *Charonia variegata* is one of the most voracious of gastropod predators here in the waters of Trinidad and Tobago. The food consists of a wide range of invertebrates, including the echinoderms, *Echinaster sentus*, *Eucidaris tribuloides*, *Tripneustes sp.*, *Synapta sp.*, *Cucumaria sp.*; the molluscs, *Laevicardium laevigatum*, *Chione cancellata*, *Fasciolaria tulipa*, *Cypraea zebra*; and the crustaceans, *Panulirus argus* and *Panulirus guttatus*.

The method of attacking the prey, employed by specimens observed, was fairly constant. A creeping approach, with tentacles being swept from side to side. This is followed by contact with the prey by the tentacles and the extension of the large proboscis ready to eject the acid saliva over the prey. This action rapidly causes paralysis of the intended prey, followed by the subsequent wrapping of the foot of *Charonia variegata* around the stunned animal.

The pleurembolic proboscis of *Charonia variegata* contains, in the odontophore, a radula armed with strong rasping teeth. Two jaws are also present, mounted laterally. These are thin chitinous plates and are not very strong but possibly are used in the process of opening bivalve molluscs, after the valves have started to gape, subsequent to being jetted with acid saliva.

However, *Charonia variegata* is capable of piercing the tests of echinoids and the author has observed specimens of *Eucidaris tribuloides* being attacked and wrenched out of their habitat in reef crevices. The test is usually pierced either in the area of the madre-pore plate or alongside the five-toothed mouth.

While engaged in feeding, the triton holds its prey firmly by the foot and completely envelopes it in thick mucus. Once the test is pierced, the extended proboscis enters the rasped hole and the entire contents are devoured, leaving only the five-toothed mouth structure, or "Aristotle's lantern," which is often detached from the test.

In Trinidad, during February, large numbers of the asteroid *Echinaster sentus* congregate in sheltered areas of bays in these waters. This behaviour is to assist in mating, the sexes being separate. While this mass grouping is taking place they are often attacked by *Charonia variegata*.

The author has observed pairs of *Charonia variegata* methodically driving dozens of specimens of this common orange-red asteroid up a silty mud slope, attacking the outside members and instead of completely devouring them as they would do under normal circumstances, just killing them and rasping a hole out of the central part of their bodies. Specimens of *Charonia variegata* examined after being engaged in one of these feeding "orgies," have their intestines stuffed full of digested asteroids.

The intestines and digestive glands are stained orange-red, and a gritty mass in the intestines is composed of the calcareous particles of decomposed dermal skeletons. Dietary preference may also play a part in determining shell colour and patterns, as the author has observed that specimens which favour a diet of the orange-red *Echinaster sentus* are usually the specimens with the most pronounced shell colouration and pattern, while specimens which favour echinoids, are a pale golden colour with reduced shell pattern (See plate).

Other gastropods are paralyzed, enveloped and devoured. The powerful proboscis with radular teeth and acid saliva, soon removes the entire animal from the shell.

The method of opening bivalves is similar. The triton emits a quick jet of acid saliva, followed by the rapid extension of the proboscis between the partially gaping valves. No observations have been made on *Charonia variegata* eating buried bivalves. They eat specimens caught on the surface of the substrate. The gastropod *Fasciolaria tulipa* often shares the same resting habitat with *Charonia variegata*, but *Fasciolaria tulipa* remains buried 5 to 10 centimetres below the resting place of *Charonia variegata*. Juvenile specimens have been observed being eaten by *Charonia variegata*.

On two occasions juvenile spiny lobsters, *Panulirus argus* and *Panulirus guttatus* have been observed being eaten by *Charonia variegata*. The method of approach and attack, was not observed but in the case of the juvenile *Panulirus argus* the animal was still moving, after the large mollusc rasped a hole through the skin at the

junction of the abdomen and carapace on the ventral surface. This is a position usually favoured by *Octopus vulgaris* when feeding on similar prey. Ten hours later, when re-observed, the abdomen and carapace were found empty.

GENERAL BEHAVIOUR AND ENEMIES

Initially, while attempting to determine movement patterns for *Charonia variegata*, the author had been hampered by the fact that while this species is not rare, it is very rarely found in any number exceeding two, in any one area. Consequently, when six large specimens were observed in various habitats off the south coast of Gasper Grande Island, they were tagged, in the hope that they could be observed over an extended period.

Previous experiments with tagging this species in a bay on the south coast of Monos Island, had resulted in the use of the conventional plastic numbered tag carefully attached to the spire of the shell with monel or stainless steel wire. The most useful development however was the use of a small plastic marker float, approximately five centimetres in diameter attached to the shell by a thin nylon cord, one half metre in length.

The use of this type of marker enabled the author to relocate specimens repeatedly for many months of observation. The tagging experiment off the south coast of Gasper Grande was quite successful and the work revealed that the deep water form moved considerable distances in one week periods. One specimen moved down the slope from 14.5 metres to 30.5 metres and laterally 200 metres, in a seven day period.

The deep water forms moved more than the shallow water forms, and while it was found that the deep water forms sometimes moved up into shallow water, the shallow water forms were never observed to venture below eleven metres. The shallow water forms were found to move and feed mainly at night time, while the deep water forms, also mainly nocturnal, were often observed moving and feeding by day.

Eventually, after about two years, all the tagged specimens were lost and could not be relocated but during the course of a deep underwater search carried out one Sunday, the author was swimming horizontally at a depth of thirty metres when one of the largest of the tagged specimens was relocated in a coarse sand gully between two large rock ridges. The animal was moribund and the

operculum had fallen out of the aperture onto the sand. Part of the dead mollusc still remained in the shell and by the stage of decomposition, it had been dead for about a week. The cause of death was not known but what surprised the author was the fact that in this same gully, several other empty shells of *Charonia variegata* were found; all large, fully adult, if not gerontic specimens. There were no shells of any other species of molluscs in the area and a careful search failed to reveal any signs of *Octopus sp.* or other predators. Some of them had been laying in this location for many years. There were no signs of damage to any of the shells and two of them had opercula lying close to the shell on the sand substrate.

Two observations with regard to the enemies of *Charonia variegata* have been made by the author. In the first instance, a medium-sized specimen was picked up and eaten by a large ray, *Aetobatus narinari*. The shell was crushed and dropped in small pieces as the ray rose up from the bottom and swam away. In the second instance a large Loggerhead turtle, *Caretta caretta*, was observed crushing and eating a large specimen of the deep water type of *Charonia variegata*. Local fishermen have also informed the author that the Hawksbill turtle, *Eretmochelys imbricata*, often eats "trumpet conks."

REPRODUCTION AND DISPERSAL OF LARVAE

In Trinidad and Tobago, *Charonia variegata* lays eggs in May just before the onset of the rainy season. The egg cases are usually laid at night time. The cases are clustered together in a large mass and coloured a pale parchment yellow. Egg cases placed in shallow water are hidden underneath fallen rocks or coral, but egg cases placed in deep water are quite often laid out in the open.

Once again, man-made objects attract females about to lay in deep water. As the author has observed, *Charonia variegata* egg cases alongside old rubber tyres on several occasions. Only one observation of copulation in this species has been made. Two specimens were observed under fallen rocks on May 5, 1967. The male was only half the size of the female. The female was a fairly old specimen with a badly eroded shell spire. The penis of the male, is capable of extension to reach into the mantle cavity of the female; however, the degree of extensibility does not compare with other large gastropods of these waters, for example—*Strombus gigas* and *Strombus costatus*.

CONCLUSION

After several years of extensive, detailed observation, we found that *Charonia variegata* is an extremely active and voracious predator, feeding on a wide variety of invertebrate prey.

This large mollusc is aided by its highly acid saliva which is used most effectively in paralyzing the prey during an encounter. This mollusc must play an important role in the ecological balance of the extensive areas of its habitat.

It is also fairly well established that this species is found in two separate forms. A shallow water, rock or coral reef form and a deeper water form. The morphological difference with regard to the shell of these two forms are quite easily discernable even to an observer underwater.

The tagging of specimens for observation has been quite successful, and especially the use of a small plastic float marker attached to specimens by a half-metre nylon cord. This has enabled the author to relocate specimens over considerable periods of time.

ACKNOWLEDGMENTS

The author would like to express sincere thanks to John B. Saunders and Dr. Hans G. Kugler for their constant encouragement. To Errol G. Law for his help underwater and many hours of diving together to collect the information for this work. To Dr. Ailsa Clark of the B.M. (N.H.) for her kind assistance in identifying the echinoderms. Also to Capt. R. Navarro for his great help with marine transport.

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CHROMOSOME NUMBER OF THE SURF CLAM, *SPISULA SOLIDISSIMA*

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Ripe eggs from the surf clam, *Spisula solidissima* (Dillwyn, 1817), an important commercial bivalve of the western North Atlantic coast (Ropes, 1967), were collected and prepared for chromosome counts. An examination of chromosome numbers was undertaken to learn more of the clam's biology after a study of its reproductive cycle (Ropes, 1968). Recent examinations of pelecypods have shown an agreement in chromosome numbers for species within a genus or family (Rosenfield, 1963; Menzel and Menzel, 1965; Menzel, 1968; Longwell and Stiles, 1968), and my results are identical to reported counts for other species in the family Mactridae.

Surf clams were obtained from commercial vessels at Ocean City, Md., during July and August 1969. The clams were brought to the laboratory, held overnight in a refrigerator at 7°C, and on the next day each clam was placed in a basin of standing sea water at room temperature (20°C). This simple thermal stimulation induced spawning. Ova were pipetted into beakers of sea water and a dilute sperm suspension was added. A microscopic examination at low power to observe chromosomal activities preceded transferring the cells onto slides, flooding them with a 1% orcein in 45% acetic acid solution, and adding a coverslip. The slides were warmed by passing them over the flame of an alcohol lamp to intensify the reaction of the stain with the chromosomes. After a 30-minute staining period, the slides were pressed between sheets of bibulous paper to squash the eggs and spread the chromosomes. A ring of adhesive painted on the edges of the coverslip and storage of the slides in a refrigerator extended the use of the preparations for several days. Egg examinations and photographs were made with a Zeiss Photomicroscope and 100X Planapochromat objective.

The unfertilized eggs of *S. solidissima*, and most other mollusks (Raven, 1958), are normally blocked from completing maturation at metaphase of the first meiotic division; after sperm penetration, maturation continues (Allen, 1953). Thus, fertilized eggs were used to obtain reduction division. Fertilized eggs held at room temperature for a 30-minute period before staining contained the lowest

and most constant number of chromosomes. The N or haploid chromosome number of 18 was observed for *S. solidissima* at metaphase of meiosis (Fig. 1A). Eggs found at anaphase of meiosis revealed that the 2N or diploid chromosome number is 36 (Fig. 1B).

The chromosome numbers for *S. solidissima* given above are comparable with those found for other species in the family Mactridae. Kostanecki (1904) reported $N=18$ and $2N=36$ for *Mactra* sp. collected from the Mediterranean near Naples and Trieste. The species used by Kostanecki were, according to Allen (1953), *M. stultorum* and *M. helvacea*. Menzel (1968) found the same haploid and diploid numbers (18 and 36) for the channeled duck clam, *Labiosa plicatella* (Lamarck), from local Florida waters and for the dwarf surf clam, *Mulinia lateralis* (Say), from Virginia.

The family Mactridae is widespread in the world. As many as 50 nomenclatorially valid generic names have been listed for the family (Vokes, 1967), which includes over 200 species (Ropes, Chamberlin and Merrill, 1969). Agreement in the number of chromosomes of the four species reported here is too little evidence to conclude that they are representative of the family. Examinations of the chromosome numbers of other Mactrid species might add more evidence of agreement within the family.

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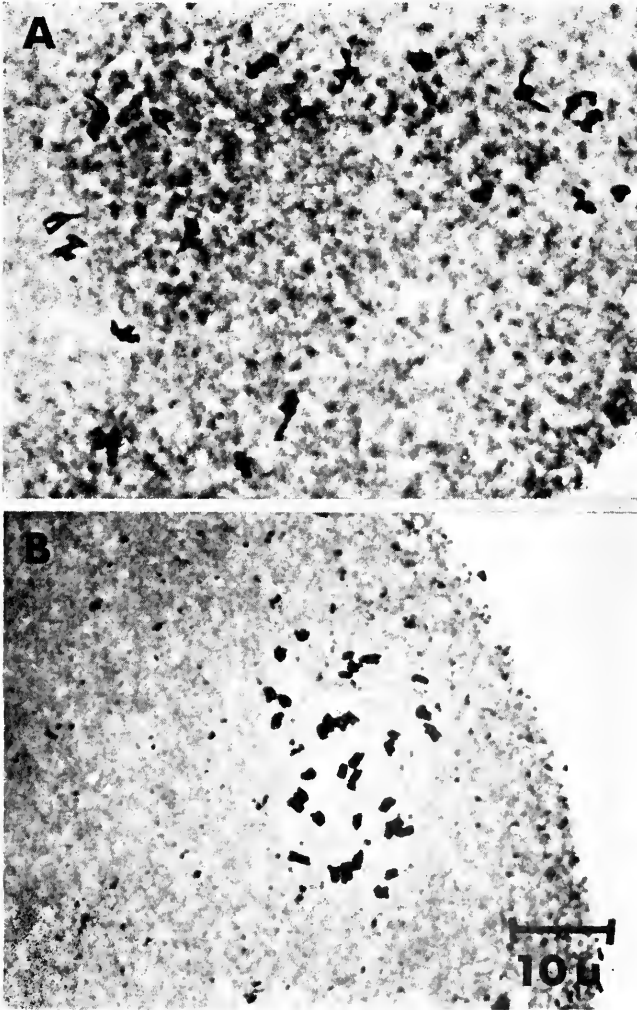


Fig. 1. Chromosomes of *S. solidissima*. A, haploid number at metaphase; B, diploid number at anaphase.

