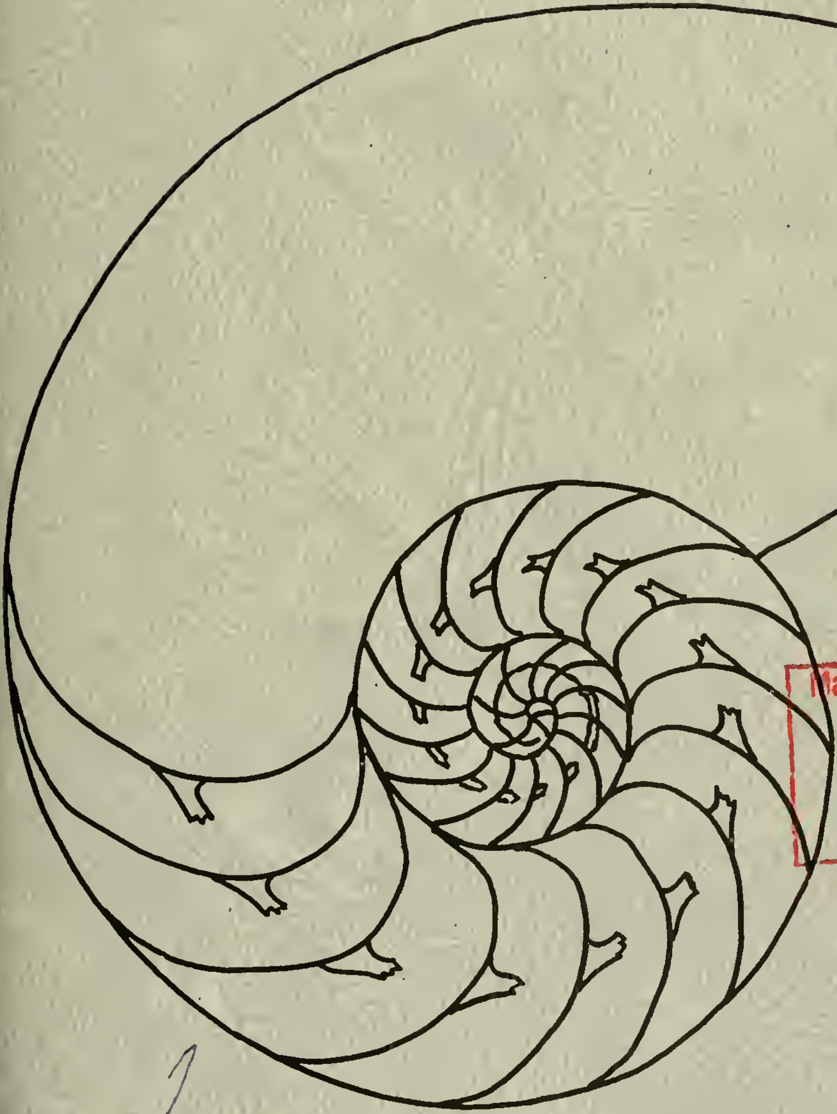
JANUARY, 1973

THE NAUTILUS

Vol. 87

No. 1

A quarterly
devoted to
malacology and
the interests of
conchologists



Founded 1889 by Henry A. Pilsbry. Continued by H. Burrington Baker.
Editors: *R. Tucker Abbott and Charles B. Wurtz*

EDITORIAL COMMITTEE

CONSULTING EDITORS

EDITORS

OFFICE OF PUBLICATION
Delaware Museum of Natural History
Kennett Pike, Route 52
Box 3937, Greenville, Delaware 19807

Second Class Postage paid at Wilmington, Delaware

Subscription Price: $7.00 (see inside back cover)

THE

NAUTILUS

Volume 87, number 1 -- January 1973

CONTENTS

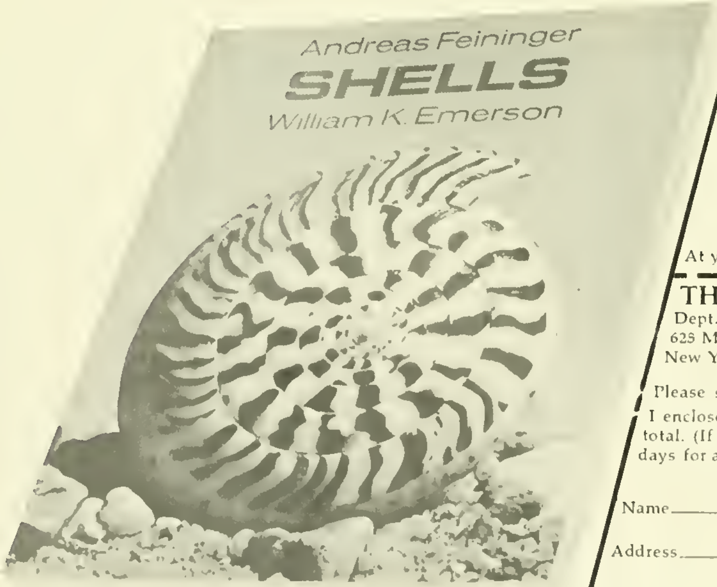
STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (Required by) Act of October 23, 1962: Section 4396. Title 39. United States Code, and postal regulation 132-622.

1. Title of publication: THE NAUTILUS.
2. Date of filing, September 25, 1972.
3. Frequency of issue: Quarterly (4 per year).
4. Location of known office of publication: Delaware Museum of Natural History, Kennett Pike, Box 3937, Greenville, De. 19807.
5. Location of the Headquarters or General Business Offices of the Publishers: Delaware Museum of Natural History, Kennett Pike, Box 3937, Greenville, De. 19807.
6. Names and addresses of publisher, editor, and managing editor: Publisher, Mrs. Horace Burrington Baker, 11 Chelten Rd., Havertown, Pa. 19083. Editor, R. Tucker Abbott, Delaware Museum of Natural History, Box 3937, Greenville, De. 19807. Managing editor, none.
7. Owner: Mrs. Horace Burrington Baker, 11 Chelten Rd., Havertown, Pa. 19803.
8. Known bondholders, mortgages, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities: none.
9. Extent and Nature of Circulation:

	Average 12 Mos.	Single Issue
A. Total No. Copies Printed (Net Press Run)	1,000	1,000
B. Paid Circulation		
1. Sales through dealers and carriers, street vendors and counter sales	none	none
2. Mail subscriptions	594	596
C. Total Paid Circulation	594	596
D. Free Distribution (including samples) by mail, carrier or other means	14	14
E. Total Distribution (Sum of C & D)	608	610
F. Office use, left-over, unaccounted and back start subscription copies	392	390
G. Total (Sum of E & F) - should equal net press run shown in A.	1,000	1,000

I certify that the statements made by me above are correct and complete.

(signed) R. Tucker Abbott, Editor



NOTES ON THE DEVELOPMENT OF *COLUS STIMPSONI* (PROSOBRANCHIA: BUCCINIDAE)[1]

David L. West
Marine Science Institute
Northeastern University
Nahant, Mass. 01908

ABSTRACT

The buccinid whelk of New England, Colus stimpsoni *(Mörch), feeds on the snails,* Littorina littorea *(Linné) and* Polinices heros *(Say), and occasionally on damaged bivalves. In the laboratory,* C. stimpsoni *lays single capsules on rocks, each containing 4,000 - 5,500 eggs, but with only 1 to 8 eventually developing into young snails. During five years of observations, capsule-laying occurred from February to May. Development to a shell length of 5 to 8 mm. takes 5 to 6 months.*

Colus stimpsoni (Mörch, 1867) ranges from Maine to North Carolina along the Atlantic coast, and occurs intertidally in its northernmost range. For the past 5 years, a population of *C. stimpsoni* has been maintained at the Marine Science Institute. The original population and subsequent additions were collected intertidally at Cobscook Bay State Park, Edmunds, Maine and at Eastport, Maine. A few observations on the larval development are herein described.

Littorina littorea (L.) serves as a food item in the field and is used to maintain *C. stimpsoni* in the laboratory as recorded by Riser (1969). However, it will feed as well on *Polinices heros* (Say). The behavior of *Colus* while feeding on *P. heros* is the same as for *L. littorea* (for description see Riser, 1969). However, there is one important additional condition. When *P. heros* is moving about and has its metapodium extended, *Colus* cannot attack. The predator cannot gain purchase when the prey's metapodium is extended over the shell. *C. stimpsoni* has also been observed to feed on damaged bivalves and, on one occasion, upon a molting hermit crab. Smaller snails (less than 7 cm.) have also been observed to feed on dead, gaping *Mercenaria mercenaria* (L.) In the laboratory the smaller snails will feed also on the deposited egg capsules of its own species. Crowded conditions in the aquaria may lend to this behavior. Thorson (1935) suggested that the capsules of *Colus (=Sipho) curtus* (Jeffreys) were attacked by various *Natica* in East Greenland. However, it is possible that the capsules were preyed upon by small *Colus.*

In the laboratory, *C. stimpsoni* deposits egg capsules throughout the year with increased deposition from February to May. Capsule-laying can be stimulated by periods of starvation followed by abundant food (similarly reported for *Thais* by D'Asaro, 1966). Capsules are laid singly and attached to rocks, the sides of aquaria, and occasionally on the shells of living *C. stimpsoni.* Each capsule contains approximately 4,000 to 5,500 eggs.

In surface view, the capsules (Fig. 1) are circular to oval (10 - 16 mm. diameter) and, in side view, are subhemispherical (4 - 8 mm. in height). The capsule operculum (exit hole) is fusiform and measures 4-5 mm. in long axis and 3-4 mm. in short axis. When the capsule is viewed from the side, the operculum is situated 1/3 - 2/3 the distance from the base to the apex. Capsules are whitish hyaline in appearance with a yellow central portion containing the eggs. The capsule surface is slightly undulated with irregular striations. These egg capsules appear very similar to those of *Colus (=Sipho) islandicus* (Gmelin) figured by Thorson (1935: 14, Fig. 5). In cross section the capsule wall is composed of 3 differentially staining layers and appears similar to the capsule wall of *Urosalpinx cinerea* (Say) described by Tamarin and Carriker (1968).

Individual eggs measure 180-190 μ in diameter and are densely packed with large yolk granules.

The number of young snails which develop in a capsule varies from 1 to 8 (occasionally none) with an average of 4. The remaining eggs serve as food for the developing young. There is apparently no relation between the size of the capsule and the number of snails

---

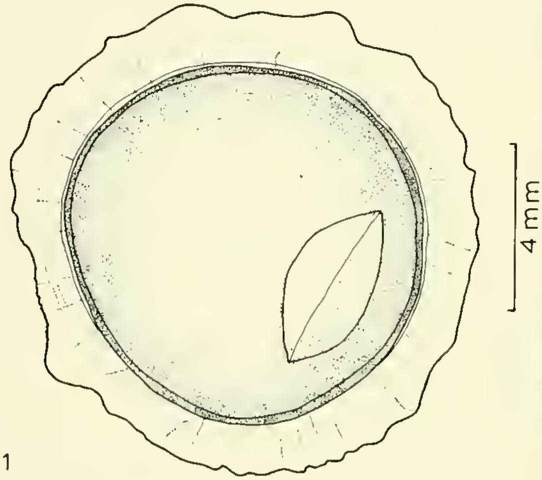
[1] Contribution number 18 from the Marine Science Institute.

which develop. The largest capsules do not always contain the largest numbers of developing young.

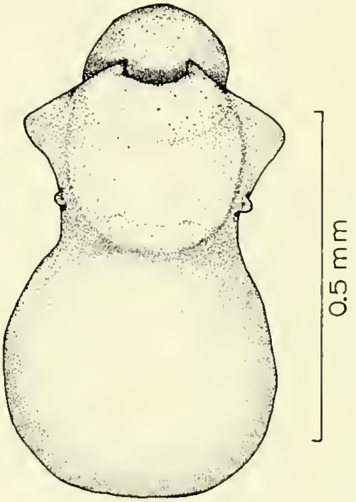
The first indication of embryos (which are young veligers) within a capsule still attached to the substrate is what appears to be an enlarged egg, 15-20 days after capsule deposition. The early veliger (figs. 2 & 3), after washing free from the surrounding eggs and albumin, measure 700-800 μ in length and 400-500 μ across the head vesicle and foot. The velum is small with the larval kidneys situated slightly ventral and near the junction of the velum and visceral mass.

As the veliger continues to ingest the nurse eggs, the visceral mass increases in size at a rapid rate. The head vesicle and foot enlarge slightly, and the velum expands laterally (figs. 4 & 5).

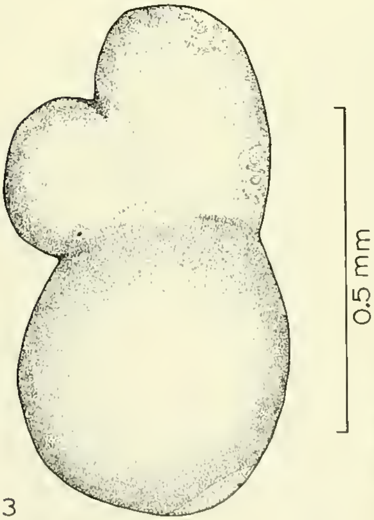
Development is usually delayed at this stage until all nurse eggs are ingested. However, this is variable depending on the number of larvae per capsule and the size of the capsule. In a large capsule with 4 veligers, development will continue before all nurse eggs are consumed; whereas, in a small capsule with 4 veligers, all nurse eggs will be consumed before development proceeds. The veligers may remain in this



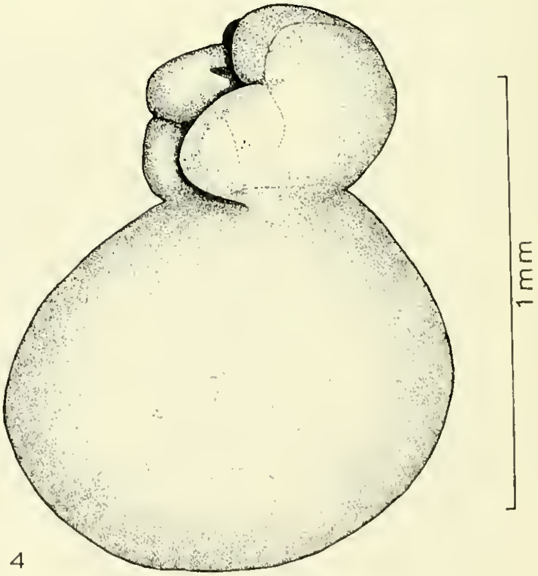
1



2



3



4

Fig. 1. Egg capsule of Colus stimpsoni.
Fig. 2. Early veliger, ventral view.

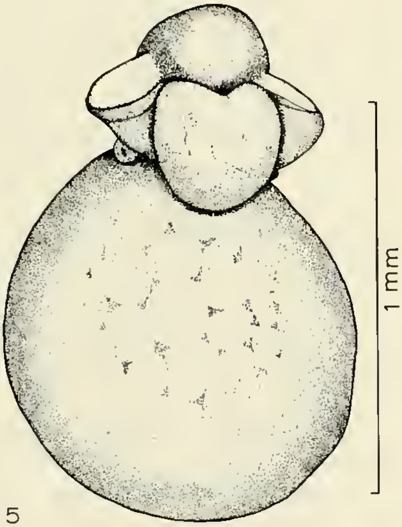
Fig. 3. Early veliger, lateral view.
Fig. 4. Late veliger, lateral view.

stage for 3 to 5 weeks, depending upon temperature and the relative number of nurse eggs.

As development continues, whether all nurse eggs are ingested or not, the velum and head vesicle enlarge, and the teloconch is laid down. The body begins to coil, and the mantle cavity enlarges (figs. 6 & 7). The foot is relatively small, and there is no apparent operculum at this stage. The digestive gland also begins to differentiate at this stage. The ingested nurse eggs can be seen through the shell.

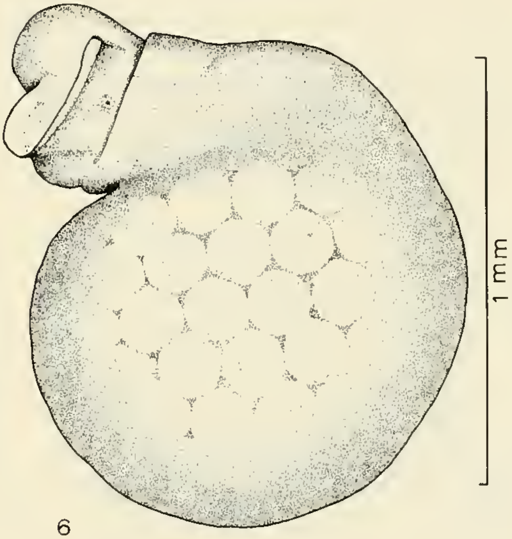
As the foot develops and the operculum is laid down, the velum enlarges laterally (fig. 8). The head vesicle does not increase and appears relatively small. The tentacles appear as small buds at the junction of the velum and head vesicle and the body cannot be retracted into the shell at this stage.

Development is completed when 2½ - 3 whorls are formed. The protoconch is cast off just before or shortly after the velum disappears. The apex of the shell has a slight indentation where the protoconch was (see fig. 10). All nurse eggs are consumed before development is completed.



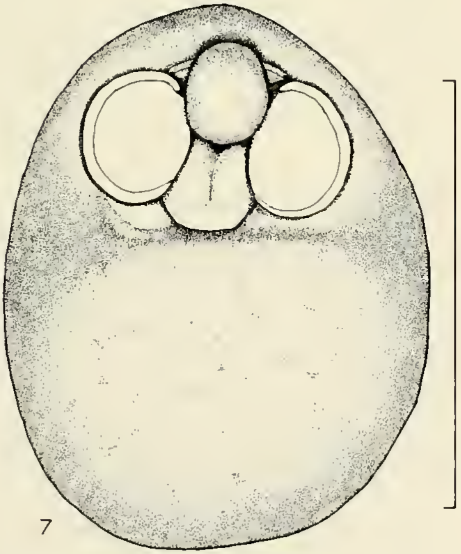
5

Fig. 5. Late veliger, ventral view.



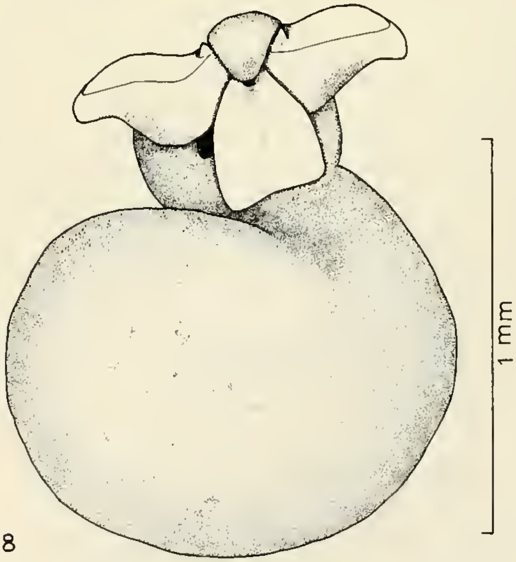
6

Fig. 6. Early pediveliger, lateral view.



7

Fig. 7. Early pediveliger, ventral view.



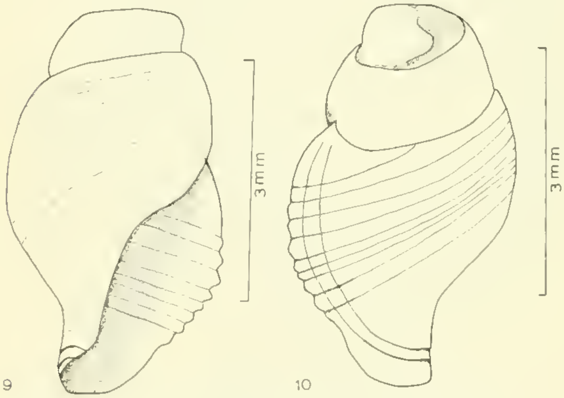
8

Fig. 8. Pediveliger, ventral view.

The young snails remain within the capsule until the capsule operculum ruptures. In cases where this has been observed, the snails aid in removing the operculum by bumping against it as they wander about within the capsule. Apparently the capsule operculum is softened by external factors such as bacteria and fungi. Young snails exit when they discover the hole in the capsule.

The shell of the emerging snail (figs. 9 & 10) is 5-8 mm. in height and 3-4 mm. wide. The aperture has an undulating margin and about the first ½ of the body whorl has fine spiral striae.