A NEW *FASCIOLARIA* FROM THE NORTHEASTERN GULF OF MEXICO

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From August 1965 through November 1967 the Florida Department of Natural Resources Marine Laboratory conducted a systematic sampling program, Project Hourglass, on the West Florida Shelf (Lyons, 1968; Joyce & Williams, 1969). Collections of benthic animals were taken along two east-west transects off Egmont Key near St. Petersburg and off Sanibel Island. Stations on each transect ranged in depth from 6 to 73 m. Two specimens of *Fasciolaria* collected at Hourglass station E (73 m) represent an undescribed species. Searches of the mollusk collections of the U.S. Museum of Natural History, Washington, D. C., the Museum of Comparative Zoology, Cambridge, Massachusetts, and the Academy of Natural Sciences of Philadelphia, Pennsylvania, failed to uncover any other material. Two additional specimens were provided by Mr. Harvey R. Bullis, Jr. from collections made off the Florida west coast by the U.S. Fish and Wildlife Service exploratory fishing vessel *Oregon*.

***Fasciolaria bullisi*, new species**

Fig. 1

Description: Shell thin, fusiform, slender; length/width ratio of the 3 unbroken specimens increasing with shell length from 2.62 to 2.87; largest specimen with nearly 8 whorls including nucleus; background color pale yellow with large patches of deeper yellow and orange. Embryonic whorls $1\frac{3}{4}$, first smooth except for two faint spiral threads on lower end (on unworn specimen), final $\frac{3}{4}$ whorl with 16-18 moderately strong axial riblets. First post-embryonic whorl with five incised, equidistant spiral lines, replaced by five thin brown bands on later whorls. Large specimens with 10-12 primary brown bands and 6-9 secondary bands on body whorl. Aperture ovo-elongate; outer lip thin, simple, finely lirate within. Columella straight to arcuate, with two shallow, oblique anterior plicae; siphonal canal long, slender, oblique, of a rich amber, deepening to brown at tip. Operculum thick, corneous, ovo-elongate, attenuated obliquely at anterior end. Periostracum on dried specimens tan, very thin.

* Contribution No. 182



Figure 1. *Fasciolaria bullisi* Lyons, new species. Holotype, off Egmont Key, Florida, 73 m. Length: 134.1 mm.

Type depositories: The holotype and one paratype are in the collection of the U.S. Museum of Natural History, Smithsonian Institution (USNM), Washington, D. C. Additional single paratypes are in the collections of the Museum of Comparative Zoology (MCZ), Harvard University, and the Florida Department of Natural Resources Marine Research Laboratory (FSBC), St. Petersburg, Florida.

Material examined: *Holotype:* USNM 706880. Length 134.1 mm, width 46.8 mm (living). Hourglass station E, 27°37'N, 84°13'W, 73m; bottom temperature 19.0°C; June 7, 1966. *Paratypes:* USNM 706881. Length 117.0 mm, width 43.0 mm (living). Oregon station 1024, northwest of Dry Tortugas, 25°13'N, 83°55'W, 119 m; bottom temperature 20.0°C; April 19, 1954.—FSBC I 7294. Length 59.3 mm, width 22.6 mm (dead shell). Hourglass station E; bottom temperature 19.5°C; May 12, 1967.—MCZ 261430. Length 119.0 mm, width 49.1 mm (dead shell, siphon broken). Oregon station

1254, south of Pensacola, 29°43'N, 87°18'W, 164 m; bottom temperature 17.2°C; March 1, 1955.

Remarks: The species is named for Harvey R. Bullis, Jr., Associate Director, U.S. Bureau of Commercial Fisheries, Washington, D. C., who graciously loaned his specimens for study.

The dead specimen with damaged siphon from off Pensacola (MCZ 261430) was apparently more globose than unbroken specimens. Although the spire is 4 mm shorter than that of the holotype, the width of the body whorl is 2.3 mm greater, suggesting a lower length/width ratio. Color, banding, nuclear sculpture, and absence of a presutural ridge, however, indicate that it should be assigned to *Fasciolaria bullisi* sp. nov.

It is difficult to place *Fasciolaria bullisi* within the currently accepted systematic scheme. Hollister (1957) erected the subgenus *Cinctura* to contain *Fasciolaria lilium* Fischer von Waldheim, *F. lilium tortugana* Hollister, *F. hunteria* (Perry), *F. branhamae* Rehder and Abbott, and *F. apicina* Dall. This group was distinguished from *Fasciolaria* s.s. (type species *F. tulipa* Linné) by a prominent spiral ridge extending onto the parietal wall from within the posterior portion of the aperture. The validity of *Cinctura* is questionable; specimens of *F. tulipa* with a swollen or raised "hump" on this area of the shell are common, though I have seen none as strongly expressed (ridge-like) as those borne by species of *Cinctura*. *Fasciolaria bullisi* lacks any indication of this ridge.

Primary and secondary banding of later whorls of *F. bullisi* is weak, often interrupted like that of *F. tulipa*, but unlike the strongly expressed bands of *Cinctura* species. Distinct axial riblets on the last embryonic whorl readily separate it from *F. hunteria*, which lacks such sculpture. However, *F. bullisi* has the longer spire and more slender outline of certain *Cinctura* and, like the latter, lacks the incised spiral lines found on later whorls of *F. tulipa*. Also, like *Cinctura*, *F. bullisi* bears only traces of the rough, presutural wrinkles of *F. tulipa*.

The radula of the holotype of *F. bullisi* is similar to that of *F. hunteria*, both in the subtriangular cusps of the median tooth and in the number and shape of cusps of the lateral teeth. Cusps of the median tooth of *F. tulipa* are longer and more slender; those of the laterals are much more numerous and are also more slender. Radulae of *F. lilium* and *F. branhamae* have not been described.

It is possible that *F. bullisi* is the eastern Gulf analogue of *F. branhamae*, which occurs from Texas to Campeche in moderate depths. *Fasciolaria branhamae* has an axially sculptured nucleus and elongate siphon like *F. bullisi*, but differs in color, strength and number of bands, possession of a strongly-defined presutural ridge, and in having a more globose body whorl. It occurs sympatrically with *F. lilium*, the western Gulf analogue of *F. hunteria*. Certain similarities of sculpture, banding and outline between specimens from separate localities suggest that *F. branhamae* may be merely a subspecies of *F. lilium*. It was described as a subspecies of *F. distans* Lamarck (= *lilium* Fischer von Waldheim) by Rehder and Abbott (1951), but Hollister (1957) elevated it to specific rank. No such similarities have been noted between *F. bullisi* and any other western Atlantic *Fasciolaria*.

The possibility that *F. bullisi* represents a hybrid of *F. hunteria* and *F. tulipa*, the two other eastern Gulf species, seems untenable. No other specimens of *F. bullisi* are known from North Carolina to the Mississippi Delta, the region where *F. hunteria* and *F. tulipa* occur sympatrically. The deepest record I have seen for *F. tulipa* is 73m (Work, 1969:674) from off Suriname. In Hourglass collections, *F. tulipa* decreased in numbers markedly with increased depth; only two specimens were collected in 73 m from 110 tows at this depth. *Fasciolaria hunteria* showed a similar decrease in abundance, but was still fairly common at 73 m stations. However, specimens of the latter from 73 m had remarkably heavy shells with very short siphons quite unlike those of *F. bullisi*. The deepest-collected *F. hunteria* I have seen is a juvenile from 77 m off northwest Florida. Specimens of *F. bullisi* seem to occur only at the extreme edge or beyond the bathymetric range of their hypothetical parents. It appears best at present to treat *F. bullisi* as a species distinct from other western Atlantic *Fasciolaria*.

ACKNOWLEDGMENTS

I thank Mr. Bullis for the loan of his specimens, and the many workers at the above museums for their assistance. Dr. R. T. Abbott, R. C. Bullock, H. R. Bullis, and D. K. Serafy critically read an early draft of the manuscript. Most of their comments were incorporated into the final copy. Mrs. S. D. Kaicher photographed the type.

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**HEMPHILLIA DROMEDIARIUS, A NEW ARIONID
SLUG FROM WASHINGTON¹**

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During a survey of the terrestrial Gastropoda of the Olympic Peninsula, Washington, several specimens of the peculiar arionid slug genus *Hemphillia* were secured, including an apparently new species. The genus exhibits a somewhat circumscribed distribution in Idaho and Alberta, Canada (*H. camelus* Pilsbry and Vanatta) (LaRocque, 1953; Pilsbry and Vanatta, 1898; Smith, 1943), Montana (*H. danielsi* Vanatta), Oregon, Washington, and British Columbia (Henderson, 1929; Pilsbry, 1948). Pilsbry's (1917) *H. malonei*, described from a single formalized specimen collected near Mt. Hood, Oregon, remains problematic.

Hemphillia and *Binneya* comprise the subfamily Binneyinae, a complex of slug species morphologically intermediate between normally coiled, testaceous snails and shellless slugs in possessing an exposed shell (partially coiled in *Binneya*) and short visceral cavity confined to a dorsal hump or pouch-like arrangement of the body (Pilsbry, 1948; Webb, 1961). In *Hemphillia*, the platelike shell is only slightly attached to the mantle at its edges and, contrary to Pilsbry's (1948) observation that "in life the shell is usually almost or quite covered," usually exposed, even at rest. The foot is undivided.

¹ Supported in part by a Sigma Xi-RESA grant; in part by an Eastern Kentucky University faculty grant

Hemphillia burringtoni Pilsbry

Fig. 1b, d

Pilsbry (1948: pp 741-742, Fig. 397a, b, c, d)

In elevating this form to full species' rank, I was guided by the consistent differences of genitalia and external pigmentation patterns. *Hemphillia glandulosa* Bland and Binney, in which Pilsbry (1948) placed *H. burringtoni* as a subspecies, exhibits a papillose mantle in contrast to the smooth one of *H. burringtoni*; a rugose stimulator in contrast to a smooth one; and a considerably different external color pattern. In *H. burringtoni*, the sides of the foot (Fig. 1d) bear spaced black lines which terminate in round black spots (between the granules); this pattern is lacking in *H. glandulosa*. Holotype and paratypes, Academy of Natural Sciences of Philadelphia (ANSP 182093); type locality: Rialto Beach, Clallam County, Washington.

Distribution: *Hemphillia glandulosa* occupies mainland Washington west of the Cascades and adjacent British Columbia westward to the Olympic and Grey Wolf mountains and southward to northern Oregon. *Hemphillia burringtoni* is restricted to the Olympic Peninsula of Washington State.

Collecting sites for Hemphillia burringtoni: 1, S17, R11W, T23N, Macafee Quadrangle, 545 feet mean sea level (MSL), Grays Harbor County, Washington, 5 July 1969; 1, Bush Pacific State Park, near Bay Center, Pacific County, Washington, 5 August 1969; 1, S4, R9W, T27N, rain forest of Mt. Tom Quadrangle, 1,000 feet MSL, Clallam County, Washington, 11 July 1969; 1, three miles up trail to Enchanted Valley from Dosewallips Campground, Olympic National Park, Mt. Christie Quadrangle, 780 feet MSL, Jefferson County, Washington, 3 July, 1969; 2, Deer Park Road, 10.3 miles after leaving U.S. 101, Mt. Angeles Quadrangle, 2,460 feet MSL, Clallam County, Washington, 7 July 1969; 1, Cox Valley, R5W, T29N, Mt. Angeles Quadrangle, 3,435 feet MSL, Clallam County, Washington, 13 July 1969; and 1, North Point Lookout, R2W, T27N, Mt. Walker, 2,625 feet MSL, Mason County, Washington, 26 June 1969.

The following descriptions were secured from living specimens, but the measurements are from relaxed, alcoholized individuals.

The jaw is dark-brown in most individuals and bears 10 central striations, the lateral margins being non-striate. The body is strongly laterally compressed, almost keel-like, behind the posterior

tip of the mantle, and likewise deeply incised (from a lateral view: Fig. 1d) to bear the visceral pouch. Posteriorly, the moderately developed hornlike protrubance above the caudal mucus gland is bluntly rounded behind, but is rather triangular in lateral view. Colorwise, the posterolateral margins of the mantle are mostly pigmentless, except for a distinct band which sends a series of very thin lines toward the shell to produce a reticulum. The anterior and dorsal portions of the mantle are much-speckled and blotched with dark grey and black, and the head and tentacles are black. The sole is pale yellowish-white and immaculate, whereas the foot immediately above the pedal furrow, which is broken up into 17 to 23 cell-like granules, bears a single row of round, very black spots that are contacted by thin, oblique lines. The sides of the body below the dorsal hump are sooty gray to yellowish white, diagonally marked by 7 to 9 rather broad, dark gray bands. The shell tapers sharply caudad, the anterior quarter being yellow and the posterior three quarters greenish-gray; the shell is farther subdivided (in appearance) by a dense black accumulation of pigment beneath its middle. The secretory groove, located at the posterior end of the mantle, is directed nearly straight downward; in life this groove stands open most of the time. The pneumostome is located just posterior to the middle of, or as far back as the posterior one-third, of the mantle. There are a few granules on the mantle caudal to the shell. Proportional measurements: total length 13.07 mm (8.0-19.3); width of foot/total length = 0.20 (0.15-0.24) (in small specimens, this percentage is larger); posterior end of mantle to pneumostome/total length = 0.37 (0.35-0.40); width of shell/length of shell = 0.68 (2.0-2.8/2.2-4.5 mm); width visceral pouch/length visceral pouch = 0.51 (2.5-5.0 mm/5.0-10.4 mm); width back behind pouch/height behind pouch = 0.39 (0.8-1.4 mm/1.8-3.5 mm); length body behind mantle/total length = 0.33 (1.5-9.0 mm/8.0-19.3 mm).