Total development time, from capsule deposition to emergence, takes 5 to 6 months in the laboratory. Development time apparently depends on temperature as well as the number of young and the number of nurse eggs available to the embryos. In all cases, all nurse eggs were ingested before emergence. Usually the young are of different sizes during development and at emergence. The development of *C. stimpsoni* is similar to that of *Buccinum undatum* (L.) described by Portmann (1925). Both *C. stimpsoni* and *B. undatum* emerge with about 3 whorls. However, the embryos of *C. stimpsoni* are of unequal size whereas Portmann (1925) indicates that the young of *B. undatum* are of equal size throughout development and emergence.



Figs. 9 & 10. Shell of emerging young Colus stimpsoni.

LITERATURE CITED

D'Asaro, C. N. 1966. The egg capsules, embryogenesis, and early organogenesis of a common oyster predator, *Thais haemastoma floridana* (Gastropoda: Prosobranchia). Bull Mar. Sci. 16: 884-914.

Mörch, O. A. L. 1867. Faunula molluscorum Insularum Faeroënsium. Beretning om de hidtil fra Faeröerne bekjendte Blöddyr. Vidensk. medd. fra Naturh. Forn. Kjb. 1867 No. 4-7: 67-111.

Portmann, A. 1925. Der Einfluss der Nähreier auf die Larvenentwicklung von *Buccinum* und *Purpura*. Z. Morph. Ökol. Tiere 3: 526-541.

Riser, N. W. 1969. Feeding behavior of some New England marine gastropods. The Nautilus 82: 112-113.

Tamarin, A. and M. R. Carriker. 1968. The egg capsule of the muricid gastropod *Urosalpinx cinerea:* an integrated study of the wall by ordinary light, polarized light, and electron microscrope. Jour. Ultrastr. Res. 21: 26-40.

Thorson, G. 1935. Studies on the egg-capsules and development of Arctic marine prosobranchs. Medd. Grønland. **100**(5): 1-71.

BOOK REVIEW

SNAILY VERSE by Pat Halliday. 48 pp., numerous pen drawings; paperback. 1972. Volturna Press, Wellington House, Peterhead, Aberdeenshire AB4 7JH, Scotland. 30 pence (about 90c U. S.).

This charming booklet of malacological rhymes and limericks is the funniest to be published in a century, and contains a remarkable amount of zoological information, as well as several parodies of English poets laureate. The numerous teleological etchings add to the humor of the 39 conchological poems.

> Otala, Otala, O, snail of Morocco!
> Please answer me this, if you will -
> Do you suffer a lot during summer sirocco?
> Do you wish that the air was more chill?
> etc . . .

R. Tucker Abbott
Delaware Museum of Natural History

VARIATION IN THE RADULAR TEETH OF *HELISOMA ANCEPS* (Menke)

T. S. Katsigianis[1] and W. N. Harman[2]
[1] Graduate student in Malacology, Biology Dept.,SUNY,Oneonta, New York 13820
[2] Assoc. Prof., Aquatic Biology, Biology Dept.,SUNY,Oneonta, New York 13820

ABSTRACT

Variation in the structure of the radular teeth in several populations of Helisoma anceps *(Menke) (Pulmonata: Planorbidae) have been studied in central New York State.*

A ratio was calculated, utilizing measurements obtained from a series of the first lateral radular teeth from individuals in each population. The data show that interpopulation variation is greater than intrapopulation variation, and that individual variation is less than intrapopulation variation.

Interpopulation differences in the number and size of the cusps of the radular teeth of H. anceps *were observed. Two populations studied possess first lateral teeth with simple entocones, mesocones and ectocones; another exhibits an accessory cusp on the distal portion of the entocone, while a second shows accessory cusps both distal and proximal on the entocone.*

INTRODUCTION

The existence of intraspecific variation within species is an important aspect in the study of freshwater mollusks. Morphological differences of an ecophenotypic or genetic nature often are apparent. Since populations of freshwater animals are normally separated in isolated environments, it is relatively easy for genetic differences to arise. This phenomenon is further enhanced by the hermaphroditic characteristic of pulmonate gastropods, which makes it possible for an entire population to be founded by a single individual having only a fraction of the genetic potential of the parent population. However, due to the relatively short duration of most freshwater biotopes, this genetic variation does not usually proceed to the species level (Hübendick, 1962).

It has often been logically assumed that the morphology of the radulae of the omnivorous freshwater pulmonates is not subject to severe selection pressures in the relatively homogeneous microhabitats in which these organisms live. Therefore, the radular teeth of these mollusks have long been considered conservative characters and have always been an important part of the descriptions of these species [e.g., figure 1 illustrates the first lateral tooth of *Helisoma antrosa (=anceps)* (Menke) from Baker's (1928) description of the species].

A comparative study of the radular teeth of *Lymnaea peregra* (Muller) (Pulmonata: Lymnaeidae) (Berrie, 1959) showed that although the structure of the teeth on the same radula, and within the same population exhibited variation, this was greatly exceeded by interpopulation differences. In fact, there was often statistically significant differences between populations.

This work was initiated to determine if differences could be observed between the structure of the radular teeth in four populations of *Helisoma anceps* (Menke) (Pulmonata: Planorbidae) occurring within a 20 mile radius of Oneonta, Otsego Co., New York, U.S.A.

METHODS

Samples were taken at: 1. Wilber Reservoir, Oneonta, Otsego Co., Susquehanna watershed; 2. Susquehanna River, Oneonta, Otsego Co., Susquehanna watershed; 3. Moe Pond, SUNY at Oneonta Biological Field Station, Cooperstown, Otsego Co., Susquehanna watershed; 4. Delaware River, Walton, Delaware Co., Delaware watershed (figure 2).

Upon collection, snails of approximately the same size were preserved in 70% ethanol. The radula of each snail was removed from the buccal mass by heating it in a concentrated potassium hydroxide solution. Each radula was then rinsed in water followed by 90% ethanol and mounted unstained in euparol. An eyepiece micrometer was used to make measurements of individual teeth. All measurements were taken at 970X with an oil immersion lens on a phase contrast microscope.

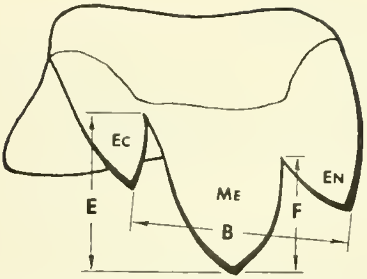


FIGURE I. First lateral tooth of H. anceps showing measurements. Ec = ectocone, Me = mesocone, En = entocone (modified from Baker, 1928).

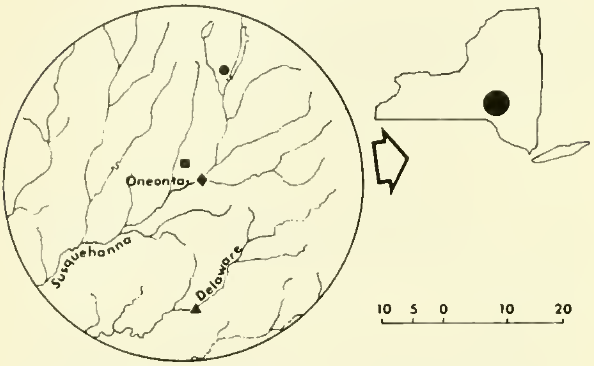


FIGURE II. A portion of New York State showing the location of each population. ■ Wilber Reservoir, ◆ Susquehanna River, ● Moe Pond, ▲ Delaware River.

Figure III. First lateral radular teeth of H. anceps (drawn to scale, 1940x). A = Delware River, B = Moe Pond.

We calculated the B/E ratio as shown in figure 1, where B is the distance between the tips of the ectocone and the entocone, and E is the height of the mesocone from its junction with the ectocone to its tip. These measurements were taken on the first lateral teeth of one transverse row of teeth. Teeth from three rows, five rows apart, were studied on each radula. Six individuals were chosen from each population, therefore, a total of 36 teeth were studied from each. All teeth measured were from the central portion of the radulae. It is in this region that the teeth are fully developed, yet not severely eroded.

These are the same methods utilized by Berrie (1959). He calculated the B/E and F/E ratios (figure 1) on the first and sixth lateral teeth of each snail but concluded that the calculation of the F/E ratio and the analysis of measurements on the sixth tooth were not necessary. The F/E ratio varied independently from the B/E ratio as did the data collected from the first and sixth lateral teeth.

RESULTS

The means, standard errors, and standard deviations of the calculated B/E ratio are given in Table I.

By adopting the method used by Berrie (1959), the interpopulation differences have been estimated. This analysis utilizes the following ratio.

$$\frac{\text{Mean}_1 - \text{Mean}_2}{\text{Standard Error}_1 + \text{Standard Error}_2}$$

A value of more than two for this ratio indicates a significant interpopulation difference while a value of three or more indicates that the populations are obviously different. Table II summarizes these results.

In all cases a significant difference exists between each population. Although the Delaware River population is from an entirely different watershed than the other groups considered, it is extremely different only from the Wilber Reservoir population. There is no correlation between the proximity of each population and the degree of interpopulation variation.

The Moe Pond population was selected to examine the intrapopulation variation and the differences that occur between the teeth on the same radula. To accomplish this, the standard deviation for the entire population was compared to the standard deviation of the teeth on one radula of one snail from that population (Table 3). The standard deviation is much greater between the teeth from several members of the population than from the teeth of one individual, which parallels Berrie's results with *L. peregra.* This indicates less variation between the radular teeth of each individual than between the radular teeth of the members of the population.

DISCUSSION

Although there were not as many populations considered in this work as were studied by Berrie (1959), and although the populations are geographically much closer together, the results obtained are similar. The data show that interpopulation variation in the B/E ratio of the first lateral radular teeth of local populations of *H. anceps* is greater than intrapopulation variation, and that individual variation is less than intrapopulation variation.

Interesting interpopulation differences in the number and size of cusps of the first lateral teeth of *H. anceps* have been observed. Figure 3 illustrates teeth from snails in two of the four populations studied. Each tooth was drawn with the aid of a Whipple micrometer in a phase contrast microscope at 1940X. All teeth are drawn to scale. They should be compared with figure 1, showing Baker's (1928) typical *H. anceps*. Note the three cusps on the entocone of the tooth representing the Moe Pond population. This is the only population studied which had teeth that exhibited this morphology. The size of the marginal cusps on the entocone vary considerably. In some cases all three cusps are of equal size, in others the accessory cusps are much smaller. Other variations within this population include teeth which entirely lack the marginal cusps on the entocone and others which have a small cusp between the mesocone and ectocone. All of these variations may appear on the same radula. The population from the Delaware River exhibits teeth with one marginal cusp on the entocone. However, some individuals in that population show teeth having only the simple ectocone, mesocone, and entocone more typical of the Wilber Reservoir and Susquehanna River populations. The latter populations never exhibited accessory cusps on the first lateral teeth of their radulae and were essentially the same as the tooth illustrated in figure 1.

LITERATURE CITED

Baker, F. C. 1928. The freshwater mollusca of Wisconsin, Pt. I. Gastropoda. Wisconsin Geol. Nat. Hist. Surv. Bul. 70(1): 1-507, pl. 1-28.

Berrie, A D. 1959. Variation in the radula of the freshwater snail *Lymnaea* peregra (Müller) from northwestern Europe. Arkiv. for Zool. 12(27): 391-404.

Hübendick, B. 1962. Aspects on the diversity of the fresh-water fauna. Oikos. 13(2): 251-261.

POPULATION	B/E RATIO FOR 1st LATERAL TOOTH.
wilber reservoir	1.305 + 0.045 0.192
delaware river	1.547 + 0.034 0.169
susquehanna river	1.458 + 0.031 0.184
moe pond	1.730 + 0.047 0.212

Table I. Means, standard errors and standard deviations of the B/E ratio for the first lateral tooth.

POPULATION POPULATION	wilber reservoir	delaware river	susquehanna river	moe pond
wilber reservoir		3	2	3
delaware river	3		2	2
susquehanna river	2	2		3
moe pond	3	2	3	

Table II. Differences between the means of the first lateral teeth for the calculated B/E ratio.

	6 INDIVIDUALS	1 INDIVIDUAL
B/E RATIO	1.730 + 0.047 0.212	1.721 + 0.101 0.078

Table III. The variation between the teeth of the six Moe Pond specimens as compared to one specimen from Moe Pond. Means, standard errors and standard deviations are given.

SIGNIFICANT PELECYPOD RECORDS FROM OKLAHOMA

Branley A. Branson
Eastern Kentucky University
Richmond, Kentucky 40475[1]

ABSTRACT

34 species of Unionidae and one Sphaerium *are reported from the Ouachita Mountain river drainages of southeastern Oklahoma, and all show a relationship with the fauna of the lower Mississippi Valley, rather than the Ozarkian Assemblage. Construction plans for the Arkansas River threaten these species.*

In a previous paper (1966), I indicated that the entire molluscan fauna of the Oklahoma Ozarks (as well as that of adjacent Kansas) belonged to van der Schalie's (1950) so-called Ozarkian assemblage, and that the fauna was probably most closely related to that of the Cumberland region. However, there is at least a small segment of this assemblage which reflects a lower Mississippi Valley relationship (Branson, 1963; 1970).

The fauna of Ouachita Mountain streams, and of those flowing through the Gulf Coastal Plains south of them, in extreme southeastern Oklahoma is another matter. The relationship here is not Ozarkian, but is primarily with the lower Mississippi Valley, the southeastern U. S., and, of course, Texas and Louisiana. Isely (1925) indicated some of this in reporting *Ptychobranchus clintonensis, P. phaseolus* (merely a southern form of *P. fasciolare,* in my opinion) and *Lampsilis hydiana* from several Red River tributaries. Hubricht (1965) and I (1963) reported *Eupera singleyi* from southeastern Oklahoma, a species occurring mainly in northern Florida and adjacent Georgia, and southern Louisiana and Texas.

Over the years, several interesting pelecypod records have accumulated in the author's files, records which lend some weight to the comments made above. Most of these records resulted from collections secured while I was on the staff of the University of Oklahoma Biological Station, Willis, Oklahoma, to which I am indebted for laboratory facilities and vehicles. I am also grateful to Drs. J P. E. Morrison and Joseph Rosewater, Division of Mollusks, U. S. National Museum, for verifications and identifications. The entire collection (plus many others) herein discussed reside under accession number 23470 at the U. S. National Museum. Records for 20 genera and 34 unionid species, and one sphaeriid species are presented below.

COLLECTING STATIONS

In the annotations the following form is used: 3(A), 2(B), etc. The Arabic numeral indicates the number secured, and the letter in parentheses refers to the station number as listed below: (A) 17 April 1959, Machire Creek, State Hwy 31 crossing, Haskell Co., Oklahoma; (B) 3 May 1959, Illinois River, 5 M east of Tahlequah, Cherokee Co., Oklahoma; (C) 16 May 1960, Grand Lake (Lake O' the Cherokees), Delaware Co., Oklahoma; (D) 11 June 1960, Slate ford, Poteau River, Leflore Co., Oklahoma; (E) 17 April 1959, Mountain Fork River, just above mouth, McCurtain Co., Oklahoma; (F) 22 April 1959, Mountain Fork River, T75, R6E, S10, McCurtain Co., Oklahoma; (G) 6 July 1952, Little River, between Broken Bow and Idabel, U. S. 70 crossing, McCurtain Co., Oklahoma; (H) 24 April 1955, Kiamichi River, State Hway 2 crossing, McCurtain Co., Oklahoma; (I) 2 September 1955, Lost Creek, near Wyandotte, Ottawa Co., Oklahoma; (J) 16 March 1955, Lake Carl Blackwell, Payne Co., Oklahoma; (K) 7 May 1960, Honey Creek, Camp Classen, Arbuckle Mountains, Murray Co., Oklahoma; (L) 6 May 1958, Water fall Creek, just east of Idabel, State Hwy 21, McCurtain Co., Oklahoma; (M) 28 June 1960, Blue River, at Connorville, Johnston Co., Oklahoma; (N) 6 June 1960, Muddy Boggy Creek, 1 M north of Jessie Pontotoc Co., Oklahoma; (O) 28 June 1960, Mountain Fork River, 6 M southwest of Smithville, State Hway 21, McCurtain Co., Oklahoma; (P) 24 July 1960, Yashau Creek, 3 M south of Broken Bow, U. S. 70, McCurtain Co., Oklahoma; (Q) 11 June 1959, Pennington Creek, 5 M north of Tishamingo, Johnston Co., Oklahoma.

---

[1] Contribution from Fisheries Management, Department of Biological Sciences.

UNIONIDAE

1. *Strophitus undulatus* Say. Collections: 11(B). A common species throughout the Ozarks, in lowland, mudbottomed streams with a relatively low profile.

2. *Anodonta imbecilis* Say. Collections: 4(L). Very dark, chlorophyll-green with indistinct, broad rays; locally abundant in vegetated backwaters.

3. *Anodonta grandis* Say. Collections: 1(C); 1(0).

4. *Lasmigona complanata* Barnes. Collections: 1(I). This species, nowhere exceptionally abundant, gives way in numbers to the next species in southeastern Oklahoma.

5. *Lasmigona costata* Rafinesque. Collections: 1(0).

6. *Tritogonia verrucosa* Rafinesque. Collections: 3(A); 1(E); 1(F); 4(H). A common species throughout the watersheds of eastern Oklahoma, but absent in the far west.

7. *Fusconaia cerina* (Conrad). Collections: 25(B); 1(M). The distribution of this interesting little unionid demands more intensive study. The species was, and probably still is, abundant in the Little Red River of Arkansas (Call, 1895), southern Louisiana and Mississippi (Meek, 1896), and clear streams of east Texas (Murray and Ray, 1968). In most of the streams of Oklahoma, *F. flava* outnumbers *F. cerina*, but the latter is quite abundant in the Illinois River (Ozarks) and common in Blue River (Red River System). Probably should be synonomized with *F. flava*. Blue River is a typical stream with regard to most of the other drainages in its vicinity. It is clear and spring-fed, and has several relicts of fishes, such as *Etheostoma microperca*, *Etheostoma radiosum*, *Notropis chrysocephalus*, and others. The clam fauna, several representatives of which are listed here, may likewise be considered in part to be relict.

8. *Quadrula pustulosa* Lea. Collections: 3(B); 2(F); 3(0).

9. *Quadrula cylindrica* Say. Collections: 4(F); 1(M). Another relict form and locally common in Blue River. The next sizable populations of this clam are found in Mountain Fork and Little Rivers of McCurtain County.

10. *Quadrula metaneura* (Rafinesque). Collections: 1(H).

11. *Plectomerus trapezoides* (Lea). Collections: 1(F). This specimen, representing several collected, was diagnosed as *P. dombeyanus* by the U. S. National Museum, a form relegated to synonomy by Murray and Ray (1968), whom I follow. Strecker (1931) found this species to be highly variable in east Texas, and the same is surely true of adjacent populations in Oklahoma. *P. interruptus* (Say) is a synonym.

12. *Amblema perplicata* (Conrad). Collections: 2(F). Merely a "washboard" variation of *A. costata*.

13. *Amblema costata* (Rafinesque). Collections: 1(E); 1(F); 1(H); 1(0). Very common at all localities (riffles).

14. *Pleurobema cordatum* (Rafinesque). Collections: 1(F); 2(0), but very common. These specimens are of the *P. c. catilus* (Conrad) form, but I consider this, as well as *P. coccineum* (Conrad), *P. pyramidatum* (Lea) and *P. c. solidum* (Conrad) to be ecotypes rather than races or species.

15. *Pleurobema antillus* (Conrad). Collections: 1(F). Merely a southern variety of *P. cordatum*.

16. *Elliptio dilatatus* (Rafinesque). Collections: 1(D).

17. *Uniomerus tetralasmus* (Say). Collections: 3(F); 12(J). In most lakes and ponds of central and western Oklahoma.

18. *Ptychobranchus clintonensis* (Simpson). Collections: 5(F) (Common). Simpson (1914) delimited the range of this southern form as the Little Red River of Arkansas and, questionably, west to Oklahoma. It is probably *P. phaseolus* (Hildreth).

19. *Proptera alata* (Say). Collections: 1(B); 1(C).

20. *Proptera (Leptodea) ohiensis* (Rafinesque). Collections: 6(C). Questionably distinct from *P. laevissima* (Lea).

21. *Proptera (Leptodea) fragilis* (Rafinesque). Collections: 1(F) (Common).