Key to species of Hemphillia

- 1 a. Body behind pouch at first depressed to receive the visceral mass then forming a high, compressed keel 2
- b. Body behind pouch neither depressed nor forming a compressed keel 3
- 2 a. Visceral pouch bearing numerous papillae; penial stimulator rugose within *Hemphillia glandulosa*

- b. Visceral pouch nearly smooth; penial stimulator smooth within
 *Hemphillia burringtoni*
- 3 a. Penis narrow, with an accessory sac; color yellowish-gray to
 whitish with black markings *Hemphillia danielsi*
- b. Penis broad, lacking an accessory sac; color ashy-gray, bluish-
 black to black 4
- 4 a. Tail with a conspicuous horn-like protrubance above meeting
 of the pedal grooves *Hemphillia dromedarius*
- b. Tail lacking a horn-like protrubance above meeting of pedal
 grooves *Hemphillia camelus*

Hemphillia dromedarius, new species

Fig. 1a, c

Description of holotype. The head is dark-gray, the tenacles somewhat lighter. A pair of shallow, pale yellowish white grooves occupy the head immediately behind the tentacles. The mantle, including the visceral pouch, is mottled gray, but much whiter on the sides. Below the visceral pouch, the sides of the body are white flecked with gray. Posterior to the pouch, the back is moderately narrowed and rounded rather than keeled, and dark gray on the midline, lighter below and tending to white flecked with gray along the sides. The sole and sides of the foot are pale yellowish, the cell-like granules above the pedal groove being delineated by gray, the gray streaks coalescing posteriorly to color the edge of the foot gray. The integument of the back is broken up into diagonal rows of low

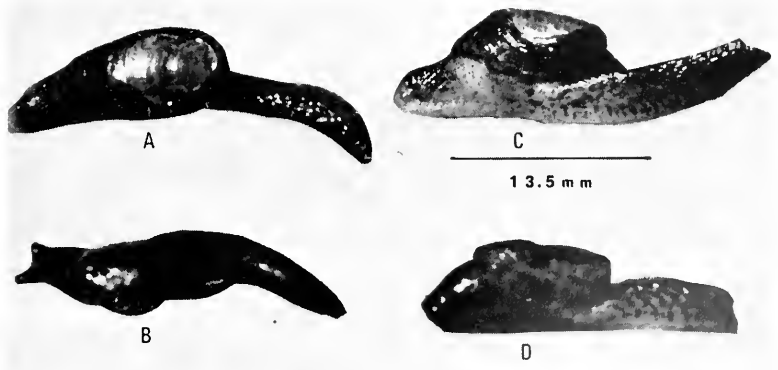


Fig. 1. A. Holotype, *Hemphillia dromedarius*, dorsal view. Staircase Falls, Olympic National Park, Washington. B. *Hemphillia burringtoni*, dorsal view. Mt. Christie Quadrangle, 3 miles up Enchanted Valley Trail from Dosewallips Camp, Olympic National Park, Washington. C. *Hemphillia dromedarius*, left lateral view of holotype. D. *Hemphillia burringtoni*, left lateral view.

ridges which emanate from the midline and extend dorsoventrad and posteriad. The pneumostome, on the right in the posterior one-half of the mantle, is surrounded by a narrow, white halo. The shell, located on the posterior one-half of the visceral pouch, is pale yellowish-horn in color, is transparent, and is approximately twice as long as wide; its position causes the surrounding integument to be thrown into five concentric grooves and furrows. The external surface of the shell shows a series of fine growth ridges. From a point on the midline of the dorsal pouch, immediately behind the shell, a definite secretory groove extends posteroventrad slightly toward the left. A deep caudal mucus pit occurs near the posterior tip of the tail, and there is a definite horn-like process above it. A white groove extends to the tip of the tail from the pit. The brownish jaw possesses 20 plates, and the genital pore is located near the base of the right tentacle. Total length 29.8 mm; width of foot (4.0 mm) is 13% the length; the measurement from the posterior tip of the visceral pouch to the pneumostome (6.5 mm) comprises 22% of the length, and the length of the foot posterior to the visceral pouch (12.5 mm) 42% of the length. The visceral pouch, 7.0 mm/13.0 mm, is slightly more than twice as long as wide (54%). Width of the back behind the dorsal pouch (3.5 mm) is 70% of the depth of the back (5.0 mm.), and the width of the shell (5.5 mm) is 69% of the length (8.0 mm). Holotype: USNM 577690; type locality (28 June 1969): Staircase Rapids, Staircase Campground, Olympic National Park, Mt. Steel Quadrangle, Mason County, Washington; 645 feet MSL.

Specific epithet from that of the Arabian or one-humped camel, *Camelus dromedarius*.

Collecting localities for paratypes: 1, 3 miles up trail to Enchanted Valley from Dosewallips Campground, Olympic National Park, Mt. Christie Quadrangle, 780 feet MSL, Jefferson County, Washington, 3 July, 1969; Delaware Museum of Natural History (DMNH 43029); 2, slope between the junction of main road and Obstruction Point Road, Olympic National Park, 4,710 feet MSL, Mt. Angeles Quadrangle, Clallam County, Washington, 14 July 1969; 1, S32, T25N, R10W, Queets Campground, Olympic National Park, 284 feet MSL, Salmon River Quadrangle, Jefferson County, Washington, 8 July 1969; 1, R9W, T23W, extreme southeast corner of Kloochman Rock Quadrangle, 400 feet MSL, Jefferson County,

Washington, 2 July 1969, Field Museum of Natural History (FMNH 173022); 1, 5 miles above Flapjack Lakes trail head, Olympic National Park, Mt. Steel Quadrangle, 3,353 feet MSL, Jefferson County, Washington, 20 July 1969; 2, 0.3 mile downgrade from the second station listed above, 4,620 feet MSL, Mt. Angeles Quadrangle, Jefferson County, Washington, 14 July 1969; 1, North Point Lookout, Mt. Walker, 2,586 feet MSL, Mason County, Washington, 26 June 1969.

Corroborative description and proportional measurements. The mantle color pattern varies from nearly black or blue-black through dark gray in front of the shell (slightly lighter behind it) to bluish-black maculated with yellowish or yellowish densely spotted with blue-black and gray, and is mostly devoid of papillae. Sometimes the apex of the dorsal hump is creamy orange-yellow, but this is probably associated with the reproductive period. The sides of the body below the pouch range from white to yellowish white and immaculate. The sides of the body behind the pouch bear numerous gray to blackish maculations. The rather wide edge of the foot is light gray, and there are 54 to 56 cell-like granules above the pedal groove. The head varies from nearly white to light gray, which allows the intensely black optic tracts to show through the integument. The strongly arcuate jaw is striated to its margin, and bears 18 to 20 striae. The secretory groove, located posterior to the shell, is variable in position: directed directly caudad, slightly to the left, or slightly to the right. The inflated penis does not bear an accessory sac. Total length 28.5 mm (24.0-31.0); width foot/total length = 0.13 (2.5-4.0 mm/24.0-31.0 mm); posterior end visceral pouch to pneumostome/total length = 0.24 (4.5-8.2 mm/24.0-30.6 mm); shell width/shell length = 0.59 (2.5-6.0 mm/5.0-9.0 mm); width pouch/length pouch = 0.56 (5.5-7.5 mm/9.9-16.2 mm); width back behind pouch/height behind pouch = 0.68 (3.3-6.0 mm/5.0-6.0 mm).

Comments on natural history. The oval, semi-opaque eggs, 50 to 60 of which are deposited in wet to moist decaying wood, average 3.3 mm (3.0-3.5) in length and 2.5 mm (2.7-2.7) in diameter. At rest, this slug is coiled counterclockwise so that the tip of the tail touches the head. From this position, the animal is capable of quickly recoiling, even to the extent of "jumping" an inch or so, a feature which has been previously recorded in the literature

(Hemphill, in Pilsbry, 1948, and Pilsbry, *Loc. Cit.*; Smith, 1943). This is, to my way of thinking, a very definite anti-predation startle reaction. The histology and musculature of *Hemphillia* needs thorough investigation.

Diagnosis: *Hemphillia dromedarius* is an arionid slug most closely related to *H. camelus* Pilsbry and Vanatta of Idaho and adjacent Canada but which is distinguished from that species by being darker and more boldly marked (*H. camelus* is mostly ashy-gray with a tendency to produce lateral bands on the visceral pouch, whereas *H. dromedarius* tends toward blue-black), by having a less keeled tail and in possessing a definite caudal horn (Fig. 2) (lacking in *H. camelus*). It differs from *H. danielsi* in matters of coloration and in possessing the inflated penis and in lacking an accessory stimulator

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WINTER DISTRIBUTION OF *MELAMPUS BIDENTATUS* (SAY) ON A CAPE COD SALT MARSH¹

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Salt marsh snails (*Melampus bidentatus* Say) sometimes comprise much of the food for wintering black ducks (*Anas rubripes*) (Addy,

¹ A portion of the author's Ph.D. dissertation in the Department of Forestry and Wildlife Management, University of Massachusetts.

1945). Despite recent studies on *Melampus* (Apley, *et al.*, 1967; Russel-Hunter and Apley, 1966), however, the winter distribution of these snails has not been documented. This paper reports the results of a two-year study on the winter distribution of salt marsh snails in Nauset Marsh (a salt marsh), Eastham, Massachusetts. *Salt Marsh*. Dexter (1947, pp. 285-290) divided a New England salt marsh into high and low marsh. The plant species listed by Dexter that are common in Nauset Marsh are:

High Marsh—salt meadow grass (*Spartina patens*); sea lavender (*Limonium* sp.); salt grass (*Distichilis spicata*); glasswort (*Salicornia* sp.)

Low Marsh—salt marsh cordgrass (*Spartina alterniflora*); algae (*Fucus* sp.); algae (*Anscophyllum* sp.)

Salt meadow grass is the most common high marsh species in Nauset Marsh, and salt grass is the most uncommon. Kerwin (Unpub. Ms.), working in a Virginia salt marsh, recognized a zone of short *Spartina alterniflora* (referred to in this paper as short *Spartina marsh*). In Nauset Marsh, the short *Spartina* marsh occurs between the high and low marsh, and is pronounced when the high and low marsh are connected by a gently sloping surface. The ribbed mussel (*Modiolus demissus*) occurs in the short *Spartina* marsh and locally in the high marsh.

Methods. On October 1, 1969, I established 2 plots, 4.5 inches in diameter, in the high marsh and 2 plots in the short *Spartina* marsh. *Melampus* movements through these plots were monitored until mid-November 1969.

Between September 20 and December 27, 1970, I established 20 plots (diameter either 4.5 or 12 inches) in the high marsh or short *Spartina* marsh, and marked the snails within with white, quick-drying enamel paint. These plots were checked periodically to determine movements of snails to wintering areas. Much of the information in this report was obtained during more than 80 hours of observations in fall and winter 1969 and 1970.

Results and Discussion. Plots established in 1969 and before December, 1970, were of little value. Counting in 1969, and marking and recounting in 1970 disturbed the habitat, allowing the marsh surface to dry and apparently forcing the salt marsh snails to move. Relocating marked snails was hampered by approaching the marking site, with the chance of stepping or kneeling on marked

individuals. In contrast, marking *Melampus* snails in their wintering locations was valuable, and indicated that the snails remained sedentary during winter and that they adopted winter habitat in late November 1970. Major wintering locations for Nauset Marsh were:

1. High marsh around the bases of salt meadow grass and salt grass, with shells in upright position with spires from 1/16 inch below to 1/4 inch above the peat surface, in clusters up to 20. (Potential concentrations must depend on *Melampus* density; hence, concentrations listed for different wintering areas should be viewed as being relative). Salt meadow grass provided the most consistent wintering location.

2. Beneath an empty shell (i.e. quahog, *Venus mercenaria*; ribbed mussel) on the high marsh wherever the empty shell touches the marsh surface. *Melampus* snails lay imbedded slightly in the marsh surface with their length against the side of the empty shell. Concentrations are highly variable, but 23 were found beneath one empty ribbed mussel shell on January 30, 1971.

3. Around the base and along the sides of the living ribbed mussel, in upright position and slightly imbedded in the marsh, in highly variable concentrations up to 30.

4. Around the base of short *Spartina alterniflora* and within the sheathing leaves, in upright position, with no more than five wintering in each plant.

5. Around the base of *Limonium* sp. and *Salicornia* sp., in upright position, with no more than one or two *Melampus* wintering around each stem.

6. In holes (about the diameter of *Melampus*) in the high marsh surface, disassociated from the stems of vegetation but beneath the salt meadow grass or salt grass, in upright position, with no more than one snail per hole. Certainly, larger holes, where present, might contain more snails.

Kerwin (Unpub. Ms.) working in the fall on a Virginia salt marsh, found *Melampus bidentatus* associated primarily with salt grass and salt meadow grass, and secondarily with short *Spartina alterniflora*. Dexter (1945, pp. 137-138, and 1947, pp. 288-290) working in summer on a Massachusetts salt marsh found *Melampus* associated with salt grass and salt meadow grass. Hence, *Melampus* inhabits the same general marsh areas throughout the year. The

only apparent differences in summer and winter ecology are the lack of movement and the tendency to cluster in suitable winter habitat.

Melampus snails are not always found in each of the locations noted. Research is needed to determine why, for instance, one area of salt meadow grass contains no wintering snails while another area, less than 10 feet away, may contain many snails.

ACKNOWLEDGMENTS

I thank Mr. J. A. Hagar for his encouragement and support. Dr. M. L. Apley furnished information concerning *Melampus*, and Dr. John Teal, Woods Hole Oceanographic Institution, reviewed the manuscript for errors in terminology used to describe a salt marsh. This paper is a contribution of the Massachusetts Cooperative Wildlife Research Unit, (Bureau of Sport Fisheries and Wildlife, Massachusetts Division of Fisheries and Game, Wildlife Management Institute, and University of Massachusetts).

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NOTES

THE WESTERN SOCIETY OF MALACOLOGISTS' fifth annual meeting will be held at Redlands University, June 18 to June 21. Symposia on Pelecypoda led by Dr. Vida Kenk and on Opisthobranchia led by Mr. Wesley Farmer and papers on other malacological topics will be presented.

Inquiries may be sent to the secretary, Mrs. Edith Abbott, 1264 W. Cienega Ave., San Dimas, Ca 91773. Applications for membership in the W.S.M. should be sent to the Treasurer, Mr. Ralph O. Fox, Department of Invertebrate Zoology, California Academy of Sciences, Golden Gate Park, San Francisco, Ca 94118. Dues are \$2.50 for Regular Members and \$1.00 for students.

Executive Board members for the year are: President Mrs. Beatrice L. Burch; First Vice-President Mrs. Twila Bratcher; Second Vice-President Dr. James H. McLean; Secretary Mrs. Edith Abbott; Treasurer Mr. Ralph O. Fox; Members-at-Large Mr. Anthony D'Attilio and Mr. Hans Bertsch; the three most recent Past Presidents are Dr. William K. Emerson, Dr. A. Myra Keen and Dr. Eugene V. Coan.