22. *Proptera (Leptodea) amphichaema* (Frierson). Collections: 1(F). An interesting species, common in Texas (Murray and Ray, 1968; Strecker, 1931).

23. *Proptera (Proptera) purperata* (Lamarck). Collections: 7(E); 5(F).

24. *Truncilla perniculata* (Rafinesque). Collections: 2(F). I cannot believe this form is distinct from *T. donaciformis* (Lea).

25. *Carunculina parva* (Barnes). Collections: 1(H); 4(J); 2(L). Common in small creeks and ponds. See remarks below.

26. *Carunculina texasensis* (Lea). Collections: 1(P) (but common). Although Murray and Ray (1968) consider this form a subspecies of *C. parva*, and Strecker (1931) opinioned that typical *L. parva* was not known from Texas, I have found both forms together in northeastern Texas, and Meek (1896) re-

ported *C. texasensis* to dominate the *Carunculina* populations in portions of the abandoned channel of the St. Francis River near Greenway, Arkansas; both species were present.

27. *Lampsilis anodontoides* Lea. Collections: 3(A).

28. *Lampsilis luteola* Lamarck. Collections: 2(C); 1(E); 2(K); 6(M); 1(0) (very common).

29. *Lampsilis hydianus* (Lea). Collections: 2(E); 3(F) (common); 1(O). This species, still common in the St. Francis and Saline Rivers of Arkansas (Call, 1895), Texas tributaries of the Red River (Strecker, 1931),is characteristic of the lower Mississippi Drainage (Louisiana, Texas, Arkansas and neighboring states) (Coker, 1919).

30. *Lampsilis (Villosa) lienosa* (Conrad). Collections: 2(E); 4(F) (common). This species, with a type locality in southern Alabama (Clench and Turner, 1956), has a rather wide distribution in the Ohio and Mississippi basins of Kentucky, Red and Saline rivers of Texas (Strecker, 1931) (highly variable), southern Arkansas (Meek, 1896), and Oklahoma. The habitat is invariably in mud.

31. *Lampsilis cardium saturna* (Lea). Collections: 1(F) (common). Probably a synonym of *Lampsilis ventricosa* (Barnes).

32. *Ligumia subrostrata* (Say). Collections: 4(F); 1(H).

33. *Obovaria jacksoniana* Frierson. Collections: 5(F); 1(O) (common in both localities). A species characteristic of the Pearl and Yalabusha rivers of Mississippi.

34. *Actinonais carinata* (Barnes). Collections: 1(C); 4(E); 1(G); 1(O). Specimens from southeastern Oklahoma are almost invariably referred to *A. c. gibba* (Simpson).

SPHAERIIDAE

35. *Sphaerium partumcium* (Say). Collections: 4(K); 26(M); 2(N); 3(Q). Generally distributed in the eastern two-thirds of the state.

Discussion

As Meek (1896) indicated in his appraisal of some pelecypod faunules in southern Arkansas, many of the species listed herein have a decidedly southern relationship when compared with populations in northeastern Oklahoma. Regardless of their systematic distinctness as full-species, the following nominate forms indicate southern affinity: *Pleurobema antillus, Ptychobranchus clintonense, Proptera amphichaema, Proptera purpurata, Carunculina texasensis, Lampsilis hydianus, L. (villosa) lienosa, Actinonais carinata gibba,* and *Obovaria jacksoniana.*

In view of the extensive habitat modification such as dam constructions and the opening of the seaway in the main Arkansas River, it is imperative that much field work be accomplished in the Ouachita drainages, particularly in the Poteau, Mountain Fork and Little Rivers, before it is too late.

LITERATURE CITED

Branson, B. A. 1963. New Mollusk records from Oklahoma and their Zoogeographical Significance. Trans. Kansas Acad. Sci. 66: 501-512.

Branson, B. A. 1966. A partial Biological Survey of the Spring River Drainage in Kansas, Oklahoma and Missouri. Part I, Collecting sites, basic limnological data, and mollusks. Proc. Kansas Acad. Sci. 69: 242-293.

Branson, B. A. 1970. *Glebula* in Oklahoma. Sterkiana 36:25.

Call, R. E. 1895. A study of the Unionidae of Arkansas, with Incidental Reference to their Distribution in the Mississippi Valley. trans. Acad. Sci. St. Louis 8:1-65.

Clench, W. J. and R. D. Turner. 1956. Freshwater Mollusks of Alabama, Georgia and Florida, from the Escambia to the Suwannee River. Bull. Fla. State Mus. 1:97-239.

Coker, R. E. 1919. Freshwater Mussel Industries of the United States. Bull. Bur. Fish. 36:11-89.

Hubricht, L. 1965. *Eupera singlegi* in Oklahoma. Nautilus 78:106.

Isely, F. B. 1925. The Freshwater Mussel Fauna of Eastern Oklahoma. Proc. Okla. Acac. Sci. 4:43-118.

Meek, S. E. 1896. A List of Fishes and Mollusks Collected in Arkansas and Indian Territory in 1894. Bull. U. S. Fish. Comm. 1895:341-349.

Murray, H. D. and E. C. Ray. 1968. Checklist of Freshwater and Land Mollusks of Texas. Sterkiana 30:25-42.

Simpson, C. T. 1914. A Descriptive Catalogue of the Naiades or Pearly Freshwater Mussels. Bryant Walker, Detroit, Mich. 1540 p.

Strecker, J. K. 1931. The Distribution of the Naiades, or pearly Freshwater Mussels, of Texas. Baylor Univ. Mus. Sp. Bull. 2:1-71.

Van der Schalie, H. and A. 1950. The Mussels of the Mississippi River. Amer. Midl. Nat. 44: 448-466.

A NEW RECORD OF *CORBICULA MANILENSIS* (PHILIPPI) IN THE SOUTHERN ATLANTIC SLOPE REGION OF GEORGIA

James B. Sickel
Emory University
Department of Biology
Atlanta, Georgia 30322

ABSTRACT

Based on previous extensive surveys, it appears that the freshwater clam, Corbicula manilensis (Philippi), *was introduced into the Altamaha River system of Georgia in 1968, initially into the Ocmulgee River from which it has spread downstream into the Altamaha River, being found there for the first time in the summer of 1971. This is a first record of this Asian species occurring in the Southern Atlantic Slope region.*

The range of *Corbicula manilensis* (Philippi) continues to expand and has finally reached the Southern Atlantic Slope region, an extension of its range from the Gulf of Mexico drainage. As of last year, Sinclair (1971) excluded the Atlantic Slope region from the known range of *Corbicula.* In 1968 the author (Sickel, 1969) made extensive collections of bivalves in all habitat types from the Altamaha River, Appling County, Georgia, between River Mile 113 and 118. Ten species of unionids were found but no *Corbicula.* Recent collections have shown *Corbicula* is now in the Altamaha River system, both in the Ocmulgee River and the Altamaha River itself.

On October 15, 1971, while collecting in the Altamaha system, the author found one *Corbicula manilensis* shell on a sandbar in the Ocmulgee River three miles from its confluence with the Oconee River at which point the Altamaha begins. Shell annual rings are not absolute determinants of age since they are frequently indistinct, but based on what appear to be annual rings, i.e., variations in the width of concentric ridges, and the size, 10.0 x 8.6 x 6.3 mm., the shell is estimated to be two years old and to have died in the spring of 1971.

While collecting in the Flint River, Crawford County, on November 4, 1971, the author found an abundance of *Corbicula manilensis.* The Flint River is a part of the Apalachicola River system in the Gulf drainage and is not connected with the Altamaha system, but tributaries of each reach within a mile of the other. The Flint River population was in coarse sand along the upstream end of most sandbars where the sandy bottom was relatively stable. Using a viewing box in shallow water and viewing a 1 sq. ft. area, 10 to 15 adult *Corbicula* could be seen in any square foot area chosen within the favorable habitat. Along the middle and downstream reaches of the sandbars fewer *Corbicula* were found, and scattered among them were the following unionids: *Lampsilis anodontoides floridensis* (Lea), *Lampsilis binominatus* (Simp.), and *Quincuncina infucata* (Conrad). Where the *Corbicula* were most dense there were no unionids, even though the habitat appeared suitable. This indicates some form of competition, and it is unlikely to be simply spatial competition since the size of *Corbicula* and its density did not appear to be great enough to exclude the much larger unionids.

The adult *Corbicula* in the Flint River were still expelling veliger larvae on the date collected. This extended breeding season is probably common in southern rivers and means that control measures taken by industry will have to be extended correspondingly.

In the Altamaha River, Appling County, at one of the same sites where the author collected unionids in 1968, five juvenile *Corbicula* were found on December 15, 1971. Using a modified Peterson dredge, samples were taken on sandy and muddy bottom. The *Corbicula* were found only in coarse sand near the bank where the sand grades into mud. Six grab samples taken at one site produced five *Corbicula* which ranged in length from 6.0 mm. to 7.8 mm. Each still retained a byssal thread and had the characteristic purple rays of the juveniles. They were obviously in their first year of development.

The first report of *Corbicula* in the Altamaha came from Drs. Donald C. Scott and James Schindler, University of Georgia (personal communication), who found several young specimens while sampling in

August, 1971, near the same area where the author collected.

Corbicula manilensis is not yet abundant in the Altamaha River. No adults over 2 years old have been found. Many sites have been examined in the Altamaha and lower Ocmulgee in which *Corbicula* has not been found.

The author proposes that *Corbicula* was introduced into the Ocmulgee River by overland transfer from the Flint River in 1968 or 1969. This transfer could have occurred by fishermen who frequent both rivers and use mussels for bait or accidentally in the sand dumped into boats, possibly from anchors or nets. One fertile adult could produce enough offspring to establish a breeding population from which veligers would be carried downstream to populate the entire Altamaha to the Atlantic. It will be only a matter of time before *Corbicula* moves northward to inhabit the remainder of the Southern Atlantic Slope region.

Appreciation is expressed to John G. Adams and the Georgia Power Company for the boat, collecting equipment, and facilities so graciously provided for the Altamaha River collections.

LITERATURE CITED

Sickel, J. B. 1969. A survey of the mussel populations (Unionidae) and Protozoa of the Altamaha River with reference to their use in monitoring environmental changes. MS Thesis. Emory University, Atlanta.

Sinclair, R. M. 1971. Annotated bibliography on the exotic bivalve *Corbicula* in North America, 1900-1971. Sterkiana 43:11-18.

BOOK REVIEW

SHELLS. Photography by Andreas Feininger, text by William K. Emerson. A Studio Book, the Viking Press, New York. 295 pp. (including the plates), 175 pls. (including 32 in color), 7 numbered and 194 unnumbered figs. 1972. $27.50.

This is a large format (12 3/8" x 10") book of photographs of marine mollusk shells, chosen by a distinguished photographer "not from the point of view of the scientist but from that of the engineer intrigued by structure and the interdependence of function and form, and from the point of view of the artist who is fascinated by shape and design." It is said to be "a shell-appreciation book" differing from other shell books which "are too much preoccupied with facts."

Most of the photographs are indeed spectacular. They are grouped around chapters with the following headings: Forms of the Sea; an Infinite Variety of Shapes; Carrier Shells; the Structure of Shells; the Spiral; the Color of Shells; the Surface Texture of Shells; Knobs and Spines, and Ornamental Design. Magnifications vary greatly, and the shells are oriented in all sorts of positions, resting on sand, gravel, boulders, or glass bespattered with water, sometimes with a background of sky or cloud. Not a single shell is shown alive or in its natural habitat.

There is an elementary Introduction to malacology and the text following it parallels fairly well the sequence of photographs, diverting in places to such subjects as fluorescence. There is no first-hand information about the biology of mollusks. The plate captions consist solely of the scientific name and a reference number relating it to the systematically arranged catalog at the end. Only by referring to the latter would the novice learn that the *Haliotis* shells shown on pls. 119 and 120 are polished. Most of the shells in the catalog are refigured at natural size and in more conventional orientations. There are also a glossary, bibliography and index.

The Foreward unwisely states that the text is "scientifically accurate down to the last detail." The phyletic successions of marine bivalves and snails (figs. 2 and 3) are grossly misleading. Two entirely different species on pl. 101 each are identified as *Conus maldivus* Hwass. Various scientific names are misattributed to authors, and various adjectival specific names disagree in gender with the generic names. *Vermicularia* is wrongly included in the Vermetidae.

How well does this book achieve its objective of being "a complement to all other kinds of shell books"? It differs little in intent from *The Shell: Five Hundred Million Years of Inspired Design* by Stix, Stix and Abbott (1968). Both of these are modern photographic counterparts of the type of shell book begun by Buonanni in 1684: *Recreatio Mentis et Oculi.* Thus there is nothing unique about the Feininger-Emerson book; the photographs are its most redeeming feature.

Robert Robertson
Academy of Natural Sciences of Philadelphia

NON-MARINE MOLLUSKS AND TWO NEW SPECIES OF *PISIDIUM* FROM THE TONGUE RIVER FORMATION (PALEOCENE), NORTH DAKOTA.

David Bickel
Science Division
Minot State College
Minot, North Dakota 58701

ABSTRACT

Fifteen taxa of Paleocene freshwater Mollusca were recovered from relatively soft carbonate sediments of the Tongue River Formation (Paleocene: Fort Union Group). The beds, exposed at two sites in southern Ward County, North Dakota, apparently accumulated in a small hard-water lake. The faunule is discussed and illustrated. Unlike the few previously described species of Pisidium *from early Tertiary rocks, preservation of* Pisidium wardensis *and* Pisidium russelli *n. spp. is good enough to permit detailed description of their hinge morphology.*

INTRODUCTION

The Late Cretaceous and early Tertiary deposits in the North Dakota portion of the Williston Basin record a conformable transition from marine to brackish water to non-marine sediments. The Fort Union Group includes Paleocene rocks in North Dakota and occurs in the western half of the state and on an outlier in northeastern North Dakota. These strata in North Dakota include from base to top the Tullock, Ludlow, Cannonball, Tongue River, and Sentinel Butte Formations. All are of alluvial origin except for the Cannonball Formation which apparently accumulated in an early Tertiary relic or rejuvenation of the Cretaceous seaway that crossed the midcontinent region. The Tongue River Formation was deposited over Tullock, Ludlow, and Cannonball sediments by a system of streams flowing from a western source with low gradients and velocities (Royce, 1970). Tongue River sediments are mostly poorly consolidated yellowish silts and clays with lesser amounts of sand, lignite coal, and limestone. Thick units that formed in backswamp and floodplain environments characterize the formation. Thick deposits of glacial drift cover pre-Pleistocene rocks east and north of the Missouri River and bedrock outcrops are small and generally limited to the larger stream valleys, shallow road cuts, and strip mines. Royce (1970) summarizes the sedimentary history of the Tongue River and Sentinel Butte Formations.

A highly fossiliferous exposure of the Tongue River Formation (Paleocene) was brought to my attention in January, 1971, by Mr. Fred Ballentyne of

Unit	*Paleocene: Tongue River Formation*	*Thickness (Feet)*
4	Buff to light gray limestone, friable, blocky; lower half coarse grained near base, finer textured toward top; mollusks abundant in limonitic band near middle.	11.3
3	Dark gray calcareous shale, soft, strongly fissile	1.0
2	Light gray to buff limestone, blocky; moderately hard at base; moderately friable above.	6.2
1	Brown to gray lignitic clay, weakly calcareous; base not exposed.	0.3
	TOTAL	18.8 ft.

Sawyer, North Dakota. Most of the fossils were collected that month. The faunule from this locality is notable for the number of taxa present and the occurrence of new species of *Pisidium.* The outcrop is located about 8 miles south of Sawyer, Ward County, North Dakota in NW¼, sec. 19, T152N, R81W. The exposure is an isolated man-made cut on the west wall of a shallow coulee at about 1800 ft. above sea level. A stratigraphic section is described below:

Bedrock is completely covered on both sides of the outcrop; however, more typical Tongue River clastic sediments are exposed at the same elevation in an abandoned strip mine about 100 yds. to the west. Carbonate sediments with similar lithology and stratigraphy are poorly exposed at the same elevation about 1 mi. to the east in SW¼, NW¼, sec. 20 of the same township, but any lateral transition of this sequence into silt-clay facies that outcrop nearby is also covered.

The stratigraphic position of these beds in the Tongue River Formation cannot be accurately fixed at present. Lemke (1960, p. 30, 33) places the Tongue River-Cannonball contact at an elevation of 1540 ft. along the Souris River 8 to 9 mi. to the northeast. Allowing for a slight northeast dip in this area, these exposures are probably 200-250 ft. above the base of the Tongue River Formation.

The deposit apparently accumulated in a shallow floodplain depression or series of depressions that held a permanent hard water lake. The lake formed over clastic and organic backswamp sediments and maintained a permanent water level long enough for diverse molluscan and ostracode assemblages to become established. *Pisidium,* small amnicolids, and ostracodes suggest a lacustrine environment. Viviparids are prominent elements in the Fort Union fauna and these snails probably inhabited slower moving streams as well as standing water in backswamp areas.

SYSTEMATIC PALEONTOLOGY

Family Unionidae

Plesielliptio priscus (Meek and Hayden, 1856)

Fig. 16

Unio priscus Meek and Hayden, 1856, Proc. Acad. Nat. Sci. Philadelphia 8: 117.

Unionid mussels are common and generally occur with both valves connected, aligned, and closed. Preservation in place is often excellent except for fractures induced by compaction, but specimens crumble and exfoliate during extraction even with careful field and laboratory techniques. One specimen is intact enough to show both the double looped beak sculpture of *Plesielliptio* and the proportions of *P. priscus.* Its measurements are: length 78.0 mm., height 45.0 mm., width 21 mm. Three valve fragments have the concentric looped ornamentation of *Plesielliptio* but are too incomplete for specific determination. About 30 other large fragments of exfoliated hinge areas cannot be identified to genus.

Family Corbulidae

Bicorbula mactriformis (Meek and Hayden, 1856)

Fig. 15

Corbula mactriformis Meek and Hayden, 1856. Proc. Acad. Nat. Sci. Philadelphia 8: 117.

Bicorbula mactriformis is the most common bivalve encountered. The numerous specimens examined range in length from a few millimeters to a maximum of 23 mm. Outlines vary from sub-ovate to sub-trigonal with most valves appearing somewhat triangular. Sub-trigonal valves seem to have greater heights in proportion to length than do ovate specimens. The genus is inequivalved. Dentition is well preserved and all intact specimens are easily distinguished from other bivalves.

Family Pisidiidae

Hinge tooth terminology in the following descriptions is that of Herrington (1962, p. 11) with addition of the abbreviations RV and LV for right and left valves.