LOCOMOTION OF *MARGINELLA OLIVAEFORMIS* KIENER—Members of the Marginellidae usually have been observed to move by crawling in the ordinary gastropod fashion. However, at Point of Almadies, north of Dakar, Senegal, in April 1971, Clover observed *Marginella olivaeformis* Kiener, 1834, to progress through loose sand underwater by a swimming-like motion. The animals were found at lowest tide level in coarse sand and coral debris among green-slime-covered rocks.

The foot of *M. olivaeformis* is broadened anteriorly into two ovate lobes which are alternately flexed up and down, propelling the animal forward. In their most strongly reflexed position the lobes are appressed to the mantle-edge which is held extruded about halfway around the shell. Thereafter the lobes flap downward with some force. In a pan of seawater the animals were also seen to crawl normally on the hard surface, sometimes using the swimming-like motion in an attempt to scale the sides of the pan.

A broad anterior foot-margin is characteristic of some other Marginellidae also (notably *M. aurantia* Lamarck, 1822, and *M. hyalina* Thiele, 1913), but its function in these species has yet to be observed.—Barry Roth, 1217 Waller St., San Francisco, Calif. 94117, and Phillip W. Clover.

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THE SPAWN, EARLY DEVELOPMENT AND LARVAE OF *CYPHOMA GIBBOSUM* (CYPRAEACEA)

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During the summer of 1964 while working at the Bermuda Biological Station for Research, Dr. R. Tucker Abbott pointed out that the egg capsules and developmental stages of the flamingo tongue, *Cyphoma gibbosum* Linné had not been described in the literature.

On July 13 three specimens of *C. gibbosum* were collected on the north reef and isolated in a battery jar aquarium with running sea water and a screen cover. A basal section of the normal prey of *Cyphoma*, the rough sea whip *Muricea muricata* Pallas, was included as food.

Between 2000 hrs on July 13 and 0800 hrs on July 14, three egg capsules were laid in a slightly curving row, with the attachment plates touching, on the wall of the glass aquarium.

The capsules (fig. 1) were hat-shaped and were identical in form and surface pattern so that each ridge and groove were identical in shape and position even though there was some variation in size. The similarity of surface pattern indicates that the capsules were laid by a single female, for as Ankel (1936) noted in *Nassarius* and *Philbertia* each female has a characteristic "fingerprint"-like pattern in the sculpture of the egg capsules. The same characteristic is true of *Nassarius vibex*, *Ilyanassa obsoleta*, *Cypraea caputserpentis*, *C. moneta*, *Conus leopardus*, *C. pennaceus* and *C. mindanus*. The basal attachment disc of *Cyphoma's* egg capsule varied from 3.12 to 3.39 mm while the egg capsule proper were from 2.37 to 2.62 mm and 1.50 mm wide. A well-formed operculum covered about half of the dorsal side of the capsule (fig. 1).

The capsules contained 11, 18 and 19 eggs which were 0.260 mm in diameter and spherical when first observed at 0800 hours. The eggs were the same bright orange color as the adult snail's mantle.

There were no membranes around the individual eggs, which were surrounded by the viscous capsular albumen. The lack of individual egg membranes in those mesogastropods and neogastropods with firm multi-egg capsules rather than gelatinous masses has been verified with the electron microscope (Weymouth et al., 1961; Taylor and Anderson, 1969) as well as with the light microscope. The formation of individual egg membranes described by Ghiselin and Wilson (1965) can only be considered artifactual due to their admittedly defective histological material. The role they ascribe to the membrane gland requires re-evaluation.

When the eggs were first observed, both polar bodies had been extruded. The first cleavage occurred 3 hours and 10 minutes later at 25°C and was markedly unequal with the smaller AB blastomere only one-fifth the size of the CD blastomere. The first cleavage was completed at 4 hours.

We were unable to rear the isolated eggs further, but have since found that similar large eggs can be cultured in pasteurized sea water (Costello et al., 1957) with methyl cellulose added to give the consistency of the capsular albumen, for support of the large eggs, which will otherwise flatten against the container and cytolysse. Sodium Sulfadiazine (50 mg/l) and Streptomycin Sulfate (50 mg/l) were added to prevent bacterial growth.

Further observations were made in Miami, Florida, in November 1969. After 11 days in an aquarium, on November 19, one of four specimens was observed cleaning an area of 8 sq cm of the glass wall about 3 cm below the water surface. On the morning of November 20 one of the snails deposited 23 capsules in an irregular mass on the cleaned area. The snail returned to the egg mass each morning and added more capsules to a total of 73 by late evening of November 24. The eggs were initially white but became light flesh pink by the tenth day, after which they became progressively darkened to a deep rose as the veligers matured. The embryos were motile by the fifth day and on the fifteenth day the first veligers escaped from the capsule through a slit in the capsule top. One average sized capsule contained 1,270 veligers.

In spite of removal of capsules for observation and of predation by a *Cypraea*, the mother snail would return each day to the capsule mass. When the veligers hatched the capsules were invaded by the microfauna and maternal care ceased. Protection and clean-

ing of egg masses is well known in the Cypraeacea (Ostergaard, 1950; Crovo, 1971) but in the cowries the female seldom if ever leaves the egg mass.

A second snail spawned on November 27 and over a period of four days produced 78 capsules in a manner similar to that described.

There are some significant differences between the Bermuda and Florida spawns although all specimens were carefully identified and the egg capsules are as near identical as is expected within the normal range of variation of a species. In the Florida forms there are large numbers of white eggs which hatch rapidly into veligers while in the Bermuda form the eggs are large and develop slowly and are bright orange in color.

At present we must attribute these differences to geographic variation although seasonal variation cannot be excluded. We hope to obtain more material from a broader geographical range for further studies.

We wish to thank Martha B. Lackey for her excellent drawing of the egg capsule, and Axel A. Olsson for encouragement and for reading the manuscript, and Dr. Alan Kohn for identifying *Conus mindanus*.

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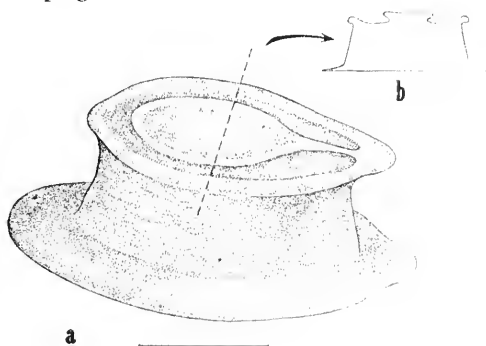


Fig. 1. The egg capsule of *Cyphoma gibbosum*. (a) The basal attachment disc is rather flat with the body of the capsule shaped like the crown of a hat with a well formed operculum on top. The line represents 1 mm. (b) A cross section of the capsule, where indicated.

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REEF MOLLUSKS OF SOUTH CAROLINA

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Collections off Beaufort, North Carolina have verified the existence of calcareous reefs and associated reef-building corals, *Solenastrea hyades* and *Siderastrea siderea* (Macintyre and Pilkey, 1969). The distribution of these reefs appears to coincide with the inner edge of the Gulf Stream southward, occurring intermittently with

rocky outcroppings at least as far south as Charleston, South Carolina. Merrill and Petit (1965) found off the South Carolina coast mollusks previously unrecorded or rare north of the Caribbean Province and south Florida region and they hinted at the possibility of a much greater occurrence of southern mollusks in Carolina waters. Later dredging by Menzies *et al* (1966) recorded over 130 species of mollusks in the Beaufort area, many of which were, indeed, unknown north of the Bahamas and Florida Keys. Merrill and Petit (1969) further added to this list of known molluscan species off South Carolina and pointed out the need for more research in this area. In October, 1970, a survey was undertaken aboard the R/V Eastward of the Duke University Marine Laboratory under the direction of F. John Vernberg of the Belle W. Baruch Coastal Research Institute, University of South Carolina, to verify the occurrence of these reefs off South Carolina. Since broken patches of rocky outcroppings and coral reefs were found off Charleston and Georgetown, South Carolina, later dredgings in March, 1971 were undertaken to examine the faunal diversity. This paper will deal with the molluscan assemblage found on the March, 1971, cruise.

This cruise was made possible by NSF grant GB-17545 to Duke University.

PHYSICAL CHARACTERISTICS OF THE REEF

The reefs which lie parallel to the Gulf Stream occur in the area off Georgetown as raised benches, rounded humps, or ridges. Other areas within the vicinity are not raised but are still hard, rocky, and contain coral, as evidenced by large numbers of byssally attached *Arca zebra*. The reefs and flat rocky areas are interrupted, however, by sandy patches. Typical sand bottom bivalves, such as *Glycymeris americana* and *Macrocallista maculata*, are found wherever these patches occur. The area surveyed is roughly 32°55'N and 78°45'W. Stations 16621 and 16624 are deeper reefs located off Charleston and contain no living coral. Only the shallower reefs of 25m to 30m depth contain living, reef-building corals, while the first two deeper reefs supported a much smaller faunal community, molluscan or otherwise.

METHOD OF COLLECTION

Stations not included in this listing, as evidenced by gaps in the numbering sequence, represent sand bottoms or other shipboard

Table 1 - Location of the reefs.

<u>Station</u>	<u>Latitude</u>	<u>Depth</u>
16621	32°2.9'N 79°26.6'W	48m
16624	32°6.8'N 79°12.6'W	74m
16633	32°53.5'N 78°33.0'W	40m
16634	32°53.6'N 78°33.0'W	40m
16635	32°55.3'W 78°36.5'W	30m
16642	32°57.5'N 78°45.6'W	25m
16643	32°57.5'N 78°45.6'W	25m
16646	32°56.0'N 78°45.0'W	26m

events not important to the present paper. Each station required 30 minutes to complete in order to fill the dredge. A rock dredge was used at all stations and all material was collected in a heavy chain link bag trailing the dredge. Although very small mollusks may be lost in this dredge, a fine mesh dredge which could be used on soft bottoms would be damaged or lost on rocky bottoms like these. Material to be kept alive comes aboard in better condition when collected in a chain bag which has enough flexibility to allow for abrasion against other incoming materials.

BIVALVIA

At first glance, all of these bivalves appear to be southern or tropical species. Very few are found north of Cape Hatteras, North Carolina, where colder currents seem to keep them from extending their range. The occurrence of *Crassostrea virginica*, *Noetia ponderosa*, *Mercenaria mercenaria*, and *Dinocardium robustum* probably marks the area as a shallow marine or estuarine habitat in Pleistocene times, since all of these shells were dead and appear to be subfossil remains. All other records are from living or, in a few instances, freshly dead individuals. *Macrocallista maculata* and *Glycymeris americana* are typically sand bottom species and, as mentioned previously, are found on patches of sand which occur intermittently among the reefs and rocky areas. *Arca zebra*, listed

Table 2 - Mollusca

	<u>Sample stations</u>							
	16621	16624	16633	16634	16635	16642	16643	16646
<u>Bivalvia</u>								
<i>Aequipecten gibbus</i>		R			R			
<i>Aequipecten muscosus</i>					R			
<i>Americardia media</i>						C		
<i>Anadara lienosa floridana</i>		R			C			
<i>Anadara notabilis</i>				C				
<i>Arca imbricata</i>						R		
<i>Arca zebra</i>	C		A	A	A	A		A
<i>Barbatia candida</i>				F				
<i>Chama congregata</i>		C	C	A	A	A		A
<i>Chama macerophylla</i>					C	C		
<i>Chione latilirata</i>				C				
<i>Crassostrea virginica</i>	R				C	C		
<i>Dinocardium robustum</i>			R		C			
<i>Eucrassatella speciosa</i>				C				
<i>Glycymeris americana</i>				A	C			
<i>Laevicardium pictum</i>						R		
<i>Lithophaga aristata</i>	C					C	C	A
<i>Lithophaga bisulcata</i>					R		C	A
<i>Lyropecten nodosus</i>		R		C				
<i>Macrocallista maculata</i>			R	R				
<i>Mercenaria mercenaria</i>						C		
<i>Modiolus americanus</i>			R	C		A		R
<i>Noetia ponderosa</i>			R			C		
<i>Ostrea equestris</i>			R			R		
<i>Pecten zigzag</i>		C	R					

as abundant at most stations, was present in great numbers and probably paves the rocky bottoms, with many attached to each other by their strong byssal threads. They also provide a substrate for the equally common *Chama congregata*, *Chama macerophylla*, *Pseudochama radians*, and *Crepidula aculeata*, and many corals, bryozoans, and tunicates. The boring mussels *Lithophaga aristata*

Table 2 - cont.

	<u>Sample stations</u>							
	16621	16624	16633	16634	16635	16642	16643	16646
<i>Plicatula gibbosa</i>							R	C
<i>Pseudochama radians</i>				A	A	A		A
<i>Pteria colymbus</i>					P	A	R	A
<i>Spondylus americanus</i>	C							
<u>Gastropoda</u>								
<i>Cantharus tinctus</i>			A	A	A			A
<i>Conus floridana floridensis</i>						P		
<i>Conus sozoni</i>	R							
<i>Crepidula aculeata</i>			A	C	A			A
<i>Crepidula plana</i>					C			
<i>Cypraea cervus</i>					P			
<i>Cypraea spurca acicularis</i>					R			
<i>Diodora cayenensis</i>			R	R				
<i>Fasciolaria hunteria</i>				R	R	R		R
<i>Murex dilectus</i>		R		C				
<i>Murex fulvescens</i>								R
<i>Murex pomum</i>						R		
<i>Murex rubidus</i>								R
<i>Phalium granulatum</i>						R	R	R
<i>Scaphella junonia</i>			R					
<i>Terebra floridana</i>		R						
<i>Tonna galea</i>		R						
<i>Trivia pediculus</i>		R						
<i>Turritella exoleta</i>			R					

R=rare, 1 individual; C=common, 2-4 individuals; and A=abundant, over 4 individuals.

and *Lithophaga bisulcata* were common, found in tunnels dug in coral heads and in burrows within the shells of *Spondylus americanus*. The other species were much less common, occurring only once or twice, possibly because their habitat is truly limited.