Pisidium wardensis new species

Figs. 9, 10

Description: Shell small, inflated, outline ovate; walls moderately thick; beaks prominent, slightly to distinctly raised, sub-central toward posterior; posterior margin rounded to slightly truncate; anterior margin rounded, narrower than posterior margin; dorsal margin broadly angular at umbo, forms slight rounded angle with posterior margin, smoothly curved into anterior margin; ventral margin convex; striae fine, evenly-spaced; growth pauses shallow indentations or steps; hinge narrow; lateral teeth long, covering about four-fifths of shell length; inner anterior lateral tooth AI (RV) pointed, triangular; outer anterior lateral AIII (RV) linear, narrow, near distal hinge margin; anterior lateral AII (LV) straight, triangular, cusp distal; posterior lateral teeth PI, PIII, (RV) with short cusps; posterior lateral tooth PII (LV) toward proximal hinge margin, cusp prominent;

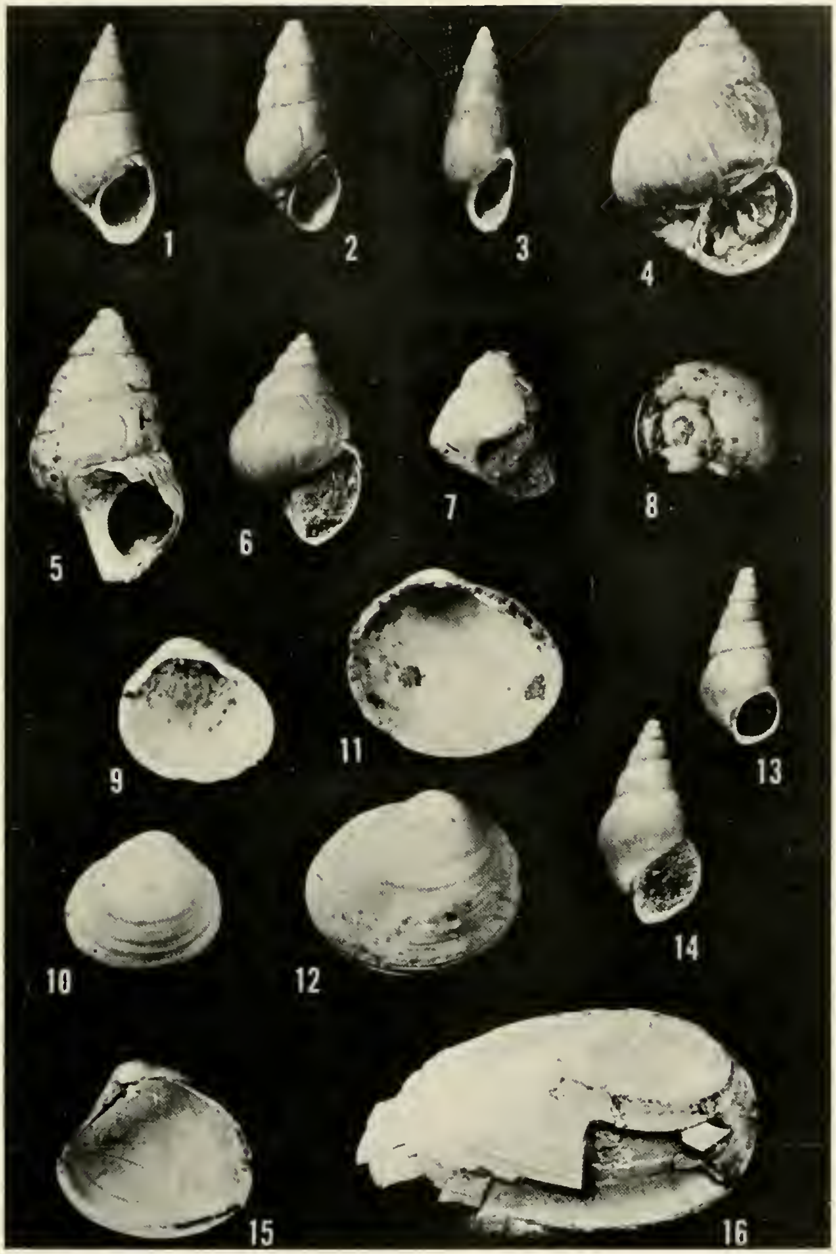


FIG. 1. Lioplacodes nebrascensis producta *(White) X 1; FIG. 2.* Lioplacodes mariana *Yen X 1; FIG. 3.* Lioplacodes limnaeformis *(Meek and Hayden), a slender specimen X 1.5; FIG. 4.* Viviparus raynoldsanus *Meek and Hayden, specimen slightly compressed into plane of illustration X 1; FIG. 5.* Campeloma nebrascensis whitei *Russell X1; FIG. 6.* Campeloma nebrascensis *(Meek and Hayden) X 1; FIG. 7.* Viviparus peculiaris *(Meek and Hayden) X 1; FIG. 8.* Gyraulus *cf.* G. militaris *(White) X 10; FIG. 9.* Pisidium wardensis *n. sp. interior of Holotype (USNM 180367) X 10; FIG. 10.* Pisidium wardensis *n. sp., exterior of Holotype X 10; FIG. 11.* Pisidium russelli *n. sp., interior of Holotype (USNM 180370) X 10; FIG. 12.* Pisidium russelli *n. sp., exterior of Holotype X 10; FIG. 13.* Hydrobia warrenana *(Meek and Hayden) X 4; FIG. 14.* Hydrobia anthonyi *(Meek and Hayden) X 4; FIG. 15.* Bicorbula mactriformis *(Meek and Hayden), interior view X 2; FIG. 16.* Plesielliptio priscus *(Meek and Hayden) X ½.*

cardinal tooth C3 (RV) distinctly curved, enlarged posteriorally; cardinal teeth C2, C4 (LV) slender, roughly parallel; C2 curved, shorter than C4; C4 slightly curved or distinctly curved on anterior half.

Types and measurements: Types are deposited in the United States National Museum of Natural History. Holotype (USNM 180367) length 2.0 mm., height 1.8 mm.; Paratype (USNM 180368) length 1.9 mm., height 1.8 mm.; Paratype (USNM 180369) length 1.6 mm., height 1.5 mm.

Type locality: About 8 mi. south of Sawyer, North Dakota, NW¼, NW¼, sec. 19, T152N, R81W. Paleocene; Tongue River Formation. Collected Jan. 1971.

Remarks: The 40 specimens examined vary in outline and the degree to which beaks project above the hinge line. Smaller specimens tend to appear quite inflated. *Pisidium wardensis* is distinguished from other Late Cretaceous and early Tertiary pisidid clams by its inflated ovate shell, broad and rather prominent beaks, and small size. The species is named for Ward County, North Dakota.

Pisidium russelli new species

Figs. 11, 12

Description: Shell moderately small, moderately inflated, outline ovate; beaks prominent, raised above hinge, situated about one third of shell length from posterior edge; anterior and posterior valve margins rounded; dorsal margin slightly convex, rounded posteriorally, forms rounded angle with anterior margin; ventral margin convex; striae fine, evenly spaced; hinge narrow; lateral teeth long, covering about three-fourths of shell length; anterior inner lateral tooth AI (RV) long, cusp toward distal end; anterior outer lateral AIII generally parallel to AI, prominent; anterior lateral AII (LV) on inner margin of hinge, straight, cusp rounded and distal; posterior lateral teeth PI, PIII (RV) slender, low, parallel, depression for opposing tooth long, narrow; posterior lateral tooth PII (LV) slender, low cusp rounded; cardinal tooth C3 (RV) distinctly curved, enlarged posteriorally; cardinal teeth C2, C4, (LV) parallel, very slightly curved, C2 slightly shorter than C4.

Types and measurements: Types are deposited in the United States National Museum of Natural History. Holotype (USNM 180370) length 2.85 mm., height 2.4 mm.; Paratype (USNM 180371) length 1.75 mm., height 1.55 mm.; Paratype (180372) length 1.8 mm., height 1.5 mm.

Type locality: About 8 mi. south of Sawyer, Ward County, North Dakota, NW¼, NW¼, sec. 19, T152N, R81W. Paleocene: Tongue River Formation. Collected Jan. 1971.

Remarks: Pisidium russelli resembles *P. wardensis* in outline and hinge structure. It is distinguished from that species by its less inflated shell, slightly angular dorsal-anterior margin, more posteriorally situated beaks, and parallel cardinal teeth on the left valve. The name honors Dr. Loris S. Russell.

Family Viviparidae

Viviparus peculiaris (Meek and Hayden, 1856)

Fig. 7

Paludina peculiaris Meek and Hayden, 1856, Proc. Acad. Nat. Sci. Philadelphia 8: 122.

The species is characterized by having a thin trochiform shell, about 5½ flattened and slightly convex whorls, fine growth lines, and very indistinct spiral ridges. The body whorl is angular at its base and the aperture is ovate to sub-quadrate. Three incomplete specimens were found at this site. Two specimens measure: height 18.6 mm. (juvenile whorls missing) and 18.2 mm.; width 16.5 mm. and 13.4 mm.; aperture height 11 mm. and 10 mm.

Viviparus planolatere Russell from the Paleocene of Alberta seems to be a junior synonym of *V. peculiaris.* The relationship of *V. peculiaris* to the similar Cretaceous species, *V. conradi* (Meek and Hayden), is uncertain, and the name *V. conradi,* has priority if the two shells are conspecific.

Viviparus raynoldsanus Meek and Hayden, 1861

Fig. 4

Meek and Hayden, 1861, Proc. Acad. Nat. Sci. Philadelphia 13: 446.

Large adult specimens are crushed but several body whorl fragments suggest maximum shell widths of over 25 mm. The largest intact shells have heights of about 30 mm. and widths of about 20 mm. Four of eleven specimens have somewhat flattened whorls, a rounded angle where the side and base of the body whorl meet, and whorls with slight shoulders. Such specimens have an almost turbonate appearance. Meek (1876, p. 584) mentions specimens of *V. raynoldsanus* with slightly flattened and shouldered whorls.

On the basis of crushed and fragmentary specimens of *V. peculiaris* and *V. raynoldsanus,* I incorrectly reported *V. trochiformis* (Meek and Hayden) and *V. retusus* (Meek and Hayden) from this locality in an abstract (Bickel and Hall, 1971).

Campeloma nebrascensis (Meek and Hayden, 1856)
Fig. 6

Bulimus nebrascensis Meek and Hayden, 1856, Proc. Acad. Nat. Sci. Philadelphia 8: 118.

Two specimens from this site have the convex whorls, inflated body whorl, slight shoulder, and raised spiral lines of the typical form of *C. nebrascensis.* Meek (1876, p. 586) states that on some specimens "the lower whorl shows faint traces of an obscure revolving ridge just below the suture." This characteristic occurs commonly on specimens I have seen from other localities in the Williston Basin and Delimata (1969, p. 29) notes it on material from the Little Missouri Badlands. Shoulders, when present, are less prominent than on *C. nebrascensis whitei* Russell. The two specimens measure: height 27.0 mm. and 16.6 mm.; width 18.0 mm. and 12.8 mm.; aperture height 13.3 mm. and 9.0 mm.

Campeloma nebrascensis whitei Russell, 1931
Fig. 5

Russell, 1931, Trans. Roy. Soc. Canada, ser. 3, 25 (sec. 4): 12, pl. 2, fig. 1.

This shell is the most common of the larger viviparids encountered with 17 fairly intact specimens being recovered. Many shells are crushed by sediment compaction and others were destroyed during collection. *Campeloma nebrascensis whitei* differs from typical *C. nebrascensis* in having a prominent shoulder at the top of the penultimate and body whorl and a broad, shallow depression or sinus just below the shoulder. Five specimens lack raised spiral ornamentation. This form occurs with typical *C. nebrascensis* and is easily distinguished from it, suggesting that *C. nebrascensis whitei* may be a distinct species.

Lioplacodes limnaeformis (Meek and Hayden, 1856)
Fig. 3

Bulimus limnaeformis Meek and Hayden, 1856, Proc. Acad. Nat. Sci. Philadelphia 8: 118.

Specimens are fairly common at the exposure and generally well preserved. Most specimens have a slightly convex spire but occasionally shells (4 of 50 specimens) have relatively straight-sided spires. Three specimens have the following measurements: height 17.0 mm., 15.5 mm., 12.2 mm.; width 7.9 mm., 7.5 mm., 5.5 mm.; aperture height 7.2 mm., 6.8 mm., 5.8 mm.

Lioplacodes mariana Yen, 1946
Fig. 2

Yen, 1946, Amer. Jour. Sci., 244: 44-45, pl. 1, figs. 5a-5c.

Five specimens are referred to this species which is distinguished from *L. nebrascensis* by having a slender spire, less inflated body whorl, more loosely coiled whorls, and a smaller aperture. The upper two-thirds of each whorl is slightly convex and the lower third is strongly convex where it meets the lower suture. Two specimens measure: height 27.5 mm. and 26.5 mm.; width 14.0 mm. and 12.7 mm.; aperture height 11.0 mm. and 10.0 mm.

Lioplacodes nebrascensis producta (White, 1883)
Fig. 1

Campeloma producta White, 1883, U. S. Natl. Mus. Proc., 3: 97, pl. 3, figs. 7-9.

Over 100 specimens were examined and they vary in spire height, convexity of whorls, and degree of ornamentation. The original description of *L. nebrascensis* (Meek and Hayden, 1856, p. 124) depicts the variability of this species, and Russell (1931) considers *L. nebrascensis producta* and typical *L. nebrascensis* end members in the range of variation in one species. The trinomial is used here as a form name. Many of the specimens are ornamented with fine spiral raised lines that are occasionally developed enough to make juvenile and intermediate whorls appear lightly carinate. Lightly carinate shells resemble *L. tenuicarinata* (Meek and Hayden) but lack the strongly keeled and convex whorls of that species. About one-fifth of the material has the tall, slender spire and whorl morphology of *L. mariana* but retains the fuller body whorl and larger aperture of *L. nebrascensis producta.*

Family Planorbidae

Gyraulus cf. *G. militaris* (White, 1880)
Fig. 8

Planorbis militaris White, 1880, Proc. U. S. Natl. Mus. 3: 159.

Two specimens of small planorbids, both crushed along the axis of coiling, resemble *G. militaris.* The illustrated specimen shows the proportions of *G. militaris* and has the deep umbilicus of that species. Shell widths of the two specimens are 1.9 mm. and 1.8 mm.

Family Amnicolidae

Hydrobia anthonyi (Meek and Hayden, 1856)
Fig. 14

Melania anthonyi Meek and Hayden, 1856, Proc. Acad. Nat. Sci. Philadelphia 8: 124.

On large specimens, penultimate and body whorls are somewhat more convex than the immature whorls. Intermediate sized shells tend to have slightly convex whorls and well impressed sutures. Smaller specimens generally have subrounded apertures, while apertures on larger individuals tend to be more elongate. Persistant and very fine spiral striae are present on adult whorls but are absent or extremely fine on juvenile whorls. Fifty-seven specimens were examined. One large and one intermediate-sized specimen measure: height 6.3 mm., 3.4 mm.; width 3.3 mm., 1.8 mm.; aperture height 2.8 mm., 1.1 mm.

Hydrobia warrenana (Meek and Hayden, 1857)
Fig. 13

Melania warrenana Meek and Hayden. 1857, Proc. Acad. Nat. Sci. Philadelphia 9: 137.

Hydrobia warrenana is distinguished by its conical spire, 6 to 7 slightly convex whorls, and a body whorl that forms a rounded angle with the base. This angle tends to be sharply defined on immature shells but more rounded on large specimens. The aperture is subquadrate. Two large specimens measure: length 5.6 mm., 4.8 mm.; width 2.6 mm., 2.2 mm.; aperture height 2.0 mm., 1.7 mm. Most of the 30 specimens have lengths of less than 3.0 mm.

Family Physidae

Physa sp.

One fragmented and apparently immature specimen of this genus was found. The apex and aperture periphery are missing and specimen length is 7.0 mm.

LITERATURE CITED

Bickel, D., and Hall, D. H. 1971. Paleocene freshwater Mollusca from southern Ward County, North Dakota (abstr.). North Dakota Acad. Sci Proc. pt. 1, 25: 3.

Delimata, J. J. 1969. Fort Union (Paleocene) mollusks from southern Golden Valley and southeastern Billings Counties, North Dakota. MS Thesis, Univ. North Dakota. 73 p., 6 pls. (unpubl.. typewritten).

Herrington, H. B. 1962. A revision of the Sphaeriidae of North America (Mollusca: Pelecypoda). Mus. Zool. Univ. Michigan Misc. Publ. **118**, 74 p., 7 pls.

Lemke, R. W. 1960. Geology of the Souris River area, North Dakota. U. S. Geol. Surv. Prof. Pap. 325, 138 p.

Meek, F. B. 1876. A report on the invertebrate Cretaceous and Tertiary fossils of the Upper Missouri country. U. S. Geol. Geogr. Surv. Terr. (Hayden Survey) 9: 629 p., 45 pls.

Meek, F. B. and Hayden, F. V. 1856. Descriptions of new species of Acephala and Gastropoda . . . Proc. Acad. Nat. Sci. Philadelphia 8: 111-125.

Meek, F. B., and Hayden, F. V. 1857. Description of new species and genera of fossils, collected by Dr. F. V. Hayden in Nebraska Territory . . . Proc. Acad. Nat. Sci. Philadelphia 9: 117-148.

Meek, F. B., and Hayden. F. V. 1861. Descriptions of new Lower Silurian (Primordial). Jurassic, Cretaceous, and Tertiary fossils, collected in Nebraska . . . Proc. Acad. Nat. Sci. Philadelphia **13**: 415-447.

Royce, C. F., Jr. 1970. A sedimentologic analysis of the Tongue River-Sentinel Butte interval (Paleocene) of the Williston Basin. western North Dakota. Sedimentary Geol. 4: 19-80.

Russell, L. S. 1931. Mollusca from the Upper Cretaceous and Lower Tertiary of Alberta. Roy. Soc. Canada Trans. Ser. 3, **25** (sec. 4): 9-19, 2 pls.

White, C. A. 1880. Descriptions of new invertebrate fossils from the Mesozoic and Cenozoic rocks of Arkansas, Wyoming, Colorado, and Utah. Proc. U. S. Natl. Mus. 3: 157-162.

White, C. A. 1883. New molluscan forms from the Laramie and Green River Groups, with discussion of some associated forms heretofore known. Proc. U. S. Natl. Mus. 5: 94-99, pl. 3-4.

Yen, T.-C. 1946. Paleocene freshwater mollusks from Sheridan County, Wyoming. Amer. Jour. Sci. **244**: 41-48, 1 pl.

TO WHAT EXTENT DO SURF CLAMS MOVE?

John W. Ropes and Arthur S. Merrill
National Marine Fisheries Service
Middle Atlantic Coastal Fisheries Center
Oxford, Maryland 21654

ABSTRACT

Locomotion by surf clams, Spisula solidissima, *includes rapid burrowing, crawling, and leaping from the bottom. Observations of these activities led to the suspicion that some movement over the sea floor may occur. We found that the usual response of surf clams removed from a burrow is rapid re-entry into the substrate. Occasional leaping, when seen, was usually by recently disturbed, small and very young specimens. They propelled themselves very short distances and immediately burrowed upon landing. Unusual circumstances seemed necessary to elicit the leaping response and it was considered a relatively ineffective means of locomotion.*

Surf clams (*Spisula solidissima* (Dillwyn)), like many other bivalves, are considered to be benthic, infaunal, and sedentary. They are normally found buried and expose only their siphon tips at the sea bottom. In an account of a trip in the deep submersible *Alvin*, Edwards and Emery (1968) made a brief statement about seeing a 6-inch surf clam "leaping" across the bottom. Leaping, a behavior that seems to contradict the usual sluggish reactions of surf clams, may be a hitherto unsuspected means of escaping hazards which threaten survival. It may also be an exceptional behavior to which an observer might attach too great a significance. The purpose of this paper is to review the literature on the movement of surf clams and report on our observations of its activities.

Three general locomotor activities have been reported for surf clams: gliding, crawling, and burrowing (Belding, 1910; Ropes and Merrill, 1966; Ropes, 1967). Gliding, the result of a clam forcefully pushing itself off of a substrate by a sudden straightening of the bent, extended foot, is termed "leaping" by Ansell (1969). The clam glides with the posterior part of its shell directed like a keel (Fig. 1). Muscular activities of the foot or adductor muscles that might be used for swimming movements have not been seen during the gliding act. After a leap, a surf clam glides for only a few seconds and then falls to the bottom because of negative buoyancy.

Our observations of gliding surf clams were incidental to other experiments. The action was very infrequent. For example, more than 30,000 small clams, hand dug between 1964 and 1967 from the beach at Wallops Island, Virginia, immediately reburrowed if left on the sand surface. This action happened whether the clams were in or out of the water. Only two small ones, 25 to 30 mm. in length, were seen gliding in the water. Upon landing on the sand surface, they began to reburrow.

Stimuli for the gliding or leaping response in *Mactra corallina*, a close relative of *S. solidissima* in the family Mactridae, have been reported by Ansell (1969) to be: (1) close proximity or contact with a predator, (2) failure of the foot to penetrate the substratum, and (3) exposure to air. He considered the latter two stimuli to be of minimal ecological significance and explained that, to increase the chance of contact and obtain a reaction from predators, the clams were confined in small aquaria. No mention

FIG. 1. A small (about 25 mm. long) surf clam leaping.

was made of the possibility of a clam closing its shells or burrowing deeper in the substratum to avoid predator contact. This latter activity was described by Pratt and Campbell (1956) as a behavior of northern quahogs *(Mercenaria mercenaria)* confined in boxes with predaceous starfish.