GASTROPODA

Of all the gastropods collected, few species were found repeatedly. *Crepidula aculeata* and *Cantharus tinctus* were found in large numbers on coral and other mollusks, but since most of the other species are voracious predators, their numbers are quite limited by available food supply, intraspecific competition, low reproduction rates, and other natural population controls. While *Fasciolaria hunteria* is probably common on the reef as a whole, the *Murex* family also represents an abundant predator group. Some of these, *Phalium granulatum* and *Conus sozoni*, are also found on sandy bottoms which may indicate that their environmental requirements, such as food supply, are not necessarily reef dependent. Only three *Murex dilectus* were found on the cruise, all alive, with one individual quite large and spinous. This species has not been recorded north of southeast Florida or the Caribbean (Clench and Abbott, 1944; Abbott, 1954). All of the *M. dilectus* were of the frilly variety and varied in color from tan in the largest one to dark brown in the smallest one. *Turritella exoleta*, although found only as solitary specimens on this cruise, was found in large numbers within one sample on an earlier cruise, which may be indicative of a gregarious or colonial mode of life. In general, gastropods represent only a fraction of the total numbers of individuals of the molluscan assemblage, with *Arca zebra* alone comprising over 75% of the total number of individual mollusks, and only a small fraction represented by the largely predaceous gastropods.

CONCLUSION

The reefs off the Carolinas need to be more thoroughly sampled, both for mollusks and for other phyla with tropical representatives. This particular cruise was cut short by an untimely snow storm. Reef locations south of Charleston are unknown as yet, and although they presumably follow the Gulf Stream all the way to Florida, further work is needed to accurately plot them.

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**SOMATOGYRUS ALCOVIENSIS, NEW GASTROPOD SPECIES
FROM GEORGIA (HYDROBIIDAE)**

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Much of the interior of Georgia has never been fully explored by invertebrate zoologists, and until recently the Mollusca have been particularly neglected. Family Hydrobiidae, which includes those prosobranch gastropods with basocones on the central tooth of the radula (Thompson, 1968), is represented by many genera throughout the Southeastern States. *Somatogyrus*, itself widely distributed, belongs to subfamily Hydrobiinae, in which a single functional duct, the vas deferens, discharges at the tip of the penis (Morrison, 1949; Thompson, 1968). The present paper extends the known range of *Somatogyrus* into the headwaters of the Altamaha River system of Georgia.

Materials and Methods: Specimens were collected by hand or sieve in shallow water on 5 September 1968, April and May 1970, and 4 January 1971. The soft anatomy was described from living specimens. Permanent radular mounts were prepared after dissection and mercurochrome staining. The verge was sketched from animals preserved in sixty per cent ethyl alcohol.

***Somatogyrus alcoviensis*, new species** (Figs. 1-4)

Description: The shell is small, thin, and globose, reaching 5.1 mm. in length and 4.6 mm. in greatest diameter (Fig. 1). The three whorls are strongly convex, smooth, and unsculptured with numerous fine transverse striations. The apex is often eroded. The sutures are shallow. The aperture is large and widely ovate but acutely angular posteriorly, presenting a white interior. The outer lip is thin, not reflected; the inner lip is discontinuous, becoming a thin callus along a wide attachment to the body whorl. The umbilicus is reduced to a very narrow chink or is imperforate. Although the

shell may be coated with a black deposit, the shell itself is yellow-green.

Paratypes of *Clappia umbilicatus* and *C. cahabensis* revealed a mean obesity index (width/height) of 1.01 (0.92-1.04) and 0.95 (0.87-1.00), respectively. Fifty specimens of *Somatogyrus alcoviensis* each from the Yellow River and Alcovy River populations revealed respective mean obesity indices of 0.94 (0.86-1.06) and 0.95 (0.85-1.04).

The operculum (Fig. 2) is chitinous, ovate, and spiral with about 2.2 whorls. Externally, several strong growth lines and many finer striations radiate from a prominent nucleus, which is situated about one third the distance between the base and the apex and between the anterior and posterior margins. The inner opercular surface is featureless and smooth, but occasionally reflects the major external features.

The head is black; the rest of the animal is gray, the ventral foot and the verge being lighter. Tentacles are slender. Arising beneath the mantle collar behind the right tentacle, the verge is simple, compressed dorsoventrally, gradually tapers distally to a point, and lacks any secondary features such as papillae or glands. When relaxed the verge extends anteriorly then recurves posteriorly to the left over the neck; the penis is indistinguishable from the verge (Fig. 3)

The radula (Fig. 4) possesses the standard hydrobiid formula 2.1.1.1.2. There are about 65 rows of teeth. The central tooth arises from a broad base with four ectocones on each side of a larger mesocone, and with four basocones on each side of the anterior face. A rather rectangular projection extends slightly anteriorly from the lower face. The lateral teeth possess an extended, narrow shaft which bends outward about halfway along its length; the reflection contains four to six sharply pointed ectocones, four similarly pointed entocones, and a larger, blunt mesocone. A very large, bluntly pointed cusp projects infero-anteriorly from the lower face of the tooth. The marginal teeth curve gradually inward from the base, culminating in thirty to forty small, pointed cusps; the shaft of the inner marginal is slightly flanged.

The eggs are laid singly or in small, irregular clusters. The embryo is visible through a clear matrix, which occasionally is partially coated with the black deposit.

Dimensions: Holotype: 3.0 mm. in length, 2.9 mm. in greatest diameter; largest paratype (Yellow River): length 5.1 mm., diameter 4.6 mm.; smallest paratype (Alcovy River): length 1.5 mm., diameter 1.6 mm.

Type Localities: Holotype and paratypes are from Cedar Shoals in Yellow River about 1.0 km. S. of Porterdale, Newton County, Georgia. Additional paratypes are from Newton Factory Shoals in Alcovy River immediately above Jackson Lake in Newton County, Georgia. The species was named after its geographical location.

Type Depositories: From Yellow River: Holotype, Museum of Comparative Zoology, Harvard University No. 277838; twelve paratypes in each of the following: Harvard University No. 277839; U.S. National Museum, No. 701914; Florida State Museum, University of Florida, Gainesville, UF No. 21453; Delaware Mus. Nat. Hist. No. 41741. Additional paratypes from Alcovy River: Museum of Comparative Zoology, No. 277840; USNM No. 701915; UF No. 21454; Delaware Mus. Nat. Hist. No. 41742. All specimens were collected alive by the author.

Discussion: *Somatogyrus alcoviensis* possesses the prominent cusp projecting infero-anteriorly from the face of the lateral tooth upon which Walker (1909) primarily erected the genus *Clappia*. However, in few other respects does the present species resemble *Clappia*. Comparison with paratypes of *C. clappi* Walker 1909 (= *S. umbilicatus* Walker 1904; see Goodrich, 1944) and *C. cahabensis* Clench 1965 revealed that, while *S. alcoviensis* possesses an extremely reduced or entirely imperforate umbilicus, the umbilicus of *C. umbilicatus* and *C. cahabensis* is much larger and deep. In addition, *S. alcoviensis* presents a discontinuous columellar lip which is succeeded by a thin callus, although in *C. umbilicatus* and *C. cahabensis* the columellar lip is continuous and is attached to the body whorl only at its upper margin. Thus, the characteristics of the umbilicus and columellar lip preclude placing the present species within genus *Clappia*, because "In shell characters, *Clappia* differs from *Somatogyrus* in the conspicuous deep umbilicus, the straight, thin inner lip without any callus thickening, which is entirely separate from the body whorl, except for a very short distance at the upper extremity" (Walker, 1909).

The present species is assigned to genus *Somatogyrus* because it possesses shallow sutures, a white callus across the columellar mar-

gin of the aperture, and four basocones on each side of the central tooth of the radula (Thompson, 1968).

Somatogyrus alcoviensis is very similar to *S. (Walkerilla) tenax* recently described from Broad River, Elbert County, Georgia (Thompson, 1969), differing only in a more globose shell, more slender tentacles, somewhat lighter pigmentation, and a different number and arrangement of cusps on the teeth. The entire animal of *S. alcoviensis* is generally lighter in color than *S. tenax*; the mantle collar of *S. alcoviensis* remains light gray, although that of *S. tenax* is light grayish-orange. The central tooth of *S. alcoviensis* possesses four basocones and only four ectocones on each side, not three basocones or up to six ectocones on each side as in *S. tenax*. The lateral tooth bears four to six ectocones but only four entocones in *S. alcoviensis*, while in *S. tenax* there are either five or six ectocones and only three entocones. The marginal teeth possess about twice as many cusps as in *S. tenax*.

Ecology: *Somatogyrus alcoviensis* is restricted to shoals, where it crawls on boulders, gravel, and vegetation, being absent from silt and bottom sediments. Locally it may number in the thousands per square meter, particularly in the dense mats of *Podostemum ceratophyllum* (riverweed) which cover submerged rocks in rapid water. By its habits and radular form, *S. alcoviensis* probably is an *aufwuchs* and detritus feeder. It serves as food for the sunfish, *Lepomis* sp., and is closely associated with several other mollusks, including *Pisidium* sp., *Sphaerium fabalis*, *Elliptio hopetonensis*, *E. productus*, and *Oxytrema suturalis* (Krieger, 1969). The eggs are deposited on *Podostemum* stems and on the shells of living *Oxytrema* and *Somatogyrus*.

April and May 1970 collections of *S. alcoviensis* from Yellow River yielded specimens considerably larger (up to 5.1 mm. long, 4.6 mm. wide) than specimens collected concurrently from Alcovy River (up to 4.1 mm. long, 3.9 mm. wide), and larger than specimens collected at any other time from Yellow River (September 1968, January 1971). It was at this time, also, that eggs were obtained from the Yellow River population. Apparently *S. alcoviensis* is confined to a life cycle of only one year, rapidly attaining its greatest size in early spring and dying a few weeks after deposition of the eggs. Failure to obtain eggs or specimens of a similar size from Alcovy River may indicate a later chronology of the life

cycle due to different stream conditions, such as cooler temperatures, in Alcovy River. The pH and oxygen content of both localities, however, are extremely similar (Krieger, 1969). It is, of course, entirely possible that the *Somatogyrus* in Alcovy River reach maturity without attaining a comparable size due to genetic or environmental factors. In all other characteristics observed, both populations appear to be identical.

ACKNOWLEDGMENTS

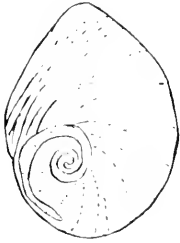
The author is grateful to Drs. W. D. and Madeline P. Burbank, Department of Biology, Emory University, for encouraging this study and for generously providing use of their facilities. Appreciation also is extended to Dr. James E. Sublette, Department of Biology, and to Dr. A. L. Gennaro, Curator, Natural History Museum, Eastern New Mexico University, as well as to the staff of the 27th Tactical Hospital, Cannon AFB, N. M., for the use of their facilities. Paratypes of *Clappia clappi* and *C. cahabensis* were loaned by Dr. Kenneth J. Boss, Museum of Comparative Zoology, Harvard University. Dr. Fred G. Thompson, Florida State Museum, University of Florida, reviewed the manuscript and contributed valuable information concerning the systematics of this species.

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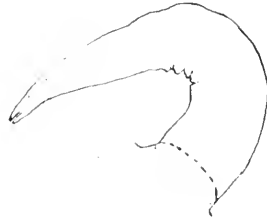
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Fig. 1. Views of two paratypes of *Somatogyrus alcoviensis* Krieger new species. Length 3.0 mm., greatest diameter 2.9 mm. (Delaware Museum Natural History, no. 41741).



2



3



4

Figs. 2-4. *Somatogyrus alcoviensis* Krieger, new species. Fig. 2. Outer surface of operculum. Fig. 3. Verge in relaxed position; broken line near base indicates the degree of dorsoventral compression. Fig. 4. Radula, frontal view: (l-r) central tooth, lateral tooth, inner and outer marginal teeth.

A SECOND OVOVIVIPAROUS *NASSARIUS*

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Nassarius muelleri (Maltzan, 1884), from West Africa has been known for some time to be ovoviviparous (Knudsen, 1956), but this reproductive process has not been shown in any other member of the genus. Two specimens of *Nassarius albus* (Say, 1826), (? *Buccinum ambiguum* Pulteney, 1799, non Solander, 1766) encountered during my current investigation of western Atlantic *Nassarius* disclosed this shallow water species to be ovoviparous, also.

A beach-drift specimen of *N. albus* (figure 2a) from Bermuda collected by Mr. Arthur Tucker Guest contained the dried animal. It had withdrawn so far into the shell that it was necessary to cut a small hole in the dorsal side of the shell to dislodge the remains. Six embryonic shells ranging from 1.2 to 1.5 mm in diameter were found within. Further probing produced the dried remains, including the radula, of the adult.

A second, slightly larger specimen (figure 2b) was collected alive by Dr. Emily Vokes in less than six inches of water during an extremely low tide in December, 1970, approximately 12 miles south of Champoton, Campeche, Mexico. This female, preserved in alcohol, carried 18 embryos as well as four incompletely devel-

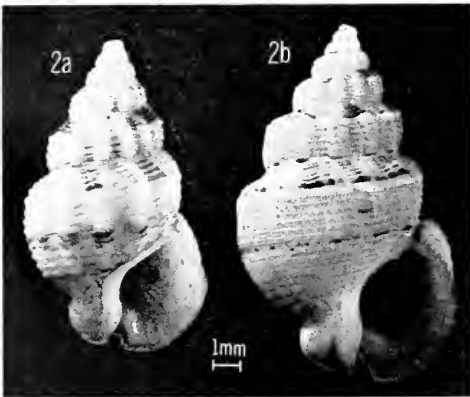
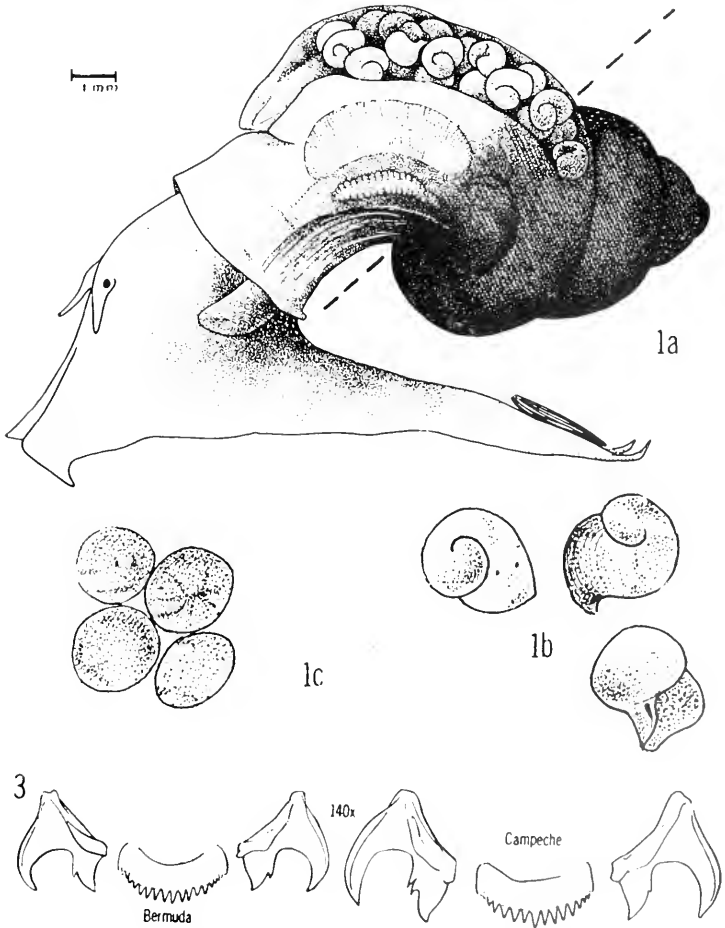


Fig. 2. Shells of female *Nassarius albus* (Say). 2a, from Bermuda. 2b, from Campeche, Mexico.

oped eggs. Although the soft parts broke as they were being extracted, enough remained intact to clearly show the embryos in the fragile oviduct (figure 1a). The embryos are about 1 mm in diameter and well-developed, with eyes clearly visible through the transparent shell (figure 1b). It seems possible that the four incompletely developed eggs (figure 1c) are undevoured nurse eggs.