Surf clams have adaptations for living in a burrow and divers have always found them there. Burial may be well below the sand surface, because the siphons can be extended nearly equal to the length of the shell. Numerous papillae fringing the siphonal openings (Morse, 1919) may be adaptations to prevent sand from being drawn into the body cavity by the respiratory and food-gathering water currents. The clean shells of most clams taken by dredges or thrown onto beaches by storms indicate that they had been covered completely. A report by Ropes and Merrill (1966) on SCUBA observation of a bed of surf clams near Cape Cod, Massachusetts, stated that the clams were completely buried in the bottom. Visible siphon holes were the only evidence that surf clams were present in the bottom. Another SCUBA diver (Bulloch, 1965) described a surf clam bed about 4 miles offshore from Point Pleasant, New Jersey. He saw surf clams with the posterior portion of their shells protruding from the sandy bottom. All seemed to be oriented in the direction of a strong current flow which had apparently removed sand from around the shells. In spite of this, no clams were seen on the surface or moving about on the surface. On rare occasions, we have seen quantities of commercially caught clams with algae growing on a portion of the shell nearest the siphon. The localized growth of algae implies that these clams have been embedded for some time in the bottom with the posterior end slightly above the surface. It is important to note that none of the divers reported surf clams out of the bottom. The diver who reported on the surf clams near Cape Cod dislodged some and they promptly reburied themselves (Ropes and Merrill, 1966). A clam of commercial size (125 mm. long) took about 2 minutes to burrow into the bottom. Subsequent to these observations, the diver has collected surf clams for us at monthly intervals during 2 years. Although we have asked him to observe and photograph movements, he has been unable to obtain any evidence of crawling, gliding, or leaping.

The movement of surf clams out of their burrows has not been clearly demonstrated as a usual locomotor activity. Surf clams have been observed to elevate themselves out of the bottom substratum on exposed beaches during periods of low tide (Ropes, 1967) (Fig. 2). Exposure of the drained bar to solar heat may have initiated the clam movement out of the bottom. Apparently the effort to dig deeper in the more compact, drier substrate moved the clam upward. However, our attempts to cause surf clams to exhume in laboratory experiments, by draining water from the bottom of the aquarium and exposing the surface of the sand to radiated heat, were unsuccessful.

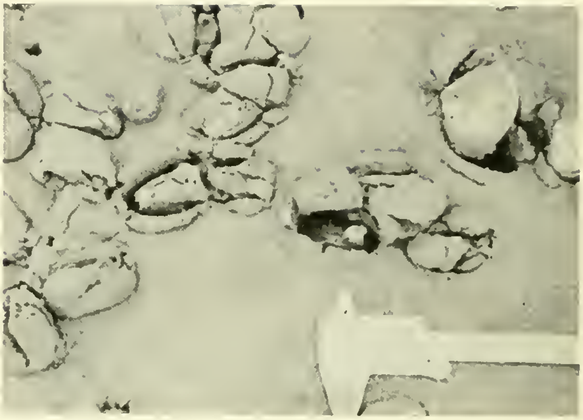


FIG. 2. Surf clams raised out of the exposed intertidal substratum at Wallops Island, Virginia.

Storms appear to be very effective in moving surf clams from an area; large numbers of surf clams are found washed upon the beach after severe winter storms (Yancey and Welch, 1968). Bottom currents, produced during storms, dislodge clams from the bottom and many are unable to burrow quickly enough to avoid being thrown further up on the beach. That many do reburrow is evident, since the surf zone at low tide is one of the best areas to collect small surf clams.

Armstrong (1965) studied the burrowing limitations of 10 species of clams. He found that the clams showed no movement other than rotational or burrowing, and that none were able to exhume or elevate in their burrows under their own power. Clams planted 4 to 7 inches below the tips of their extended siphons died. Our experiments with the juvenile and adult surf clams produced similar results.

We have conducted several other experiments to determine burrowing movements of surf clams. Burrowing ability was considered essential to survival of clams marked and replanted for growth studies

(Ropes and Merrill, 1970). Clams, 50 to 75 mm. long, placed in an aquarium, dug into the bottom soon after initiating burrowing. Descriptions and photographs of this action were reported by Ropes and Merrill (1966). However, small clams averaging 25 mm. also showed some gliding movements, suggesting that small surf clams may be more active than larger ones. Gliding by these small clams was apparently caused by the disturbance of other clams burrowing nearby. The clams burrowed upon landing on the sand surface. Burrowing was the only consistent response observed.

Clams we marked and planted off Wildwood, New Jersey, were recovered in the same area one year later. Several hundred clams were recovered up to two years after being marked and planted in shallow water near Chincoteague Inlet, Virginia (Ropes and Merrill, 1970). Recovery of clams was always within the release area, indicating a lack of movement. Heavy, hydraulic jet dredges used by commercial fishermen are not sufficiently disturbing to cause clams actively to "flee" an area, because the fishermen repeatedly dredge through a dense patch or "hot spot" for periods of several days or sometimes months and still take clams in commercial numbers. The staff of the BCF Exploratory Fishing and Gear Research Base, Gloucester, Massachusetts, have observed surf clam beds and the action of a commercial-type hydraulic jet dredge by underwater television and cinematography. At no time were surf clams seen on the surface of the sand bottom, nor were any seen gliding through the water in escape movements[1]. The many field and laboratory observations demonstrate that surf clams rarely move other than to reburrow when disturbed or removed from their burrows.

We wish to stress that, from our observations, the movement of surf clams can be considered to be infrequent and exceptional. All of the movements we have observed have occurred after the clams were disturbed by removal from the substratum, and the clams invariably reburrowed. Voluntary movements of surf clams out of the bottom have never been reported nor have we been able to induce this activity in laboratory experiments. The ability of most pelecypod mollusks to move through the water is so rare that notes are published reporting such unusual phenomena (Baker and Merrill, 1965). Surf clams, especially the larger adults of commercial size, are, for all intents and purposes, sedentary bottom dwellers.

The above observations were used to prepare a justification for adding the surf clam to the *List of Creatures of the Continental Shelf*. An amended regulation to the law included surf clams and was published in the *Federal Register* on June 23, 1971.

---

[1] Personal communication by Phillip S. Parker, Fishery Biologist, formerly with the BCF Exploratory Fishing and Gear Research Base, Gloucester, Massachusetts.

LITERATURE CITED

Ansell, Alan D. 1969. Leaping movements in the Bivalvia. Proc. Malacol. Soc. Lond. 38: 387-399.

Armstrong, Lee R. 1965. Burrowing limitations in Pelecypoda. The Veliger 7 (3): 195-200.

Baker, Emmett B. and Arthur S. Merrill. 1965. An observation of *Laevicardium mortoni* actually swimming. The Nautilus 78 (3): 104.

Belding, David L. 1910. The growth and habits of the sea clam *(Mactra solidissima)*. Rep. Comm. Fish. Game Mass. 1909, Publ. Doc. 25: 26-41.

Bulloch, David K. 1965. Field observations - 1964. Underwater Natur. 3 (1): 27-28.

Edwards, R. L. and K. O. Emery. 1968. The view from a storied sub - the *Alvin* off Norfolk, Va. Commer. Fish. Rev. 30 (8-9): 48-55.

Morse, Edward S. 1919. Observations on living lamellibranchs of New England. Proc. Boston Soc. Natur. Hist. 35: 139-196.

Pratt, David M. and Donald A. Campbell. 1956. Environmental factors affecting growth in *Venus mercenaria*. Limnol. Oceanogr. 1: 2-17.

Ropes, John W. 1967. The locomotion and behavior of surf clams, *Spisula solidissima*. Proc. Nat. Shellfish. Ass. 57: 4. (Abstract).

Ropes, John W. and Arthur S. Merrill. 1966. The burrowing activities of the surf clam. Underwater Natur. 3 (4): 11-17.

Ropes, John W. and Arthur S. Merrill. 1970. Marking surf clams. Proc. Nat. Shellfish. Ass. 60: 99-106.

Yancey, Robert M. and Walter R. Welch. 1968. The Atlantic coast surf clam - with a partial bibliography. U. S. Fish Wildl. Serv. Circ. 288, 14 pp.

LEO GEORGE HERTLEIN (1898-1972), AN OBITUARY AND FINAL BIBLIOGRAPHY

William K. Emerson
Department of Living Invertebrates
The American Museum of Natural History
Central Park West at 79th, N. Y., N. Y. 10024

Dr. Leo George Hertlein, Curator Emeritus of Invertebrate Paleontology, California Academy of Sciences, San Francisco, died on January 15, 1972 after a brief illness. His death came as a shock to his many friends, for he appeared to be enjoying robust health and looked much younger than his years. He was actively working on several research projects at the Academy until the time of his illness. He had noted on his 1971 Christmas card that he was enjoying his retirement and was now able to devote most of his time to the completion of a long-term study on the geology and paleontology of the marine Pliocene of San Diego, California. The third part of this treatise, a monograph on the pelecypods of the San Diego formation, was in press at the time of his death and has now been published (see review, *The Nautilus*, 86 (2-4). This major contribution, together with more than 150 scientific publications, testifies to his ability and devotion as a scientist who held the universal esteem of his colleagues.

On the occasion of his retirement, the October, 1970, number of *The Nautilus* was subtitled the "Leo George Hertlein Honor Issue" by his friends who contributed a biographic profile, a list of taxa proposed in his honor, a bibliography of his works, a list of names proposed by him, and original papers on Mollusca dedicated to him.

A gentleman and a scholar, Leo was a quiet, friendly man who was always willing to assist others, be they amateurs, students, or professional colleagues. He will be remembered by his many friends as a kind man who combined characters of high moral and ethical strength with a gentleness and warmth of affection that was unique. Leo Hertlein was truly a Prince of a Man.

I have appended Dr. Hertlein's bibliography and a list of new taxa proposed by him, for the period of 1970 to 1972.

Bibliography of Leo G. Hertlein for the period of 1970-1972

Papers preceded by an asterisk (*) contain new taxa.

1970a. *A new species of fossil *Kelletia* (Mollusca: Gastropoda) from the Lomita Marl, late Cenozoic of San Pedro, California. Contributions in Science, Los Angeles Co. Mus., no. 190, p. 1-8, fig. 1-3.

1970b. Review of Carrington, A. J. and B. F. Kensley, 1969, Pleistocene Mollusks from the Namaqualand Coast. Veliger, 12: 381.

1970c. Review of Figueiras, Alfredo and Omar E. Sicardi, 1968, Catálogo de los Moluscos Marinhos del Uruguay. Veliger, 12: 381-382.

1970d. Review of Work, Robert C., 1969, Systematics, Ecology, and Distribution of the Mollusks of Los Roques, Venezuela. Veliger, 12: 382.

1970e. Review of Barnard, K. H., 1969, Contributions to the knowledge of South African Mollusca. Part IV: Veliger, 12: 382.

1970f. Review of Ludbrook, Nellie H., 1969, The genus *Miltha* in the Australian Cainozoic: Veliger, 13: 114.

1970g. Review of Kensley, Brian and Mary-Louise Penrith, 1970, New records of Mytilidae from the northern South West African coast: Veliger, 13: 205.

1970h. (with Victor A. Zullo) Catalogue of specimens in the type collection of the Department of Geology, California Academy of Sciences, Cephalopoda: Occ. Papers California Acad. Sci., no. 82, 130 pp.

1971a. Review of Kosuge, Sadao, 1969, Fossil Mollusks of Oahu, Hawaiian Islands: Veliger, 13: 301.

1971b. Review of Fischer-Piette, E., M. Kempf, and A. M. Testud, 1969, Nouvelles données sur les Veneridae (mollusques, lamellibranches) du Brésil: Veliger, 13: 302.

1971c. Review of Darragh, Thomas A., 1970, Catalogue of Australian Tertiary Mollusca (except chitons): Veliger, 13: 302.

1971d. The researcher and the library: Spec. Libr. Assoc., San Francisco Bay Reg. Chap. Bull., 41 (4): 7-8.

1971e. Review of Osorio, Cecelia and Nibaldo Bahamonde, 1970, Lista preliminar de lamelibranquios de Chile: Veliger, 13: 373.

1971f. Review of Ageitos de Castellanos, Zulma J., 1970, Catalogo de los moluscos marinos Bonaerenses: Veliger, 13: 374.

1972a. *Description of a New Species of *Chlamys* (Mollusca: Pelecypoda) From the Galápagos Islands: Proc. California Acad. Sci., ser. 4, 39 (1): 1-6, 5 figs.

1972b. (with Victor A. Zullo): Catalog of Specimens in the Type Collection of the Department of Geology, California Academy of Sciences. Echinodermata: Occ. Papers California Acad. Sci., no. 91, 26 pp.

1972c. *Pliocene fossils from Baltra (South Seymour Island), Galápagos Islands: Proc. California Acad. Sci., ser. 4, 39 (3): 25-46, 39 figs.

1972d. *(and Grant, U. S., IV). The geology and paleontology of the marine Pliocene of San Diego, California, Pt. 2b, Paleontology (Pelecypoda): San Diego Soc. Nat. Hist. Mem., 2: 135-411, text figs. 7-13, pls. 25-57.

Names Proposed by Leo G. Hertlein From 1970 To 1972

The format follows that used in the previous listing for the period of 1925 to 1970 (Nautilus 84 (2): pp. 52-69). All the new taxa in the present list are mollusks and are referable to the class Bivalvia (Pelecypoda), except *Kelletia kanakoffi*, which is a gastropod.

abbotti Hertlein & Grant, *Chlamys abietis* 1972d: p. 196, pl. 34, fig. 5; pl. 36, figs. 1, 6.

allisoni Hertlein & Grant, *Chione (Chione)* 1972d: p. 273, pl. 51, figs. 11-16.

ashleyi Hertlein & Grant, *Semele* 1972d: p. 299, pl. 48, figs. 3, 4, 6, 9, 10.

axinola Hertlein & Grant, 1972d: p. 159. Type species by original designation: *Axinaea* (? *septentrionalis,* var.) *subobsoleta* Carpenter, 1864.

balboana Hertlein & Grant, *Nucula (Ennucula)* 1972d: p. 145, pl. 27, figs. 1-4.

baltrana Hertlein, *Diplodonta subquadrata* 1972c: p. 33, figs. 8, 11.

diegoana Hertlein & Grant, *Aligena* 1972d: p. 235, pl. 44, figs. 1, 6; pl. 45, figs. 6, 7, 10, 11, 13.

diegoana Hertlein & Grant, *Dosina (Dosina) ponderosa* 1972d: p. 265, pl. 47, figs. 2, 3, 6, 8, 10; pl. 49, fig. 8, pl. 51, fig. 14.

ellisi Hertlein & Grant, *Chlamys (Chlamys) hastata* 1972d: p. 190, pl. 31, figs. 2, 3; pl. 34, fig. 6.

frankiana Hertlein & Grant, *Borina (Temblorina)* 1972d: p. 238, text fig. 11.

incantata Hertlein, *Chlamys (Chlamys)* 1972a: p. 2, figs. 1-5.

irusella Hertlein & Grant 1972d: p. 279. Type species by original designation: *Venus lamellifera* Conrad, 1837.

kanakoffi Hertlein & Grant, *Chione (Securella)* 1972d: p. 274, pl. 49, figs. 1, 3, 4-6; pl. 51, figs. 4-7, 10.

kanakoffi Hertlein, *Kelletia* 1970a: p. 1, figs. 1-3.

kanakoffi Hertlein & Grant, *Thracia* 1972d: p. 338, pl. 42, figs. 11, 13-15.

orcutti Hertlein & Grant, *Lima (Limaria)* 1972d: p. 215, pl. 35, fig. 11; pl. 36, figs. 2-5; pl. 57, fig. 10.

stephensae Hertlein & Grant, *Psephidia* 1972d: p. 280, pl. 44, figs. 21, 22, 24, 26.

sternbergi Hertlein & Grant, *Mytilus (Crenomytilus) coalingensis* 1972d: p. 163, pl. 41, figs. 10, 14.

BOOK REVIEW

ART FROM SHELLS. By Stuart and Leni Goodman. 210 pp., 393 photographs, 21 in color. Crown Publ. Inc., 419 Park Ave. South, N. Y., N. Y. 10016. Paperback, $3.95; cloth, hardback, $7.95.

This is probably the most extensive and most practical book on the subject of using shells in jewelry, shell pictures, collages, figurines, and shell sculptures. It is profusely illustrated with simple pictorial steps on how to clean, mount and use shells in various art forms. There are short sections on collecting and cleaning shells, as well as a current list of suppliers.

R. Tucker Abbott
Delaware Museum of Natural History

THE PROBLEM OF THE LAND SNAIL GENUS *RABDOTUS* IN TEXAS ARCHEOLOGICAL SITES

John W. Clark, Jr.
Balcones Research Center
Rt. 4, Box 189, Austin, Texas 78756

Vast numbers of land snails, principally *Rabdotus dealbatus* (Say) in central Texas and *R. schiedeanus* (Pfr.) in south and southwest Texas (Pratt 1969: 47-48), are found in prehistoric archeological sites. These snails often occur in lenses of thousands of adult shells associated with cultural debris in burned rock middens in central Texas and in rockshelters in southwest Texas.

The area in central Texas in which this phenomenon occurs lies within the Edwards Plateau region, especially to the east and south edges of the Balcones Escarpment where limestone forms the bedrock and numerous streams dissect the plateau. This area falls within the Balconian Biotic Province described by Blair (1950: 12-13).

In southwest Texas, the area of snail-archeological association is quite restricted. It is centered on the Rio Grande River in the vicinity of the mouths of the Pecos and Devil's Rivers. This area falls on the boundaries of Blair's Chihuahuan and Balconian Biotic Provinces (Blair 1950: 105-108). It is characterized by a limestone plateau dissected by deep canyons. Both areas are within the Great Plains Province which is characterized by decreasing annual rainfall from east to west (Carr 1967: 3-4) so that the central Texas area receives between 22 and 30 inches of rain per year while the southwest area receives between 13 and 16 inches per year. *Rabdotus* shells are also found in some archeological sites in south Texas associated with Blair's (1950: 102-105) Tamaulipan Biotic Province.

The vast numbers of these snails in central Texas burned rock middens was noted as early as 1932 (Pearce) and 1933 in southwest Texas (Martin). Numerous hypotheses have been formulated since then attempting to explain this phenomenon. The four principal hypotheses are:

(1) These snails were intentionally collected as a source of protein in the diet (Martin 1933 and Suhm 1957),

(2) They represent a natural population of snails attracted by decomposing midden refuse,

(3) They were carried to the sites inadvertently on vegetation collected by the Indians, and

(4) They were collected for their shells which were used as adornment (Martin 1933). *Rabdotus* shells appear to have accumulated or been collected in the two regions over quite a long period of time, from about 8,000 B.C. at Arenosa Shelter at the mouth of the Pecos River to about 1,000 B.C. in central Texas.

Unfortunately, much of the speculation has been based on little empirical evidence. There is no good ethnographic account of Indians in either region eating snails and the evidence for the use of shells for decoration is scant. No empirical evidence for the remaining hypotheses has been obtained through archeological techniques. One of the principal problems concerning the presence of *Rabdotus* is whether they were principally collected as a food source. Providing they are preserved, the presence of radulae of these snails in coprolites (dessicated human feces) could be a major factor in assigning hypothesis number one as the principal cause of the snail lenses in the sites. Coprolites are present in a collection from a rockshelter in southwest Texas. Analysis of coprolites from occupation lenses in which numerous snail shells were found should provide some important data on the snail collection at this site and, by extension, at other sites.

This short paper is principally a plea for information concerning the validity of the hypotheses presented herein and an appeal for co-operation of malacologists in the analysis of coprolite samples for snail radulae.

LITERATURE CITED

Blair, Frank W. 1950. The Biotic Provinces of Texas. The Texas Journal of Science. 2(1).

Carr, John T., Jr. 1967. The Climate and Physiography of Texas. Texas Water Development Board, Report, 53.

Martin, George C. 1933. Archaeological Exploration of the Shumla Caves. The Witte Memorial Museum, Bulletin 3.

Pearce, J. E. 1932. The Present Status of Texas Archeology. Bulletin of the Texas Archeological and Paleontological Society 4.

Pratt, William D. 1969. *Rabdotus* in Texas, Preliminary Revision of the Land Snail Genus. The American Malacological Union, Inc., Annual Reports for 1969: 47-48.

Suhm, Dee Ann. 1957. Excavations at the Smith Rockshelter, Travis County, Texas. The Texas Journal of Science, 9(1).

NOTES ON VERONICELLIDAE AND ATHORACOPHORIDAE IN FIELD MUSEUM OF NATURAL HISTORY, CHICAGO.

Lothar Forcart
Naturhistorisches Museum, Basel
Switzerland

Dr. A. Solem entrusted me with the identification of slugs in the collections of Field Museum of Natural History, Chicago. These materials expand our knowledge on the distribution and taxonomy of several veronicellid and athoracophorid species. The following abbreviations indicate the repository of cited materials:

FMNH	Field Museum of Natural History, Chicago.
MG	Zoologisches Institut und Museum, Gottingen.
NMB	Naturhistorisches Museum, Basel.
ZMB	Zoologisches Museum, Berlin.

VERONICELLIDAE

Laevicaulis alte **(Ferussac, 1821)**

Material examined: New Caledonia, E. coast 5 km. N. of Theim (2 spec., FMNH 144278, coll. Jan. 1962 by A. & B. Solem); W. coast 8 km. W. Bourail (6 spec., FMNH 159224, 159237, coll. Oct. 1967 by L. Price).

Remarks: Grimpe & Hoffman (1925, p. 366) previously recorded *L. alte* from New Caledonia. A summary of its complex synonymy is given in Forcart (1969, pp. 148-149).

Veronicella (Tenacipes) tenax **Baker, 1931**

Veronicella (Tenacipes) tenax Baker, 1931, Nautilus, **44** (3): 131, pl. 8, figs. 3-5. (Ensenada de San Vicente, Pinar del Rio, Cuba).

Material examined: West Indies: Puerto Rico, foot of stone cliff (2 spec., FMNH 157272, coll. Feb. 1968 by M. Moran). Dominica (5 spec., FMNH 157135, coll. Feb. 1968).

Remarks: All specimens are juvenile, the largest being only 46.5 mm. long, as compared to the 96-105 mm. holotype and paratypes described by Baker. They agree with the original description in the notum having small papillae, in the sole being considerably shorter than the notum and completely surrounded by the hyponota, the posterior end being rounded and crossed by numerous fine, transverse grooves. The anus is as in the subgenus *Leidyula,* only partly covered by the foot. The vagina is without accessory bursa. The penis and the stimulatory organ (dart-gland in Baker 1931) are as figured by Baker (1931, pl. 8, figs. 4, 5) for the holotype.

All these specimens differ from the types in lacking whitish spots on the notum. The three specimens from Dominica have dark lateral bands on the notum.

?Vaginulus (Latipes) occidentalis **(Guilding, 1825)**

Onchidium occidentale Guilding, 1825, Trans. Linn. Soc., London, **14**: 323, pl. 9, figs. 9-10. (St. Vincent, Windward Islands).

Vaginulus (Latipes) occidentalis (Guilding), Baker 1925, Proc. Acad. Nat. Sci. Philadelphia, **77**: 174-177, pl. 5, figs. 18-20.

Material examined: Almirante, Bocas del Toro, Panama. (5 spec., FMNH 86536, coll. Mar. 1959 by H. S. Dybas).

Remarks: The examined specimens agree with those Baker (1925) described from Panama. No type-specimens of *V. occidentalis* exist, and I have not been able to examine specimens from St. Vincent. *Onchidium occidentale* is a *nomen dubium* and it is doubtful whether the specimens from Panama are the same species. Proposal of a new name for the Panama specimens should wait until the identity of the St. Vincent specimens has been determined.

Vaginulus (Angustipes) buergeri **(Simroth, 1914)**

Vaginula bürgeri Simroth, 1914, Mém. neuchâteloise Sci. nat., 5: 328, pl. 14, figs. 124-126. - Santo Domingo. Lectotype and 2 lectoparatypes MG (see Thomé, 1970: 73-76, figs. 1-7).

Cylindrocaulis occidentalis Hoffmann 1925, Jena. Z. Naturw., **61** (½): 144-147 partim, pl. 5, fig. 45, 2, d, F.

Material examined: Salilia, Dominica. (3 spec., FMNH 157147).

Remarks: The detailed redescription of *V. buergeri* by Thomé (1970, pp. 73-76, figs. 1-7) makes it evident that Baker (1925, 180-182, pl. 6, figs. 28-30) described another species under this name.

The bursa of the receptaculum seminis is elongate, sessile (Thomé, 1970, p. 88, fig. 5), and has no differentiated stalk as described by Baker (1925, p. 181, pl. 6, fig. 28). The stimulatory organ has only 9 tubules, of which some are bifurcated (Thomé, 1970, p. 175), and not 26, as mentioned by Baker (1925, p.

181). The verge is short, lanceolate, as figured by Hoffman (1925, pl. 5, fig. 45, d, 2, F) and Thomé (1970, p. 87, fig. 7), and has no spiral ridges, as described by Baker (1925, p. 181, pl. 6, figs. 29, 30).

Vaginulus (Sarasinula) plebeius **Fischer, 1868**

Material examined: Saint Martin, Leeward Islands (1 spec., FMNH 173062, coll. Oct. 1947 by Oden Meeker); Saba Island (1 spec., FMNH 157155, coll. Jan. 1968).

New Caledonia, 19 km north of Boulouparis (2 spec., FMNH 159240, coll. Oct. 1967 by L. Price) and 8 km west of Bourail, on pierced rock (3 spec., FMNH 159224, coll. Oct. 1967 by L. Price).

Marianas, Saipan (1 spec., FMNH 173065, coll. Feb. 1945); Guam, Ritidian Point (1 spec., FMNH 173063, coll Aug. 1945 by H. S. Dybas).

Philippine Islands, Leyte, San José (1 spec., FMNH 173064, coll. Dec. 1944 by E. Ray).

Moluccas, Ambon, Wasi (25 spec., FMNH 172984, 172986, 172991, 172992, 172993, coll. 1964, Sept. 1965 by A. M. Wegner).

Remarks: Except for New Caledonia, *V. plebeius* was not reported previously from these islands. It is probably of West Indian origin, and has been accidently introduced to Pacific and Mascarene Islands (Baker, 1931, p. 135). A full synonymy is given by Forcart (1969: 150).

Semperula schneideri **(Simroth, 1895)**

Vaginula schneideri Simroth, 1895, SB. Naturf. Ges. Leipzig, **19/21**: 7. - Tandjong, Kuba, East Sumatra.

Material examined: Tebing Tingii, Perlis, Malaya (1 juv. spec., FMNH 156725, coll. Feb. 1966 by A. Berry) under moist leaves at foot of hill.

Semperula celebensis **Hoffmann, 1941**

Vaginula melotomus, Bollinger 1918, Rev. Suisse Zool.. 26 (9): 319, not *Vaginula melotomus* P. Sarasin & F. Sarasin, 1899.

Semperula idae, Grimpe & Hoffmann 1925, Z. wiss. Zool., **124** (1): 33-36 partim, fig. 14 (p. 14); Hoffman 1925 Jena Z. Naturw., **61** (½): 186-189, 255-256 partim, pl. 6, fig. 45, k, 2. Not *Vaginula idae* Semper, 1885.

Vaginula (Semperula) idae, Forcart 1935, Verh. Naturf. Ges. Basel, 46, p. 54, not *Vaginula idae* Semper, 1885.

Semperula wallacei var. *celebensis* Hoffmann, 1941, Zool. Anz., **136**(11/12): 234. New name for *Vaginula melotomus* Bollinger, 1918, not P. Sarasin & F. Sarasin, 1899. Type locality (restricted): South Celebes, Lamontjong. Lectotype NMB 2419-b, coll. P. & F. Sarasin 1902/03. 5 lectoparatypes. NMB 2419-a from Central Celebes, Gimpu, coll. P. & F. Sarasin 1902/03.

Material examined: Western Samoa, Upolu, Solaua-Sauniato road junction, coconut-cocoa plantation (1 spec., FMNH 152677, coll. Nov. 1965, by A. Solem & L. Price). Moluccas, Ambon, Wasi (5 spec., FMNH 172987, 172988, 172991, coll. 1964 by A. M. Wegner).

On the Veronicellidae from Ambon

Van Benthem Jutting (1953, p. 300) listed from the Moluccan Island of Ambon *Laevicaulis alte* (Férussac), *Filicaulis bleekeri* (Keferstein), and *Semperula maculata* (Templeton). These citations are erroneous. Martens (1867, p. 176) described the first Veronicellid known from Ambon as *Vaginulus hasselti*, mentioning it (p. 68) from Bangkok, Thailand, and (pp. 176-177) from Sumatra, Borneo. Ambon, and Banda. Hoffmann (1925: 136-137), revising syntypes of *V. hasselti* (ZMB). found those from Bangkok and Sumatra identical with *Filicaulis bleekeri* (Keferstein, 1865), but those from Ambon and Banda with *Semperula maculata* (Templeton, 1858).

Vaginula bocagei Simroth, 1893 was described as from Ternate, Ambon, and from Banda. Grimpe & Hoffmann (1925: 29-30), revising 14 specimens in the ZMB labeled *V. bocagei*, probably the syntypes of *V. bocagei*, stated that 9 specimens from Ambon are identical with *Semperula maculata*, and 5 specimens from Banda with *Laevicaulis alte* (Fér.). *Laevicaulis alte* is consequently not known from Ambon. and the citations of Ambon as locality of *L. alte* in Grimpe & Hoffmann (1925, p. 28) and Hoffmann (1925: 227) are erroneous.

The revisions of the specimens from Ambon published as *Vaginulus hasselti* and *Vaginula bocagei* resulted that these determinations are misinterpretations for *Semperula maculata*, hitherto the sole species known from Ambon. *Semperula celebensis* Hoffmann and *Vaginulus (Sarasinula) plebeius* Fischer are added to the fauna of Ambon by the new material.

ATHORACOPHORIDAE

Aneita (Aneita) simrothi **Grimpe & Hoffmann, 1925**

Aneita simrothi Grimpe & Hoffmann, 1925, in Sarasin & Roux, Nova Caledonia, 3 (3): 421, figs. 15e, 16g, 17d, 18e, 20, pl. 5, figs. 5 a, b, 14 a, b. Type locality: New Caledonia, Mt. Ignambi near Oubatche, 700-1300 m alt. Syntypes NMB 3448 a, b, coll. April & May, 1911 by F. Sarasin & J. Roux.

Material examined: 6.4 km East of Ouegou, Northeast New Caledonia, at ± 130 m alt. (6 spec., FMNH 159245, coll. Oct. 1967 by L. Price). The biggest specimen has a length of only 53.8 mm. as compared with the 85 mm. length of the largest syntype.

LITERATURE CITED

Baker, H. Burrington. 1925. North American Veronicellidae. Proc. Acad. Nat. Sci. Philadelphia, 77: 157-184, pls. 3-6.

Baker, H. Burrington. 1931. Notes on West Indian Veronicellidae. Nautilus: 44 (4): 131-137, pl. 8.

Benthem Jutting, W. S. S. van. 1953. Annoted list of the non-marine Mollusca of the Moluccan Islands Ambon, Haruku, Saparua and Nusu Laut. Treubia, 22 (2): 275-318.

Bollinger, G. 1918. Land-Mollusken von Celebes. Rev. Suisse Zool., 26 (9): 309-340, pl. 11.

Forcart, L. 1935. Revision der Vaginuliden aus Celebes in der Sammlung des Basler Naturhistorischen Museums. Verh. Naturf. Ges. Basel, 46: 50-55.

Forcart, L. 1969. Veronicellid land slugs from the New Hebrides, with description of *Semperula solemi* new species. Fieldiana Zool., **51** (12): 147-156.

Grimpe, G. & Hoffmann, H. 1925: Versuch einer Revision der indischen, indo- und polynesischen Vaginuliden. Z. wiss. Zool., **124** (1): 1-50.

Grimpe, G. & Hoffmann, H. 1925a. Die Nacktschnecken von Neu-Caledonien, den Loyalty-Inseln und den Neuen Hebriden. Sarasin, F. & Roux, J., Nova Caledonia, A. Zool., 3 (3): 339-476, pls. 5-6.

Hoffmann, H. 1925. Die Vaginuliden. Jena. Z. Naturw., **61**(1/2): 1-374, pls. 1-11.

Hoffmann, H. 1941. Ueber einige Vaginuliden auf Grund bisher fur verschollen gehaltener Typstücke. Zool. Anz., **136** (1/2): 229-242.

Martens, Ed. 1867. Die Landschnecken. Die Preussische Expedition nach Ost-Asien, Zool., 2: I-XII, 1-447, pls. 1-22.

Thomé, J. W. 1970. Redescriçao dos tipos de Veronicellidae neotropicais: III. Espécies depostadas no "II. Zoologisches Institut und Museum der Universität" de Göttingen, Alemania. Iheringia Zool., 38: 73-88.

OBITUARY

Gilbert Ranson (1899-1972)

Gilbert Ranson, distinguished French zoologist and oyster expert died in Paris August 19, 1972, at the age of 72. He received the equivalent of B. S. in natural sciences at the Sorbonne in 1923, and was a student of Louis Joubin. He received his Ph. D. in 1927, his thesis being on the physiology of aquatic animals. He published well over 200 articles on diatoms, medusae and especially the taxonomy of oysters. In 1951, he authored the book, *Les Huitres--biologie--culture.* Dr. Ranson became sub-director of the Malacological Laboratory of the National Natural History Museum in Paris in 1938. He was born in France on September 4, 1899.

St. Croix Shell Booklet

A revised edition of "A Supplementary Listing of New Shells (Illustrated) to be added to the Check List of the Marine Shells of St. Croix" by G. W. Nowell-Usticke was published on Dec. 20, 1971. It is privately printed and distributed by the author, 1 North St., Christiansted, St. Croix, Virgin Islands 00820, and is available for $3.69 post free, or $4.00 by airmail. It has 32 pp., an index, 6 pls., many new species and subspecies, many of which are synonyms and/or homonyms.

SHORT PAPERS

CERION FROM AN ARCHEOLOGICAL SITE IN NORTHERN OHIO

James L. Murphy
Sears Library
Case Western Reserve University
Cleveland, Ohio 44106

A single fragmentary specimen of the terrestial gastropod *Cerion incanum* (Binney) has been found in collections from a Late Woodland or Late Prehistoric village site in Lorain County, Ohio. The Eiden Site lies on a bluff top in the village of Sheffield, near the confluence of French Creek and the Black River, two miles south of Lake Erie. The collections were made by A. A. Bungart over ten years ago and are now being analyzed for the Lorain County Park Board by Dr. D. H. McKenzie and Dr. J. E. Blank, Cleveland State University, Dr. O. C. Shane, Kent State University, and the author.

McKenzie and Blank estimate that the major occupation of the site lasted for approximately 50 years, sometime between 1300 and 1450 A.D. Minor Early Woodland and Late Prehistoric components also occur at the site, however. Nonetheless, the overwhelming majority of the materials recovered from the site appear to represent a Late Woodland component, and it is very probable that the *Cerion* shell found in the general midden represents the Late Woodland component.

Other shell artifacts associated with the Late Woodland component include marine shell disc beads, conch columella beads, and *Marginella* beads. The occurrence of such a variety of worked marine shell in a Late Woodland component is unusual and in itself lends support to the contention that the *Cerion* shell belongs to the Late Woodland occupation of the Eiden Site and is a Late Woodland trade item from the Florida Keys.

Dr. R. Tucker Abbott kindly identified the Eiden shell for me. The rather prominent vertical riblets of the two last whorls suggest the form *saccharimeta*, which Pilsbry (1946: 164) has found to intergrade with typical *C. incanum*.

NEW NAME FOR A TEXAN *HYDROBIA*

J. P. E. Morrison
Division of Mollusks
National Museum of Natural History
Washington, D. C. 20560

The species named *Odostomia barretti* Morrison (Proc. Biol. Soc. Wash. 78: 220, fig. 4, 1965) is preoccupied by *Odostomia barreti* L. Morlet (Journ. de Conchyl. 33: 314, 1885), as James X. Corgan of Austin Peay State University, Tennessee, has so kindly pointed out.

On July 25, 1968, with the guidance and helpful assistance of Mrs. Hollis Q. Boone of Houston, Texas, a considerable number of these tiny snails were collected from a narrow stretch of intertidal sand on the west side of Galveston Bay. Examination of the strikingly pink, living animals proved them to belong to the genus *Hydrobia*, as reported (*in litt.*) by Dr. Robert Robertson of the Academy of Natural Sciences of Philadelphia.

I wish to rename this brackish water species *Hydrobia booncae* in honor of Mrs. Boone, who first discovered them in numbers in Texas waters. At present *Hydrobia booneae* is known to be living in waters of reduced salinity between the northeast corner of Heron Bay, Mississippi (the southwest corner of that state) and the west side of Galveston Bay, Texas.

PHYSA ACUTA IN VIRGINIA

Dorothy E. Beetle
Peninsula Nature and Science Center
Newport News, Virginia 23601

Physa acuta Draparnaud, an introduced European fresh water snail, has been found at several localities in coastal Virginia. It is well-established at two localities in the City of Hampton: along the shores of Big Bethel Reservoir and in a small pond receiving water pumped out of Rice's Fossil Pit, a well-known marine Miocene deposit. In the City of Newport News, *Physa acuta* occurs in Lake Maury. It is in York County at Wormley Pond in the Colonial National Historical Park. Another locality is on the North Carolina border of the City of Virginia Beach, Rt. 165, in a small pond behind the beach at Currituck Sound.

Pond bottoms consist of sandy silt, and the snails were found along the shore in dead leaves. Specimens were kindly identified by Dr. William J. Clench.

SPREAD OF *MELANOIDES TUBERCULATA*

R. Tucker Abbott
Delaware Museum of Natural History
Greenville, Del. 19803

The freshwater Asian thiarid, *Melanoides tuberculata* (Müller) is now spreading rapidly southward from United States into Central America. Mrs. Dot Myhre, of Stuart, Florida, has sent us specimens collected in the vicinity of Vera Cruz, Mexico, where the shells are sold by the bagful for making novelties. Dr. Byron N. Chaniotis, of the Walter Reed Army Institute of Research, Canal Zone, collected live specimens in Panama in 1971. The snail, an intermediate host in China for the bile fluke, *Clonorchis sinensis,* arrived in Texas and Florida prior to 1963, and soon thereafter in Puerto Rico. A distributional map showing the range of the species from North Africa to the East Indies prior to 1927 was published by Pilsbry and Bequaert, 1927, Bull. Amer. Mus. Nat. Hist., vol. 53, p. 253.

●

FRESH-WATER MOLLUSKS FROM COASTAL VIRGINIA

Dorothy E. Beetle
Peninsula Nature and Science Center
Newport News, Virginia 23601

The following mollusks were collected from small fresh water creeks and ponds in the independent Cities of Hampton, Newport News and Virginia Beach and York County: *Anodonta cataracta* Say, *Pisidium casertanum* Poli, *Sphaerium occidentale* Prime, *S. partumeium* Say, *Campeloma decisa* Say, *Littoridinops tenuipes* Cooper, *Amnicola limosa* Say, *Pomatiopsis lapidaria* Say, *Physa acuta* Draparnaud, *P. heterostropha* Say, *Fossaria humilis* Say, *F. obrussa exigua* Lea, *Pseudosuccinea columella* Say, *Helisoma anceps* Menke, *H. trivolvis* Say, *Planorbula armigera* Say, *P. wheatleyi* Lea, *Gyraulus parvus* Say, *Menetus brogniartianus* Lea, *M. dilatatus* Gould, *M. dilatatus buchanensis* Lea, *Laevepex fuscus* C. B. Adams. Material is in the collection of the author.

MONOGRAPH REVIEW

THE GENUS *SEMELE* IN THE WESTERN ATLANTIC (Semelidae; Bivalvia) by Kenneth J. Boss. Johnsonia, Harvard University, Cambridge, Mass., Vol. 5, no. 49, pp. 1-32. May 25, 1972.

The taxonomic treatment of the six known living species of Western Atlantic Semelidae is sufficiently good to enable workers to identify their unknown material. The illustrations, descriptions, remarks and locality records are up to the usual standard of previous Johnsonia numbers.

There are, however, a startling number of typographical errors, spelling mistakes, examples of incorrect grammar, and mis-uses of words - at least 97 in only 32 pages. Part of this can be excused because of an improved format of the journal, and a change in printer. Readers should note, however, that the correct spelling for the common semele is *Semele bellastriata* (Conrad), not *bellestriata,* and that the gender of *Semele* is feminine *(lenticularis,* not *lenticulare,* and *solida,* not solidum). The geological terms, particularly those such as Group and Formation, seem not to be employed correctly in several places. Some biological terms are mis-used, such as allometric, when allopatric was meant. Scientific names have been hyphenized, contrary to the "Rules", such as *media-americana* on page 11. However, in the synonymy, they should have been retained, instead of eliminated, as on page 9. The author, and editor, of this monograph has the sympathy of fellow editors and malacologists, but we shall all look forward to a more painstaking effort in future numbers. As Dr. Boss recently stated himself in reviewing another bivalve paper (see Jour. Paleontology, Vol. 45, no. 3, p. 558), "In the final analysis, the editorial offices . . . are responsible for publishing a manuscript which was never critically reviewed in a format which was never carefully proofed, and the short-comings are now the affliction of science -- to the embarrassment of all."