The shells of the two specimens, collected from widely separated



Figs. 1 and 3. *Nassarius albus* (Say). Fig. 1a, soft parts of Bermuda female. 1b, embryos. 1c, incompletely developed eggs. Fig. 3a, radular row, from Bermuda. 3b, radular row from Campeche, Mexico.

localities, differ somewhat in form and sculpture, a common occurrence in this genus. Both fall within the range of shell variation I have observed for the species. The radulae (figure 3) are practically identical.

I am indebted to Mr. Arthur Tucker Guest of Crawl, Bermuda, and Dr. Emily Vokes of Tulane University for the specimens, and to Mr. William Lyons, Florida Department of Natural Resources Marine Laboratory, St. Petersburg, Florida, for his advice and friendly criticism during the preparation of this paper.

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GREGGELIX, A NEW GENUS OF AUTOCHTHONOUS LAND SNAILS (HELMINTHOGLYPTIDAE) FROM BAJA CALIFORNIA

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Helix löhrü Gabb, 1868, was described from a dead specimen (ANSP #58106) collected "from the higher table lands near Moleje" (i.e. Mulege of modern maps), Baja California Sur, Mexico; in accordance with Articles 27 and 32 (c) (i) of the International Code of Zoological Nomenclature (pp. 29, 35-36), the trivial name *löhrü* should be written *loehri* as will be done here.

Sonorella lohrii (sic) *lioderma* Pilsbry, 1904, was described from several dead specimens found "near Moleje, Lower California." Subsequently, Pilsbry (1916) raised *S. lioderma* to specific rank and figured the holotype. He then also synonymized *Helix steganella* Mabille, 1895, with "*Sonorella*" *loehri*. Other workers (G. D. Hanna and A. G. Smith, 1968) have placed *loehri* in the genus *Micrarionta* Ancy, 1880. However, thus far, the lack of data on the reproductive anatomy of *loehri* and *lioderma* has prevented their positive generic identification.

I am pleased to report that in December 1970, my son William Nixon Miller and I succeeded in collecting a large number of live *lioderma* specimens from two separate localities in San José Comondú and near La Purísima, Baja California Sur. Dissection

of these specimens reveals that they belong to a new genus of helminthoglyptids, described below. Their positive identification was made possible by comparison with two paratypes of *S. lioderma* kindly provided by the Academy of Natural Sciences of Philadelphia. A paratype of *lioderma* provided by the ANSP is shown in Plate I, along with the shell of one of my dissected specimens, #5313-X, from La Purísima. The holotype of *Helix loehri* Gabb (ANSP #58106) was also provided by the ANSP for examination; it had the characteristic granular sculpture of the body whorl as described for that species.

In 1966, G Dallas Hanna visited the Paris Muséum d'Histoire Naturelle and examined and photographed some of Mabille's types of Baja California mollusks. Based on his observations, he and Allyn G. Smith (1968) then concluded that *Micrarionta peninsularis* (Pilsbry, 1916) was a synonym of *Helix indigena* Mabille, 1895; that *Helix steganella* Mabille, 1895, and *H. invecta* Mabille, 1895, were synonyms of *Micrarionta lohrii* (sic) Gabb 1868); and that *Helix digueti* Mabille, 1895 was a *nomen inquirendum* because the type material was not found.

I subsequently visited the Paris Museum in August 1971, and Mr. Henry Chevallier kindly showed me Mabille's types exactly as they had been set aside for Hanna, with the addition of the types of *Helix digueti*. It was immediately apparent that *Helix indigena* Mabille, 1895, p. 64, *Helix digueti* Mabille, 1895, p. 65, and *Sonorella lioderma* Pilsbry, 1904, are all the same species, with the name *indigena* Mabille, having priority. *Helix invecta* Mabille, 1895, p. 65, and *Helix steganella* Mabille, 1895, pp. 64, 65, are very heavily granulated shells very close to *H. loehri* Gabb. However, in the type of *H. loehri*, the granulations are located on the radial striae whereas in *H. invecta* and *H. steganella* the granulations are so thick as to obliterate any underlying striation. I have several lots of specimens sent to me by Munroe Walton and collected in 1970 by Charlotte Church (née Walton) from localities near San Javier, near Loreto, which completely match the sculpture of *H. invecta* and *H. steganella* but not that of the type of *H. loehri*. At present, no population with the characteristic sculpture of *H. loehri* has been rediscovered.

Sonorelix peninsularis (Pilsbry) is not a synonym of *Helix indigena* Mabille, and is a perfectly valid name.

Pending the procurement of live animals of *H. loehri* and *H. invecta*, it is premature to speculate on the specific or subspecific standing of these names. It appears most probable, however, that they are congeneric with *indigena*, which I place in the new genus described below.

GREGGELIX W. B. MILLER, *gen. nov.*

Type species: *Greggelix indigena* (Mabille, 1895)

I am pleased to name this new genus in honor of Wendell O. Gregg, friend and colleague, who introduced me to the snails of the desert southwest.

Diagnosis: The new genus *Greggelix* is distinguished from other genera in the family Helminthoglyptidae by the following anatomical characteristics of the reproductive system: No dart, dart sac, or mucus glands; a short verge (penis papilla); a very long epiphallial caecum and a very long spermathecal diverticulum, each from nearly as long to decidedly longer than the spermathecal duct.

Description of the reproductive anatomy of the type species, *Greggelix indigena* (Mabille, 1895) (Figure 1) is as follows:

The penis is short and saccular, equipped with a short, bulbous somewhat spherical verge. The epiphallus is about twice as long as the penis. The extremely long epiphallial caecum is compressed into about twenty tight coils which first wind distally from the epiphallus, then double back proximally and finally reverse again with the distal end lying loosely, uncoiled, in the body cavity. The coils are held tightly together by a blood vessel and connective tissue. A penial retractor muscle inserts on the epiphallus about midway along its length and attaches to the floor of the lung near the mantle collar.

The vagina is about equal in length to the penis. The spermathecal duct lies uncoiled along the uterus-prostate complex bound by connective tissue. The spermatheca is located in its usual position for helminthoglyptids, namely just posterior of the ventricle, held tightly appressed by connective tissue and a loop of the anterior aorta. A very long spermathecal diverticulum originates near the proximal end of the spermathecal duct and lies bound against the uterus in loose coils, with its distal end just anterior of the albumin gland. The albumin gland, hermaphroditic duct, and ovotestes are typically helminthoglyptid.

All specimens #5313 are from La Purísima Canyon, in a lava

diverticulum is noticeably shorter than in the other specimens but rockslide 3.0 mi. east of San Isidro along the road to Canipole; specimen #5309 is from San José Comondú in a rockslide at the edge of town along the road to San Javier. It is to be noted that in one of the La Purisima specimens (5313-C) the spermathecal

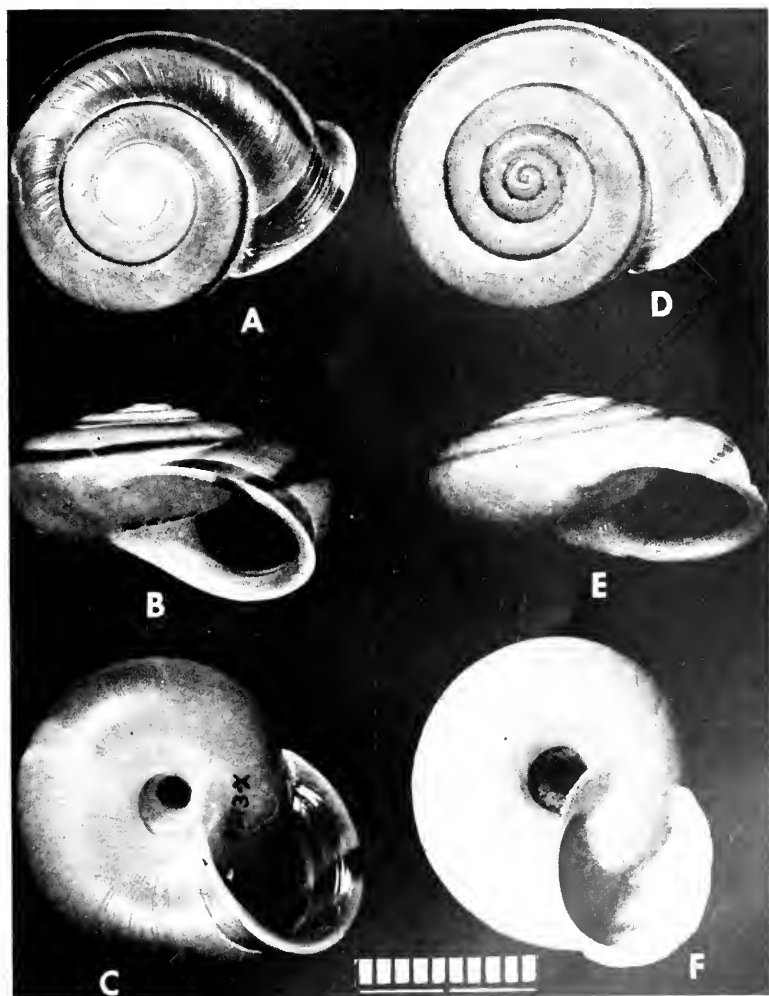
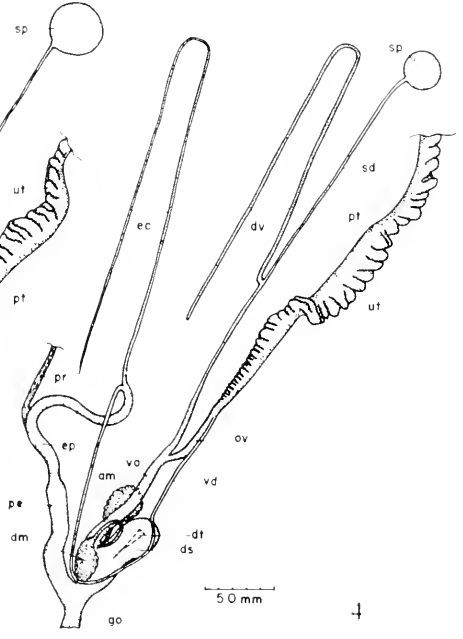
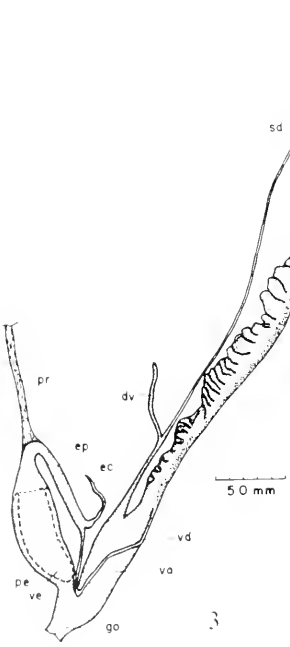
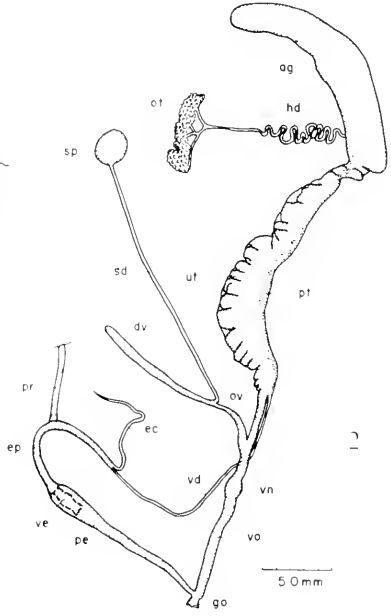
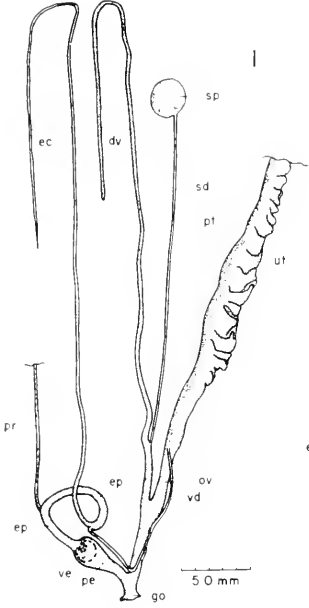


Plate 1. A—C. *Greggelix indigena* (Mabille), WBM #5313-X, La Purisima, Baja Calif. Sur. D—F. *Greggelix indigena* (Mabille) PARATYPE, ANSP #88367, "near Moleje, Lower California." Scale in mm.



Measurements (length) in mm:

	5313-X (Fig. 1)	5313-A	5313-B	5313-C	5309
Penis	4	4	4	3	5
Verge	1.5	1.1	1.0	1.0	1.0
Epiphallus	11	11	10	10	12
Ep. caecum	57	58	54	59	61
Vagina	5	5	4.5	5	5
Spermathecal duct	28	28	30	30	34
Sp. diverticulum	47	46	41	30	32

is still as long as the spermathecal duct. The San José Comondú specimen (5309) has a somewhat longer penis than found in the La Purísima specimens, while its spermathecal diverticulum is slightly shorter than the spermathecal duct. Since it was the only live adult from that locality, no conclusions can be reached on whether these differences are consistent and significant.

Live specimens of both Comondú and La Purísima populations had the mantle collar pigmented greenish-yellow in contrast to the usual orange of most *Sonorelix* and *Sonorella*. This pigmentation is not considered a generic characteristic, but it is usually consistent at the subspecific or specific level.

EXPLANATION TO OPPOSITE PAGE

Fig. 1. *Greggelix indigena* (Mabille, 1895). Lower genitalia. All drawings in figures 1-4 made from projection of stained whole mounts. Abbreviations used:

ag	albumin gland	ov	oviduct
am	ascending mucus gland	pe	penis
dm	descending mucus gland	pr	penial retractor
ds	dart sac	pt	prostate
dt	dart	sd	spermathecal duct
dv	spermathecal diverticulum	sp	spermatheca
ec	epiphallic caecum	ut	uterus
ep	epiphallus	va	vagina
go	genital orifice	vd	vas deferens
hd	hermaphroditic duct	ve	verge
ot	ovotestes	vn	vaginal node

Fig. 2. *Sonorelix (Sonorelix) borregoensis* (Berry, 1929). Genitalia. Fig. 3. *Sonorelix (Herpeteros) peninsularis* (Pilsbry, 1916). Lower genitalia. Fig. 4. *Micrarionta (Xerarionta) areolata* (Pfeiffer, 1845). Lower genitalia.

DISCUSSION

This genus appears to be most closely related to *Sonorelix* Berry, 1943, *Sonorella* Pilsbry, 1900, *Mohavelix* Berry, 1943, and *Tryonigens* Pilsbry, 1928, in that all of these genera have lost the dart apparatus. Direct phylogenetic relationship among these dart-less genera is not to be inferred, however, since evidence tends to indicate that the loss of the dart apparatus has occurred more than once in the evolution of the helminthoglyptids (Miller 1970).

In order to compare the reproductive anatomy of *Greggelix* with that of *Sonorelix*, drawings were prepared from stained whole mounts of the genitalia of *Sonorelix* (*Sonorelix*) *borregoensis* (Berry, 1929) (Fig. 2) and *Sonorelix* (*Herpeteros*) *peninsularis* (Pilsbry, 1916) (Fig. 3). It can be seen that in both subgenera of *Sonorelix* the epiphallic caecum and the spermathecal diverticulum are much shorter than the spermathecal duct. There are other salient differences. The verge of *S. (Herpeteros)* is relatively enormously large and bulbous, a characteristic of the subgenus (Berry, 1947) found not only in *S. (H.) peinsularis* but also in *S. (H.) angelus* Gregg, 1948 and *S. (H.) inglesiana* (Berry, 1928) not figured here). The penis and vagina of *Sonorelix* s. s. are both unusually long and a muscular vaginal node is present; this is the case not only in *S. (S.) borregoensis* but also in *S. (S.) rixfordi* (Pilsbry, 1919), *S. (S.) melanopylon* (Berry, 1930) and *S. (S.) awawatzica eremita* (Pilsbry, 1939) all of which were also examined but not figured. Whether *Sonorelix* s. s. and *Sonorelix (Herpeteros)* are truly congeneric remains to be determined.

It is interesting to note that the unusually long epiphallic caecum and spermathecal diverticulum of *Greggelix* are found elsewhere only in certain species of *Helminthoglypta* and in *Micrarionta (Xerarionta)* (Fig. 4). A prolific population of *M. (X.) areolata* (Pfeiffer, 1845) occurs all along the Magdalena Plain of Baja California Sur, separated from the Comondú Canyon population of *Greggelix* by not more than ten miles. While one cannot infer phylogeny simply on size of spermathecal diverticulum and epiphallic caecum or on geographical proximity, it is tempting to hypothesize an ancestral *Xerarionta* population attempting to survive an increasingly drier climate in the rockslides of the Sierra de la Giganta and losing the dart apparatus through genetic drift and saltational speciation (Miller, 1970). An extensive survey of

chromosome numbers and karyotypes of many of the helminthoglyptid genera and subgenera has now been undertaken by Noor-ullah Babrakzai at the University of Arizona and it is possible that this will yield information useful in determining phylogeny more precisely.

ACKNOWLEDGMENTS

I wish to thank the following for invaluable assistance in the preparation of this article: The Academy of Natural Sciences of Philadelphia for the loan of the holotype of *Helix loehri* and two paratypes of *Sonorella lioderma*; Mr. Henry Chevallier, Paris Muséum d'Histoire Naturelle, for making available Mabile's types of *Helix indigena*, *H. digueti*, *H. steganella*, and *H. invecta*; Dr. W. O. Gregg for the loan of whole mounts of several species of *Sonorelix* s. s.; Munroe Walton and his daughter Charlotte Church for several lots of *Greggelix* shells from many localities in Baja California Sur; my laboratory assistant, Laura Emmett, for photographs of the borrowed types; my son, Nick, for his assistance and fantastic collector's "luck" in obtaining live specimens; and Dr. J. C. Bequaert for his steady encouragement and criticism of this article.

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SHELL GROWTH IN THE GASTROPOD *LITTORINA IRRORATA*

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Littorina irrorata (Say, 1822), a rather globose, light gray snail known as the Salt Marsh Periwinkle, is common in the salt marshes from New York to the Rio Grande River, excluding those of southern Florida. Presented here are observations on several characteristics of the shell of *L. irrorata*. Behavior of the species has been treated in a separate article (in press).

GROWTH

Several hundred specimens of *L. irrorata* of various lengths were collected at random from a salt marsh near Panama City, Florida, and sorted into size classes. Four of the classes were replaced in the marsh on March 8, 1969, and collected five months later on August 9, 1969. The classes were handled somewhat differently in order to prevent breakage of smaller shells and the space requirements of the large snails. Separate plastic screen cages were used to retain classes 1 and 2 (Figure 1). The exterior surface of the shell lip of each specimen in class 3 was painted with white enamel. A notch filed in the shell lip was used in the determination of growth in class 4 (Figure 2). All measurements were made with vernier calipers accurate to 0.1 mm. The data on the four size classes of snails are presented in figure 3.

It may be taken from figure 3 that as the snails increase in size, a smaller percentage increase and a larger actual increase in length

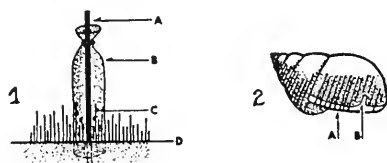


Fig. 1. Growth cage situated in salt marsh. A—wooden stake; B—plastic screen cage; C—specimens; D—marsh floor. Fig. 2. Recaptured specimen from class 4. A—shell added during study; B—filed notch.

is effected. See figures 4 and 5 for graphic representations.

The present study was carried out entirely during the warmer months of the year and so no data are available on growth during the winter. The length of time required for an individual to approach its maximum size may, then, only be estimated. If the growth rate in the winter is similar to that in the summer, which may very well be the case as no distinct growth lines appear on the shells before maximum size is approached, the growth increments of size classes 1, 2, and 3 may be combined to form a hypothetical growth curve. Such a curve (Figure 6) indicates that the snails could approach maximum size in 20 months. Sexual maturity is reached before this time as will be discussed in another paper.

GEOGRAPHIC VARIATION

Bequaert (1943) wrote of *L. irrorata*, "It is remarkably uniform throughout its range, in shape as well as in color."

The inspection of nine groups of 50 specimens each taken from Corpus Christi, Texas, to Beaufort, North Carolina, confirms Bequaert's statement, as no differences in color, and only minor ones in shell shape and number of body whorl ridges were noted from area to area (Figure 7).

SEXUAL DIMORPHISM

Several hundred large specimens were collected in the salt marsh and measured with vernier calipers for shell length. Fifty-nine specimens measured between 19.1 and 19.5 mm. Of these, 33 or

Size Class	No. of Specimens	Mode of Handling	Original average length (mm)	Final average length (mm)	% increase in length	Increase in length (mm)
1	29	Not marked, retained in plastic screen cage	4.3	8.0	86	3.7
2	48	Not marked, retained in plastic screen cage	7.2	12.4	72	5.2
3	42 Released 36 Recaptured	Marked with enamel, released in marsh	11.2	17.5	56	6.3
4	50 Released 39 Recaptured	Marked with enamel, shell lip notched, released in marsh	18.0	18.1	3.9	.7

Fig. 3. Growth in shell length of *L. irrorata*.

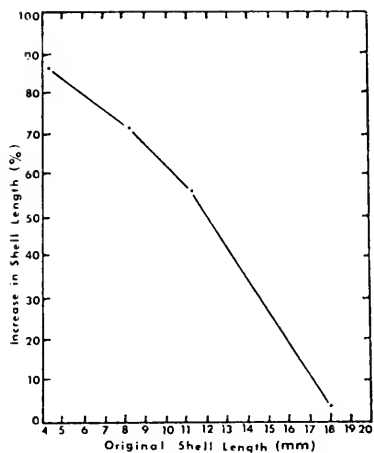


Fig. 4. Increase in shell length in *L. irrorata* (%) March-August.

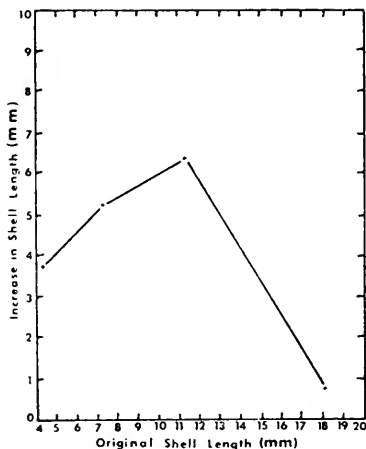


Fig. 5. Increase in shell length in *L. irrorata* (mm) March-August.

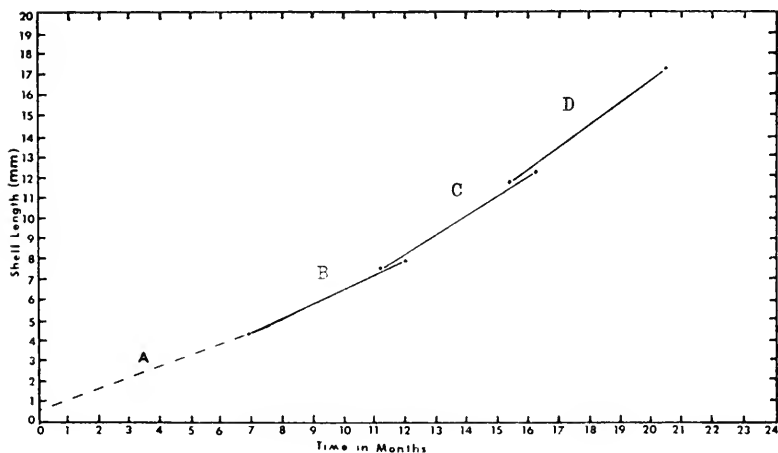


Fig. 6. Hypothetical growth curve for *L. irrorata*.
 A—extrapolation; B—increase in length, class 1; C—increase in length, class 2;
 D—increase in length, class 3.

56% were females. Thirty-nine specimens measured between 19.6 and 20.0 mm and 28 or 72% of these were females. Forty-three specimens measured between 20.1 and 20.5 mm. Of these, 27 or 63% were females. Nine specimens were longer than 20.6 mm. All of these were females.

Sexual dimorphism of shell size, with the female being larger than the male, has been observed in several other species of *Littorina* (e.g. Moore, 1937, in *Littorina littorea* (Linné); Linderking, 1951, in *Littorina angulifera* (Lamarck); Struhsaker, 1966, in *Littorina pintado* (Wood); *Littorina picta* (Philippi) and *Littorina scabra* (Linné)). The size difference is not related to protrandry and is thought by Moore (1937) and Linderking (1951) to be a consequence of a faster growth rate which they found in females.

PHENOTYPIC CHARACTERS

The anterior region of the shell lip of *L. irrorata* collected in the salt marsh was noted to possess an indentation (Figure 9) not seen in other species of *Littorina* observed by the author, and not men-

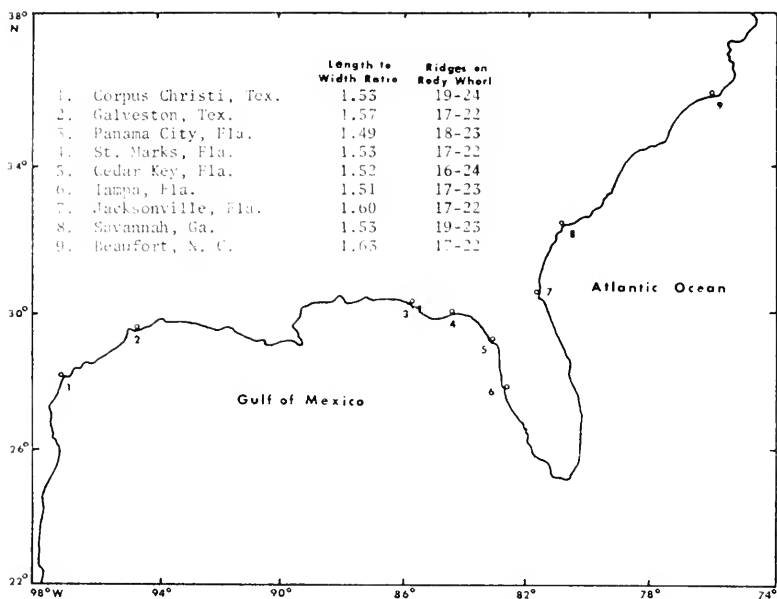


Fig. 7. Variation in shell morphology of *L. irrorata* in southeast Atlantic and Gulf states.

tioned by Bequaert (1943) in his thorough description of the shell. On the other hand, a large group of the species not showing the indentation was found living on limestone boulders near St. Marks, Florida. Fifty juvenile specimens from this group were collected and marked with white enamel on the shell lip and shortly thereafter released in the salt marsh. Fifty specimens from the marsh were marked in the same manner, released on the limestone boulders and subsequently lost during a storm. After five months growth, 41 of the specimens were recaptured in the marsh and observed for changes in lip contour. All 41 of the recovered animals, which five months earlier had possessed no indentation, possessed one upon recapture (Figure 9). Since specimens of all sizes in the salt marsh exhibit the indentation and since specimens not exhibiting the indentation develop one soon after being transferred to the salt marsh, the indentation of the shell lip is an environmentally induced character rather than a genetic one.