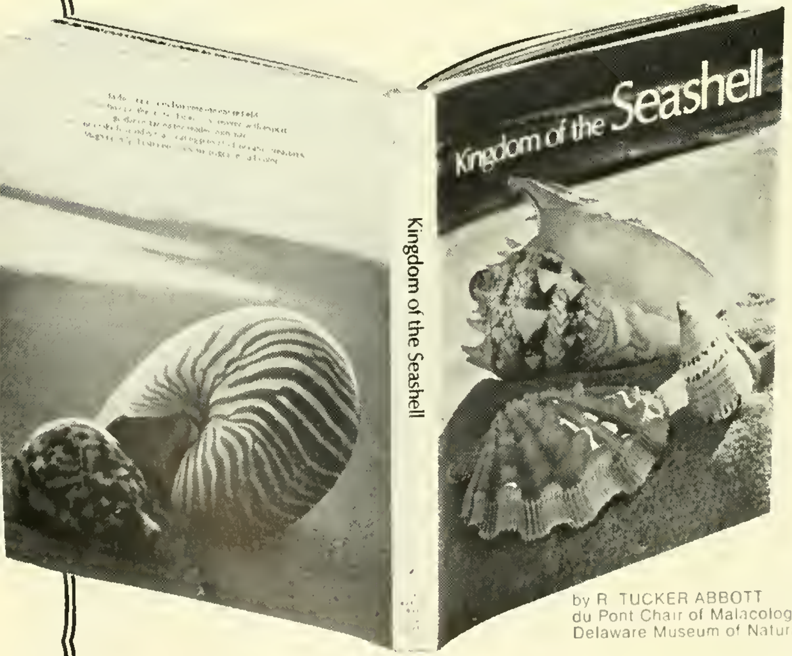
R. Tucker Abbott
du Pont Chair of Malacology
Delaware Museum of Natural History

A. M. U. Meeting

The Thirty-Eighth Annual Meeting of The American Malacological Union will be held in Newark and Greenville, Delaware, from June 25 through 28, 1973. Lodging and the main meetings will be held on the campus of the University of Delaware. Early registration will be possible on Sunday, June 24. One day of meetings will be held at the Delaware Museum of Natural History, near Greenville, about 6 miles from Newark. The current President is Dr. Dee Dundee, Dept. Biology, Louisiana State Univ., New Orleans, La. 70150. Further details will be published in the AMU Newsletter and the April issue of The Nautilus.

INDEX TO THE NAUTILUS

The extensive 279-page Author Index to The Nautilus, vols. 1-75, compiled and published by Aurele La Rocque in 1963 is still available (unbound) for the extremely low price of $2.00 postpaid. A continuation, covering vols. 76-85, was recently published in no. 49 of *Sterkiana,* 1972. Reprints of this very useful addition are also available for 25 cents. When ordering both of these indispensable indices, we suggest an additional 50 cents be added to cover postage. Write: Dr. Aurèle La Rocque, 125 South Oval Dr., Ohio State Univ., Columbus, Ohio 43210.



INFORMATION FOR SUBSCRIBERS

The *annual subscription* rate for *The Nautilus* is $7.00 for individuals and $12.00 for institutions (domestic or foreign). Subscriptions may be commenced in January when a new volume begins. Send check or money order to "The Nautilus" to Mrs. Horace B. Baker, Business Manager, 11 Chelten Road, Havertown, Pa. 19083.

Back issues from volume 72 to date are obtainable from the Business Manager. Volumes 1 through 71 (if available) may be obtained in reprint or original form from Kraus Periodicals, Inc., 16 East 46th Street, New York, N.Y. 10017.

Advertising rates may be obtained from the Business Manager or Editor.

CONTRIBUTORS

Manuscripts: Authors are requested to follow the recommendations of the *Style Manual for Biological Journals,* which may be purchased from the American Institute of Biological Sciences, 2000 "P" Street, N.W. Washington, D.C. 20036. Manuscripts should be typewritten and doublespaced; original and one copy are required, to facilitate reviews. Tables, numbered in arabic, should be on separate pages, with the title at the top. Legends to photographs should be typed on separate sheets. Explanatory terms and symbols within a drawing should be neatly printed, or they may be pencilled in on a translucent overlay, so that the printer may set them in 8 pt. type. There is a charge of 50 cents per word for this extra service. All authors or their institutions will be charged 50 cents per line of tabular material and taxonomic keys. The publishers reserve the right, seldom exercised, to charge $32 per printed page.

An *abstract* should accompany each paper.

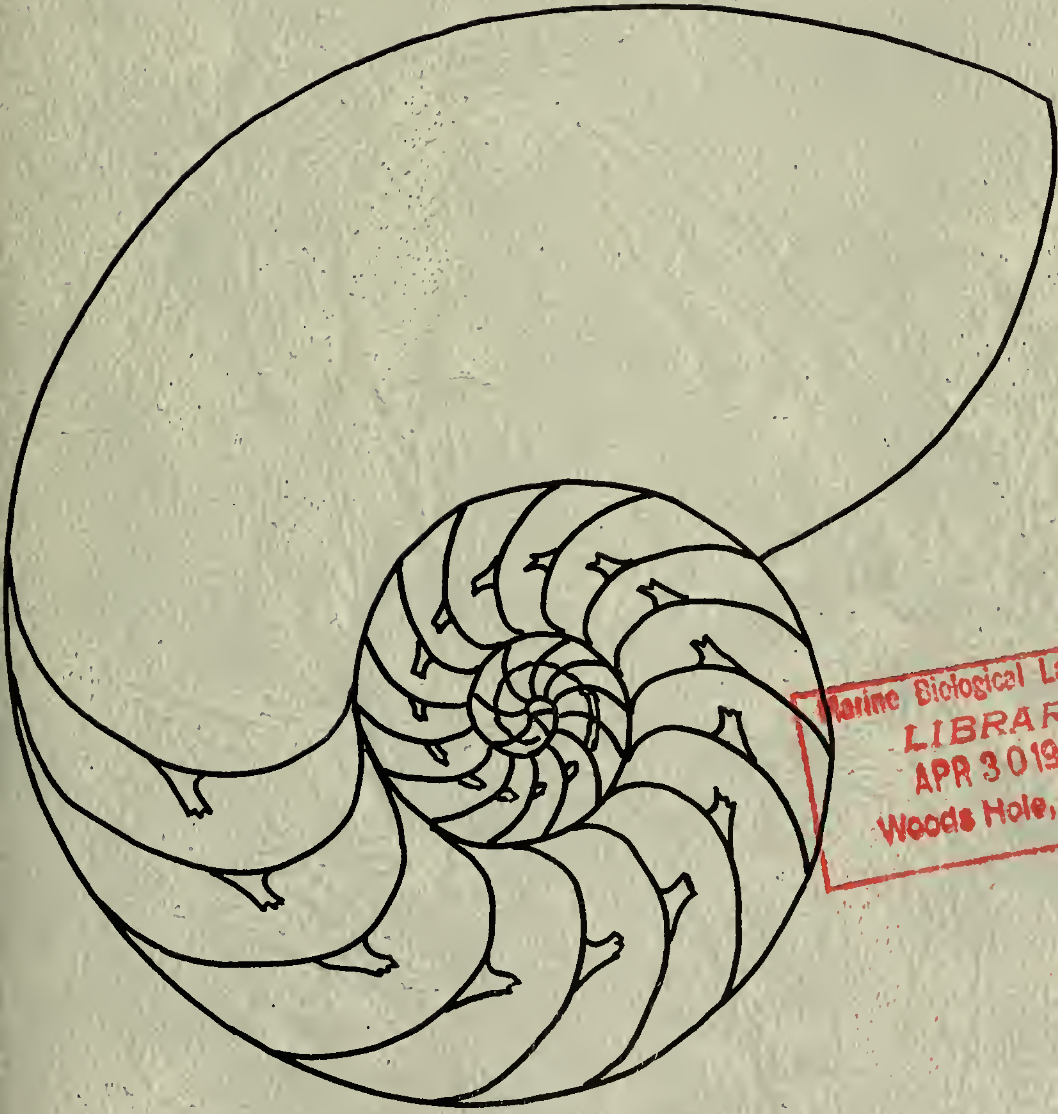
Reprints and covers are available at cost to authors. When proof is returned to authors, information about ordering reprints will be given. They are obtained from the Economy Printing Co., Inc., R. D. 3, Box 169, Easton, Maryland 21601.

APRIL, 1973

THE NAUTILUS

Vol. 87

No. 2



A quarterly
devoted to
malacology and
the interests of
conchologists

Founded 1889 by Henry A. Pilsbry. Continued by H. Burrington Baker.
Editors: *R. Tucker Abbott and Charles B. Wurtz*

EDITORIAL COMMITTEE

CONSULTING EDITORS

EDITORS

OFFICE OF PUBLICATION
Delaware Museum of Natural History
Kennett Pike, Route 52
Box 3937, Greenville, Delaware 19807

Second Class Postage paid at Wilmington, Delaware

Subscription Price: $7.00 (see inside back cover)

THE
NAUTILUS

Volume 87, number 2 -- April 1973

CONTENTS

The Shell Cabinet

Successor to:
Richard E. Petit
and
John Q. Burch

OLIVE SHELLS
OF
THE WORLD

ROWLAND F. ZEIGLER
AND
HUMBERT C. PORRECA

SPECIMEN SHELLS

NATURAL HISTORY BOOKS

International Directory of Conchologists - $3.00
A current worldwide list of 2,000 people interested in mollusks and in exchanging shells. Gives addresses and interests. Available only from The Shell Cabinet.

Olive Shells of the World by Zeigler and Porreca - $12.95
13 full-page color plates illustrating over 150 species and named varieties. The only current treatment of the popular family. Clothbound. Available from your book store or directly from us.

Other Recently Published Shell Books Available
Post Office Box 29, Falls Church, Virginia 22046

Sea Shells of
Tropical West America

Marine Mollusks from Baja California to Peru

Second Edition. *A. Myra Keen* with the assistance of James H. McLean. This revised and expanded classic now treats all molluscan species recorded from the Panamic province and is illustrated with over 4,000 halftones and 85 color photographs. The geographic range has been extended to northwestern Peru. The coverage now extends to microscopic and deepwater species and to the shell-less mollusks. For most of the 3,325 species there are detailed descriptions, synonymies, range data, notes, and one or more illustrations. Included are anatomical drawings, identifying keys, introduction and systematics, rejected species, maps and place-name list, glossary, bibliography, and index. 1,120 pages. $29.50

Stanford University Press

THE HABITS AND HABITATS OF SOME BERMUDIAN MARINE MOLLUSKS[1]

Thomas R. Waller
Department of Paleobiology
Smithsonian Institution
Washington, D. C. 20560

ABSTRACT

During a diving survey of the living habits of scallops (Pectinidae) in bermudian waters, 160 species of shelled mollusks were collected at 40 diving stations. The shallow-water bias in previous bermudian collecting is indicated by the fact that 17 of these species have not previously been reported from Bermuda and 15 of these new records are from depths greater than 30 m. Among the new records are five species of the bivalve family Pectinidae, including Argopecten noronhensis *(E. A. Smith), previously known only from off Brazil but now known to be widely but sparsely distributed in the tropical western Atlantic from Brazil to Bermuda.*

Habitat preferences and living habits are described for several species, including a discussion of species in Harrington Sound relative to the ecological zones described by Neumann (1965). Twenty-one species inadequately figured in the literature are illustrated using optical photographs and scanning electron micrographs.

INTRODUCTION

Despite the fact that Bermuda has been a haven for malacologists since Angelo Heilprin and A. E. Verrill first visited the islands in the late 1800's, the habitats of Bermudian molluscs are still poorly known. Many of the older collections, although rich in numbers of taxa, are poor in habitat data and commonly list only "Bermuda" as the sole record of occurrence for a species. The purpose of this paper is to provide data on the habits and habitats of species collected through diving and to illustrate certain poorly known or previously unillustrated species.[2]

During a period of two weeks in late May, 1971, marine molluscan communities were surveyed by the author and two diving assistants using SCUBA equipment. Although the primary purpose of the survey was to gather data on the living habits and habitats of scallops known from Bermudian waters, collections of other shelled mollusks were made at most of the diving stations. At most stations collecting was by visual spotting and hand picking. In the interest of conservation, many living individuals were examined underwater and returned to their habitat, with later identification assisted by dead shells of the same species found at the site. At the stations deeper than 30 m (Stations 21, 24, and 39), in the deepest portions of Harrington Sound (Stations 1 and 6), and on the bottom of Walsingham Pond (Station 11), short non-decompression time limits or turbid conditions prevented visual collecting, and sediment samples in both net and plastic bags were taken instead. These sediment samples were retained in running salt water and later examined in the laboratory for living material.

The resulting collections contain about 160 species of shelled mollusks (Table 1) distributed among 40 diving stations (Figs. 1, 2, and Table 2). Surprisingly, 17 of these species have not been previously recorded from Bermudian waters.[2] Because all but two of these new records are from the three diving stations deeper than 30 m (Stations 21, 24, and 39), it is clear that much of our present

---

[1] Contribution No. 546, Bermuda Biological Station for Research, St. George's West, Bermuda.

[2] With regard to new records, I am indebted to Mr. Russell Jenson, Assistant Curator, Department of Mollusks, Delaware Museum of Natural History. It is through his help and his extensive records, compiled through a painstaking search of the literature on Bermuda, that I can with reasonable confidence refer to species as having been previously unreported.

knowledge of the Bermudian marine fauna is based on shore and shallow-water collections. Although the West Indian character of the fauna has long been known, it is probable that more intensive collecting by means of diving (deeper than 45 m) and other methods not available to early collectors will continue to turn up a wealth of species previously thought to be restricted to the West Indies proper or to the Atlantic coast of South America.

The stations listed below are plotted in Figures 1 and 2. Groupings of stations according to general environment or ecological zone are shown in Table 2.

Station 1. Devil's Hole, Harrington Sound. Depth, 25 m; bottom temperature, about 20° C; barren mud bottom with mounds, trails, fine excrement, and small shells. May 19, 1971.

Station 2. Devil's Hole, Harrington Sound, on a line extending southeastward from Station 1. Depth, 17 to 9 m; fine sand bottom with abundant *Oculina, Arca,* and *Pododesmus.* May 19, 1971.

Station 3. Devil's Hole, Harrington Sound, on a line extending southeastward from Station 1. Depth, 9 to 6 m; coarse sandy bottom with little vegetation and abundant *Arca zebra.* May 19, 1971.

Station 4. Rocky shore on east side of Devil's Hole, Harrington Sound. Depth, 0 to 3 m. May 19, 1971.

Station 5. Between Trunk Island and Small Island, Harrington Sound. Depth, 3 to 4 m; sandy

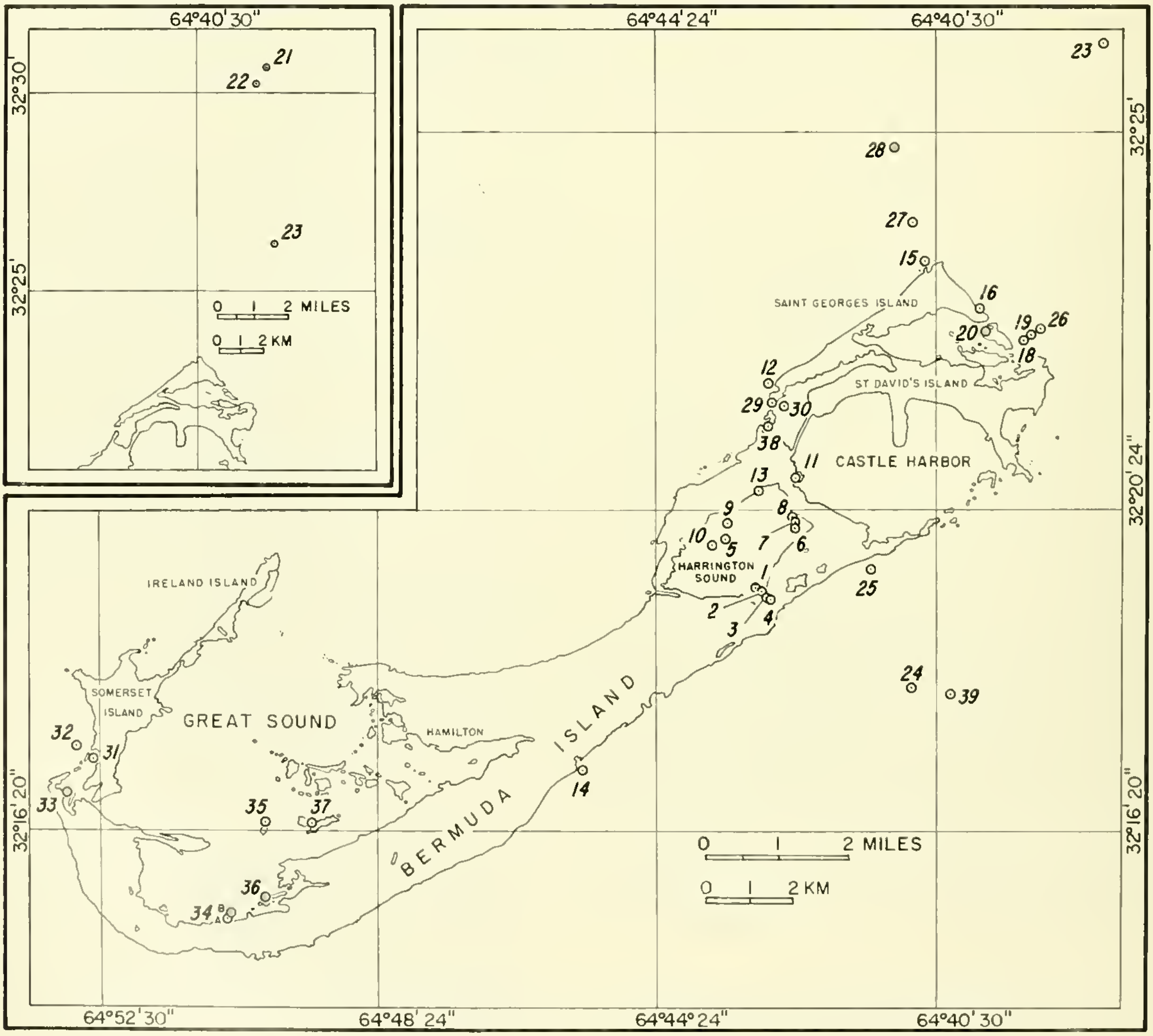


FIG. 1. *Map of the Bermuda Islands showing locations of diving stations.*

bottom with scattered patches of grass. May 19, 1971.

Station 6. Shark Hole, Harrington Sound, along traverse extending north northwestward from a depth of 21 m. Depth, 21 to 18 m; bottom temperature, 19° C; barren mud bottom with mounds, trails, scattered shells, and *Oculina* fragments. May 20, 1971.

Station 7. At 32° 20.2' N, 64° 42.5' W, near Shark Hole, Harrington Sound. Depth, 18 to 11 m; fine sand bottom with abundant *Oculina.* May 20, 1971.

Station 8. Near Station 7, Harrington Sound. Depth, 8 to 11 m. May 20, 1971. No collection was made at this station.

Station 9. Midway between Abbot's Cliff and Trunk Island, Harrington Sound. Shoal area with large areas of barren, sandy bottom covered with the shells of *Arca.* May 20, 1971. No collection made.

Station 10. Southwest side of Trunk Island, Harrington Sound. Depth, 3 to 6 m; sandy bottom with patches of grass. May 20, 1971.

Station 11. Walsingham Pond, Bermuda Island. Depth, 1.5 to 6 m; barren, dark, soupy mud bottom with film of organic matter and small shells. May 21, 1971.

Station 12. Seaward side of rocks at mouth of Whalebone Bay, western end of St. George's Island. Depth, 4.5 m; water temperature, 22°C; coarse sand bottom with abundant hard coral and Gorgonacea. May 22, 1971.

Station 13. Western end of Church Bay, Harrington Sound. Depth 3 to 6 m. May 22, 1971.