The portion of the shell lip at which the indentation occurs is that at which the snail is often attached to the rounded leaves of the marsh grass, *Juncus roemarianus*. The mantle is not extended when the snails are attached to the grass, so no special restriction on the laying down of new shell exists in the area of attachment. Abrasion of fragile newly laid down shell at this point by the grass, therefore, is possibly responsible for the indentation.

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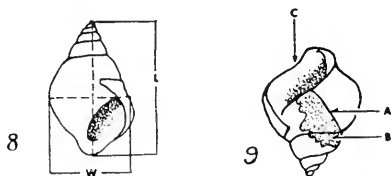


Fig. 8. Dimensions used in length-width ratio computations. L—length; W—width. Fig. 9. Specimen removed from limestone boulder and placed in the marsh for five months. A—edge of shell lip when removed from Limestone Boulder; B—paint; C—shell lip indentation.

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A MOLLUSK NEW TO LAKE BIRKET QARUN, EGYPT

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Birket Qarun is a large brackish-water lake situated in the Fayum Depression on the eastern edge of the Sahara Desert, about sixty miles southwest of Cairo, Egypt. The modern lake is about 25 miles long and four miles wide, but in Pliocene and Pleistocene times it apparently covered a much greater area. The lake has been steadily diminishing in size since its formation (probably in the late Miocene), causing increasing salinity which has resulted in the current brackish state. Although there is some doubt as to how the lake was formed, there clearly has been no connection with the sea in recent geologic time. Birket Qarun is very shallow, nowhere reaching a depth of more than six meters. Its surface is about 45 meters below sea level.

The molluscan fauna is noticeably limited in diversity, although not at all in absolute numbers. Blanckenhorn (1901) was one of the first to mention the lake itself. In his review of Egyptian geology and paleontology he listed eight mollusk species found there. E. A. Smith (1908), however, was the first to describe the Birket Qarun mollusks, listing nine gastropod species and two pelecypods. His gastropod list included all those published later by Gardner (1932) except for two species of *Planorbis*. The two pelecypods recorded by Smith are both species of *Corbicula*. All eleven forms, as noted by Smith, are typical lacustrine or fluviatile (Nilotic) forms. Pallary (1909, 1924) surveyed the entire Egyptian molluscan fauna, discussing many of the species found in the lake; however, he found no additions to the fauna.

Less than twenty years after Smith's publication, Gardner (1937) reported the discovery of two species previously unknown in Birket

Qarun. There were the pelecypods *Scrobicularia cottardi* (Payraudeau) and a variety of *Cardium edule* Linné. Neither species had been found in any of the older Fayum lake beds, or in any of the recent lakes or streams of the area. Even more significantly, neither species had been recorded by Blanckenhorn or Smith. Considering the abundance of these two forms, especially *Cardium edule*, it is very improbable that they could have been overlooked by the earlier workers. Both are brackish Mediterranean forms, and the only suitable explanation for their sudden appearance is that they were introduced to the lake as eggs or tiny young carried in mud on the feet of shore birds. Blanckenhorn was the first to suggest this method of introduction (in reference to the gastropod *Hydrobia peraudieri* Bourguignat), and Gardner (1927, 1932) supported this hypothesis.

The most comprehensive study of the Fayum mollusks (and the most recent known to this author) was published by Gardner in 1932. Fifteen species, including four pelecypods and eleven gastropods, were reported from Birket Qarun (those preceded by an asterisk were also recorded by E. A. Smith in 1908):

- Cardium edule* Linné, 1758
- **Corbicula africana* Krauss, 1848
- **Corbicula consobrina* (Cailliaud), 1827
- Scrobicularia cottardi* Payraudeau, 1826
- **Bulinus truncatus* (Audouin), 1827
- **Cleopatra bulimoides* (Oliver), 1804
- **Hydrobia peraudieri* Bourguignat, 1862
- **Lanistes carinatus* (Olivier), 1804
- **Melanoides tuberculatus* (Müller), 1774
- **Planorbis ehrenbergi* Beck, 1837
- Planorbis mareoticus* (Letourneux), 1884
- Planorbis planorbis* (Linné), 1758
- **Theodoxus niloticus* (Reeve), 1841
- **Valvata nilotica* Jickeli, 1874
- **Viviparus unicolor* (Oliver), 1804

Recently (November 1968 through January 1969), this writer had the opportunity to study the molluscan fauna of Birket Qarun. My survey resulted in the new record of *Pirenella conica* (Blain-

ville, 1829), (Potamididae, Cerithiacea), a form which was conspicuously absent from previous faunal lists. This species is now the commonest gastropod in the lake. Together with *Cardium edule* and *Hydrobia peraudieri*, this snail forms thick shell banks all along the southern shore of Birket Qarun. *Pirenella conica*, a typical Mediterranean brackish form, has been discovered in many north African brackish lakes. Like the two species discovered by Gardner (1927), is it highly doubtful that it could have been overlooked by previous students; therefore, it must have been introduced since the last faunal study (1932), also possibly by birds.

It is significant to note that *Cardium edule* is at least as successful today as when Gardner first recorded its presence. Furthermore, it is by far the commonest molluscan species in the lake. All specimens observed were noticeably small and thin-shelled as compared to typical Mediterranean specimens. This would be expected in an environment of low salinity. Many individuals were pale-yellow in color.

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NOTES

RECORDS OF INTRODUCED MOLLUSKS: NEW MEXICO AND WESTERN TEXAS—The mollusks reported are judged to have become established as a result of introductions by man. Specimens have been placed in collections of the U.S. National Museum. *Anodonta grandis* Say. (USNM 681635—cataloged as *A. stewartiana* Lea). This mussel was collected in a pond in the western part of the city of El Paso, El Paso County, Texas, in 1968 and 1971. The pond is locally known as "Cement Lake" and belongs to the Southwestern Portland Cement Company. It was constructed in 1910. Although water is sometimes pumped into the pond from the Rio Grande, establishment of the mussels from this source seems unlikely because (1) nearest records known from the Rio Grande drainage are about 700 miles to the southeast in the lowermost part of the system, (2) usually the Rio Grande is dry or merely a trickle between El Paso and Presidio, Texas, seemingly precluding establishment of permanent populations of unionid mussels in that section of the river and (3) no unionids of any kind, either fossil or living, have been seen by us or have been reported from the Rio Grande drainage above Presidio. We conclude, therefore, that this population has probably resulted from stocking with fish that bore the glochidia. According to Mr. O. P. Kroeger, Plant Superintendent (written comm., Feb. 22, 1971) "During the 1930's the lake was stocked with fish: Cat, Bass, Perch, etc., by a local group as a private fishing club." Taylor (1966. Veliger, 8:198) suggested that occurrence of an *Anodonta* in a lake in Arizona had resulted from glochidia carried by fishes. He noted that in western states ". . . this is the only known case in which a mussel has been introduced along with the fishes."

Specimens have low umbones and a slightly sinuous hinge line, lacking the inflated umbonal area and the straighter hinge line of *Anodonta stewartiana* Lea, which occurs to the east in central Texas.

Corbicula fluminea (Müller). Identification is by Dr. J. P. E. Morrison, U.S. National Museum. This clam was reported as *Corbicula manilensis* Philippi by Metcalf (1966. The Nautilus, 80: 16-20). At that time the clam was known only from two irrigation drainage ditches in the Mesilla Valley of Doña Ana County, New Mexico, and El Paso County, Texas. In subsequent years it has spread northward into Sierra County, New Mexico, where it occurs in the Rio Grande and in two of its impoundments, Elephant

Butte and Caballo Reservoirs. Seemingly dispersal of the clam into these waters has taken place in the years 1966-1970, as it was not observed there during surveys made between 1963 and 1965. (USNM 706608, Elephant Butte Reservoir; USNM 706607, Caballo Reservoir; USNM 706606, Rio Grande at Percha Diversion Dam, 5 mi. S Caballo Reservoir Dam).

Radix auricularia (L.) *s.l.* Specimens of this Palearctic lymnaeid snail have been taken in Lake Roberts on the Gila River, Grant County, New Mexico, by Carl Olsen in 1966 (USNM 706609) and from a ranch pond, located eight miles southeast of Deming, Luna County, New Mexico, by Kay S. Samson and G. I. Wilson in 1970 (USNM 706610). USNM specimens are cataloged as *Radix japonica* Say.—Artie L. Metcalf and Richard Smartt, Department of Biology, The University of Texas at El Paso, El Paso, Texas 79968.

CORBICULA MANILENSIS (PHILIPPI) IN OKLAHOMA.—This species has been found recently in Lake Overholser near Bethany, Oklahoma City. The specimens were collected by Mrs. Louise Cassel on August 25, 1969, and she stated in her letter that “the little clam variety seems to be new to Lake Overholser.”—William J. Clench, 26 Rowena St., Dorchester, Mass. 02124.

THE TYPE LOCALITY OF STAGNICOLA MONTANENSIS (BAKER) 1913—This species was described from “Hayes Creek, near Ward, Montana, altitude 3825 feet. . . . collected by Mr. L. E. Daniels in April, 1912” (F. C. Baker, 1913, *The Nautilus*, 27: 115-116). No town of Ward now exists, but by making local inquiry it was learned that shortly after the turn of the century (circa 1910) there was a post office by that name seven miles south of Hamilton, Ravalli County, Montana. The old brick building is still standing approximately one-half mile north of the Jim Ward Ranch on Hayes Creek. This ranch (at an elevation of 3780 feet) is located at the middle of the south $\frac{1}{2}$ of sec. 3, T.4N., R.21W. (U.S.G.S. Topographic Sheet N4607.5, Hamilton South Quadrangle, 1:24,000, 1964). Taylor, et al. (1962, *Malacologia*, 1(2): 240) were correct in suggesting that this area most likely represents Daniels' type locality for this snail. *Stagnicola montanensis* has been found in abundance in the boggy, spring-seepage areas on both sides of Hayes Creek near and above this ranch.—Richard H. Russell, Department of Biological Sciences, University of Arizona, Tucson, Arizona 85721.

REPRODUCTION OF *AMBLEMA COSTATA* (RAFINESQUE) IN MOOSE RIVER, MINNESOTA—Dennis 1971:86) states that *Amblema costata* (Rafinesque) “is often found in coarse gravel in strong currents seldom in silt or mud.” Many specimens of this species were found in Moose River, Minnesota near the town of Sturgeon Lake. Large adults, at least 15 years of age, were found in a strictly soft, thick, mud substrate. This rather different habitat for the species from that indicated by Dennis might be explained by host-fish dispersal patterns. Such an explanation is encouraged by the following observations which indicate that the Moose River population depends on very occasional good year-classes of shed glochidial mussel larvae from fish: On November 3, 1969, 31 juvenile *Amblema costata* were collected with a scraper net with a mesh fine enough to include one-year-old mussels. All of these specimens were 2-year-old *Amblema costata*. There were no younger or older *Amblema costata* (other than the adults). A year later a similar collection turned up only 3-year-old *Amblema costata* juveniles. Juveniles of other species in the same bottom varied in age from 1-6 or more years, thus indicating that the chance dispersal of host-specific fish rather than change in bottom conditions from year to year was responsible for the presence of just one year-class of *Amblema costata*. All of the juveniles collected were donated to the Ohio State Museum, Columbus, Ohio for investigators who wish to examine this problem in further detail.—Marc J. Imlay, National Water Quality Lab., Environmental Protection Agency, Duluth, Minn. 55804.

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NEWS

THE AMERICAN MALACOLOGICAL UNION's 38th annual meeting will be held in Galveston, Texas, from July 9 through July 14, 1972. President Arthur Merrill promises an interesting meeting that will be hosted by the Galveston Shell Club. AMU members will be sent registration information in a few weeks. Others may obtain details from Mrs. Katy W. Fowler, Titus Harris Clinic, 200 University Boulevard, Galveston, Texas 77550.

DR. JOHN TENG-CHIEN YEN, paleontologist, died in Villanova, Pa., on February 4, 1972, at the age of 68. He had suffered a stroke a few years previously. He was born in Canton, China, on February 15, 1903. He received his B.Sc. at the National University of Nanking, and his Ph.D. from Berlin University in 1939. He published on Chinese mollusks and on Mesozoic and Tertiary invertebrates. Dr. Yen taught geology at Villanova University, Pa., from 1956 to 1966.

THE COLLECTION OF KARL MAYER-EYMAR.—Karl Mayer-Eymar, stratigrapher and paleontologist, published numerous papers, mainly on fossil mollusks, from 1853 until 1906. Many of his articles are based on material he collected himself during his extensive travels through Europe and Egypt, or on material that was sent to him for identification and age assignment. Thus Mayer-Eymar assembled large collections of Tertiary mollusks during his long career. He is the author of several stage names of the European Tertiary, and he described more than a thousand new species. Therefore his collections contain the mollusk faunas upon which those stages were based and numerous type specimens.

The collections of Mayer-Eymar used to be housed at the Department of Geology of the Eidgenössische Technische Hochschule in Zürich. It may be of interest to paleontologists dealing with Tertiary mollusks to know that these collections are now deposited at the Naturhistorisches Museum Basel, by which institution they are also administered.—Peter Jung, Naturhistorisches Museum, Augustinergasse 2, 4051 Basel, Switzerland.

DR. LEO G. HERTLEIN, Curator Emeritus of Geology at the California Academy of Sciences, died on January 15, 1972, following a very brief illness. Biographical information was published in vol. 84, no. 2, of *The Nautilus* (October 1970).

THE HALL OF SHELLS, consisting of thirty exhibits on mollusks, at the Delaware Museum of Natural History, Kennett Pike, route 52, 6 miles north of Wilmington, will open to the public on May 13, 1972.

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