Station 14. Hungry Bay, on south shore of Bermuda Island. Depth, 1 m; coarse sand bottom

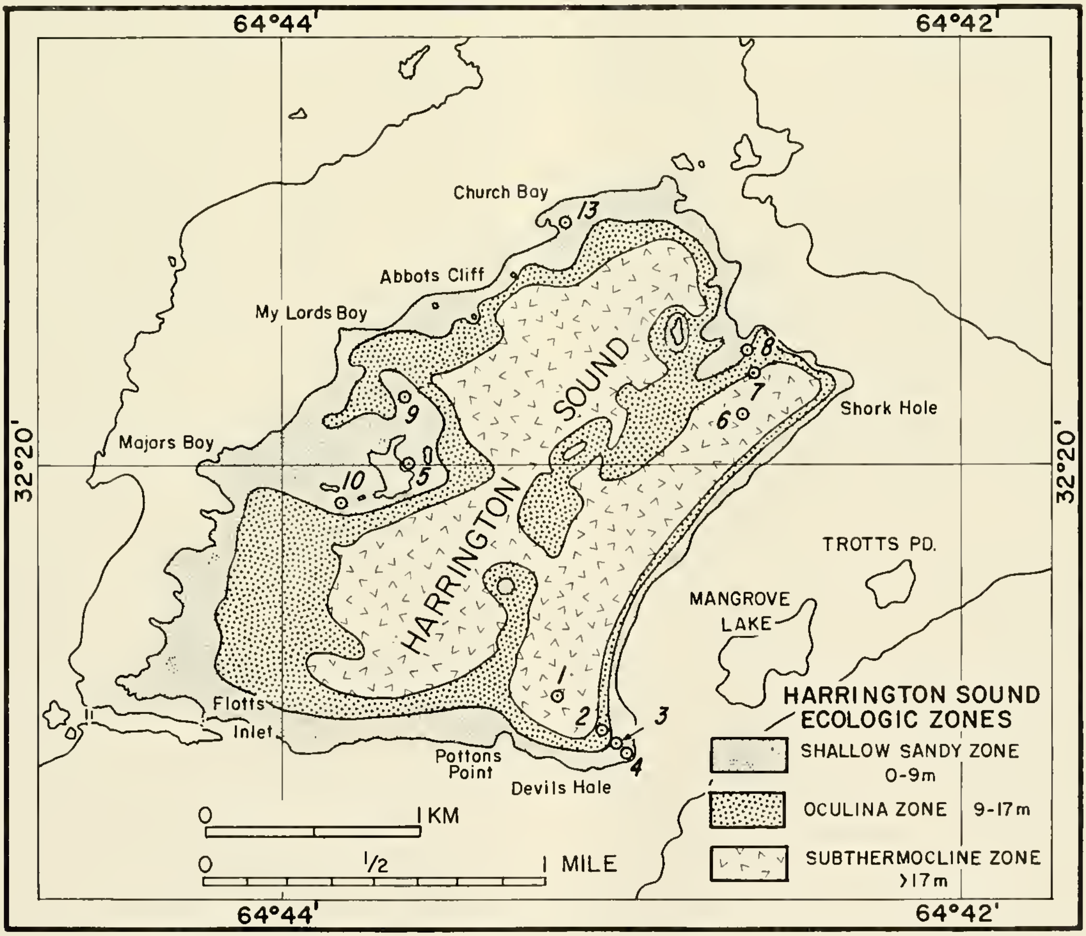


FIG. 2. *Map of Harrington Sound, Bermuda, showing locations of diving stations with respect to the zonation of Neumann (1965).*

with broad-bladed marine grass and the alga, *Pedina.* May 24, 1971.

Station 15. Outside mouth of Hungry Bay, on south shore of Bermuda Island. Depth, 4.5 to 8 m; water temperature, 22° C; bottom of coarse sand and bare rock with potholes. May 24, 1971.

Station 16. Off small bay between Tobacco Bay and Coot Pond, northern St. George's Island. Depth, 6 to 8 m; water temperature 22 to 23° C; coarse sand bottom with large and small coral-covered rocks. May 24, 1971.

Station 17. Buildings Bay, near eastern tip of St. George's Island. Depth, 0.5 to 3.5 m; very coarse, ripple-marked sand bottom with some large rocks and abundant green to lavender leafy algae. May 24, 1971.

Station 18. At 32° 22.4' N, 64° 39.2' W, off mouth of pass between Paget Island and St. Davids Island. Depth, 6 to 7 m; water temperature, 21.5° C; coarse, ripple-marked sand with patches of coral and leafy algae. May 25, 1971.

Station 19. Near Station 18, but further from shore. Depth, about 6 m. May 25, 1971. No collection.

Station 20. Higgs Cut, between Higgs Island and Paget Island at eastern end of St. George's Harbor. Depth, 0.5 to 4.5 m (within small boat channel and surrounding area) and 6 m (deep hole at western end of cut); bottom fine sand and grassy in shallow water, barren sand at bottom of channel. May 25, 1971.

Station 21. At 32° 30.6' N, 64° 38.2' W, northeast of "North East" marker buoy. Depth, 37 m; bottom water temperature, 20.5° C; small coral knolls rising a few feet from the bottom and separated by patches of very coarse, ripple-marked sand. May 26, 1971.

All specimens recorded from this station were picked from bulk samples taken from the sand patches.

Station 22. Anchor chain of "North East" marker buoy, 32° 30.2' N, 64° 38.5' W. Depth, 6 m. May 26, 1971. No collection.

Station 23. Top of large patch reef between St. George's Island and "North East" marker buoy (Station 22). Exact position not plotted. Depth, 18 m. May 26, 1971.

Station 24. At 32° 18.2' N, 64° 40.8' W, off south shore of Tucker's Town. Depth, 34 m; bottom temperature, 20.5° C; high coral patches with scattered small areas of coarse sand. May 27, 1971.

Station 25. At 32° 19.6' N, 64° 41.4' W, inside breaker zone off south shore of Tucker's Town. Depth, 6 to 8 m; patch reefs surrounded by coarse, ripple-marked sand. May 27, 1971.

Station 26. At 32° 22.6' N, 64° 39.0' W, off entrance to St. George's Harbor. Depth, 6 to 18 m; coral platform rising 12 m above a medium to fine sand bottom. May 27, 1971.

Station 27. At 32° 23.9' N, 64° 40.9' W, north northeast of St. Catherines Point, St. George's Island. Depth, 14 m; water temperature, 22° C; silty mud bottom with large colonies of *Oculina.* May 28, 1971.

Station 28. At 32° 24.8' N, 64° 41.2' W, northeast of St. Catherines Point, St. George's Island. Depth, 4.5 to 8 m; patch reef with prolific, diverse coral. May 28, 1971.

Station 29. South side of Ferry Point, western tip of St. George's Island, from rocky shore to a depth of 4.5 m in the channel between Ferry Point and Coney Island. May 29, 1971.

Station 30. At 32° 21.6' N, 64° 42.7' W, in shallow area in mouth of Ferry Reach southwest of Ferry Point. Depth, 1.5 to 3.5 m; *Oculina* patch reef and adjacent sandy bottom. May 29, 1971.

Station 31. North half of Ely's Harbor, Somerset Island. Depth, 1.5 to 6 m. May 30, 1971.

Station 32. Off mouth of Ely's Harbor, Somerset Island. Depth, 2.5 m; patch reef on sandy bottom. May 30, 1971. No collection.

Station 33. South half of Ely's Harbor, Somerset Island. Depth, 1.5 to 6 m. May 30, 1971.

Station 34a. In channel between Wilsons Island and Bermuda Island, Port Royal Bay. Depth, 1.5 to 4 m; fine silty bottom with mounds, worm tubes, and few holothurians. May 30, 1971. No collection.

Station 34b. East side of Wilsons Island, Port Royal Bay. Depth, 1 to 4.5 m; sandy, trash-covered bottom at base of steep, rocky drop-off. May 30, 1971.

Station 35. North end of Grace Island, Great Sound. Depth, 4.5 m; barren, fine sand bottom at base of rocky drop-off. May 30, 1971. No collection.

Station 36. Between Hunts Island and Perots Island, Port Royal Bay. Depth, 3.5 to 5.5 m; firm, clean sand bottom with grass in shallow areas. May 30, 1971. No collection.

Station 37. Transect across channel between Burt Island and Darrell Island, Great Sound. Depth, 1 to 4 m; firm, fine sand with patches of grass. May 30, 1971.

Station 38. Channel between Coney Island and Bermuda Island at northeastern tip of Bermuda Island. Depth, 0.5 to 4.5 m. May 31, 1971.

Station 39. At 32° 18.1' N, 64° 40.2' W, off south shore of Tucker's Town. Depth, 51 m; rubbly, coarse, foraminiferal sand with abundant dark red algal nodules. June 1, 1971.

NOTES ON HABITATS

Harrington Sound

Subthermocline Zone. Neumann (1965) has provided an excellent account of the bathymetry, hydrography, and ecological zonation of Harrington Sound. As described by Neumann (p. 1003), the Subthermocline Zone (Fig. 2) has an abrupt upper boundary at a depth of 17 m (55 feet), at which the extensive, essentially barren mud bottom of this zone meets an area of abundant branching, bushy coral *(Oculina)*, characterized by Neumann as the *Oculina* Zone. This zonal boundary is the result of seasonal water stratification and coincides with the deepest position of a thermocline in summer. During the summer there is little mixing of water beneath the thermocline, resulting in cooler, oxygen-poor water below. Neumann described the subthermocline bottom as a smooth and barren surface marked only by the scattered holes of burrowing organisms, possibly crustaceans, and having patches of a thin purplish algal or bacterial mat. He reported the valves of the small bivalve *Transennella conradina* (but see below) as common on the mud surface, with a few live specimens, and added that this species is the only significant calcareous form.

Our observations confirm Neumann's. At Station 1, near Devil's Hole, we found the upper boundary of the Subthermocline Zone to be sharp and to lie precisely at 17 m. Although underwater visibility was less than 1 m, we observed that the mud bottom was marked with numerous mounds, trails, small dead mollusk shells, and a litter of fine excrement. The dominant bivalve is *Gouldia cerina* (see Notes on Taxa), not *Transennella* as reported by Neumann, and all specimens were dead. In addition we recovered a single valve of a young *Pitar fulminata* as well as numerous dead specimens of a tiny diastomid gastropod (Fig. 26), *Finella dubia* (Orbigny).

The traverse comprising Station 6 (Fig. 2) approached the upper boundary of Neumann's Subthermocline Zone, which here is within a depth interval of 17 to 18 m. We observed that the actual thermocline was very close to this boundary, with water temperature rising from 19° C below the thermocline to 21° above. The more varied fauna than that collected from the same zone at Station 1 is most likely due to the fact that we were near the upper boundary of the Subthermocline Zone at Station 6. Most of the shells collected are rather old, the exceptions being the abundant *Gouldia* and less abundant *Pitar,* the same bivalves represented at Station 1. The valves of *Argopecten gibbus* collected here are of particular interest and are discussed under Notes on Taxa.

As pointed out by Stanley (1970, p. 83), suspension feeders (such as *Gouldia* and *Pitar*) living on soupy muds face the problem of being clogged by loose, fine-grained sediment as they sink into the substrate. Most inhabitants of this type of bottom remain small, thus keeping their surface-volume ratio large and maximizing support from the substratum per unit of animal weight. *Gouldia* appears to be an opportunistic species that colonizes the Subthermocline Zone at times when conditions are most favorable, probably during the time of maximum water mixing in the winter. The species then flourishes until conditions become lethal, probably during maximum summer stagnation.

Oculina Zone. Stations 2 and 7 in Harrington Sound are within the *Oculina* Zone of Neumann (1965, p. 1001), an area between 9 and 17 m (30 and 55 feet) in depth characterized by a fine sand bottom and abundant growth of the branching coral, *Oculina valenciennesi.* As described by Neumann, the coral supports itself on the soft mud by forming bush-like growths on its own debris or on clusters of *Arca zebra. Arca zebra* is by far the most common mollusk in this zone and lives byssally attached in clusters on or near the bottom. Other common bivalves (Table 1) are *Pododesmus rudis* (attached to *Oculina*), *Chama congregata* (attached to any hard object), and *Lithophaga bisculcata* (boring into *Oculina*). Neumann described *Vermicularia* as abundant in the *Oculina* Zone, and Gould (1969, p. 432) has also noted the common association of *Vermicularia* and *Oculina.* Neumann's report of *Anomia simplex* as common in this zone could not be confirmed, and it is probable that he was referring to *Pododesmus,* which was absent from his list.

Shallow Sandy Zone. Stations 3, 5, 8-10, and 13 lie within the Shallow Sandy Zone of Neumann (1965, p. 1001), an area extending in depth from 9 m to the surface (Fig. 2). As described by Neumann, the sandy floor is covered by marine grasses, sponges, and algae in the well-lit regions down to about 4.5 m. Below 4.5 m grass is less abundant and there are more open sandy areas, frequently with large clusters of *Arca zebra.*

The western end of Church Bay, Harrington Sound (Station 13, Fig. 2), within the harbor of a private estate, has a silty sand bottom with little vegetation, common *Cassiopeia* (the bottom-dwelling jellyfish), and common *Anadara notabilis.* About 30 m. out from shore the bottom is more typical of the Shallow, Sandy Zone, with patches of marine grass, coarser, barren sand, abundant *Arca zebra,* and many living *Argopecten gibbus, Pecten ziczac,* and *Macrocallista maculata.* Over sandy bottoms near the rocky shore of Church Bay, both *Pinctada* and *Anomia* are common on the abundant bottles and other trash that litter the bottom.

Walsingham Pond

Twenty years ago De Laubenfels (1950, p. 194), in his colorful style, described the rock walls of Walsingham Pond as a sponge metropolis and noted that the bottom is largely mud-covered, but so deep that the water is clear. A more detailed summary of conditions in the pond was provided by Walton (1969), who studied the bathymetry, sediments, and water chemistry. The maximum depth is about 6 m and the bottom throughout the deeper portions of the pond consists of soupy, pelleted mud covered by a mat of organic matter 5 to 10 cm. thick. The most abundant mollusks in this soupy, mud layer are, according to Walton (op. cit., p. 44), *Batillaria, Vermicularia,* and *Gouldia.*[3] Beneath this layer is a thicker layer of brown pelleted mud with more abundant shells interpreted by Walton to represent a time when the pond was less restricted than at present. Gould (1968) studied the molluscan fauna of Walsingham Pond, listing 9 species of bivalves and 15 species of gastropods. Although he did not distinguish living from dead or fossil material, he stressed the similarity of the overall assemblage to other mangrove-mud environments in Bermuda.

Our collecting concentrated on the mud bottom of the southwest arm of the pond. Contrary to the pristine quality of water implied by De Laubenfels' description, light penetration to the bottom of the pond is now very low, and it was necessary to use lights in order to see small objects on the bottom. Underwater visibility was poor and would rapidly drop to zero if we allowed our trail of disturbed mud to overtake us. As noted by Gould (1968), the bottom harbors a profusion of the bottom-dwelling jellyfish, *Cassiopeia.* Below the organic film and soupy layer is an accumulation of small shells,

---

[3] I infer that Walton's *"Batillaria minima"* is actually *Cerithium variabile* and his *Gouldia* is actually small *Ctena orbiculata.*

FIGS. 3-15. *Bermuda Marine Mollusks. All specimens in optical photographs are coated with ammonium chloride and those in scanning electron micrographs coated with gold unless indicated otherwise.*

FIGS. 3, 4. *Matching left and right valves of* Aequipecten acanthodes *(Dall), syntype, USNM 333637, Santa Lucia, Cuba, height 31.5 mm.*

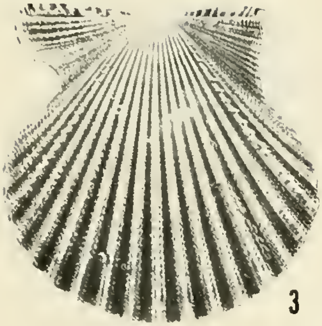
FIGS. 5-7. *Right valve uncoated, matching left valve coated, and sculptural detail of left valve (x 9),* Argopecten noronhensis *(E. A. Smith), USNM 501857, Barbados, height 15.0 mm.*

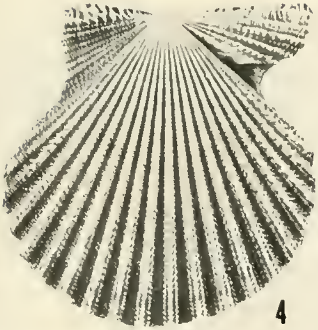
FIG. 8. *Fragment of left valve of* Argopecten noronhensis *(E. A. Smith), USNM 708130, Bermuda Sta. 39, height of fragment 8.0 mm.*

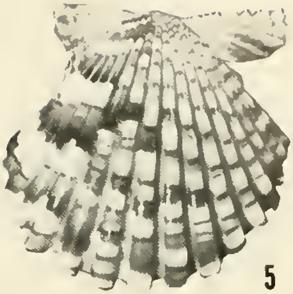
FIGS. 9-11. Chlamys multisquamata *(Dunker), matching left and right valves of specimen from off Palm Beach, Florida, in collection of F. M. Bayer, height 46.8 mm, and fragment of valve, USNM 708131, Bermuda Sta. 39, height of fragment 7.0 mm.*

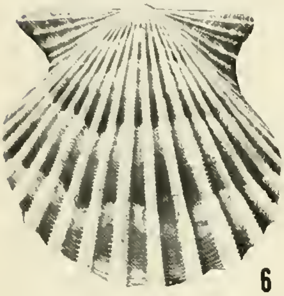
FIGS. 12, 13. *Structural detail of outer surface (x 17) and inner surface of right valve of* Neopycnodonte cochlear *(Poli), USNM 708132, Bermuda Sta. 39, height 12.5 mm.*

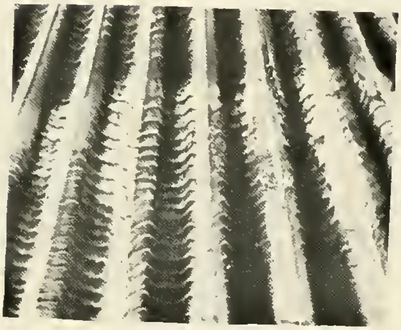
FIGS. 14, 15. *Matching left and right valves of* Limaria hyalina *(Verrill and Bush), USNM 708133, Bermuda Sta. 39, height 4.1 mm.*


3


4

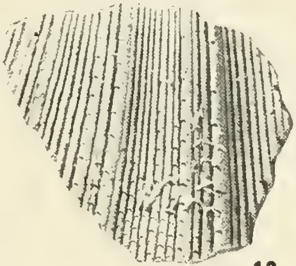

5

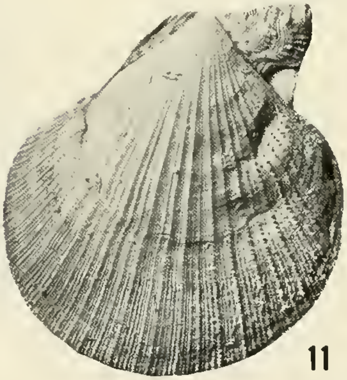

6

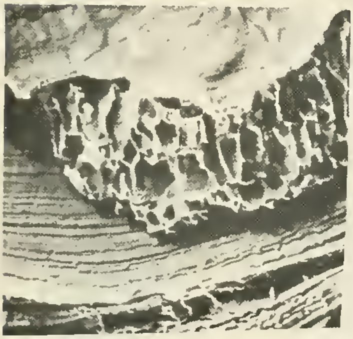

7

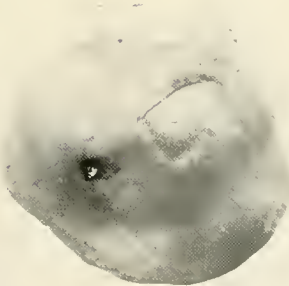

8

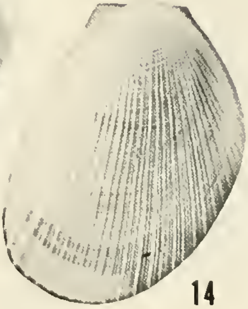

9


10


11


12


13


14


15

Bermuda Marine Mollusks
(explanation on opposite page)

primarily *Vermicularia, Cerithium,* and *Ctena* (Table 1). Live individuals of these species were brought up in samples, but their living positions in the substrate were not observed. Seven species of bivalves and 26 species of gastropods were recovered, with the most abundant species essentially the same as those listed by Gould (op. cit., p. 3). However, our samples, obtained by visual collecting and digging in the muddy bottom by hand, contained no *Gouldia cerina,* listed as "very common" by Gould, and numerous *Anachis catenata,* not recovered by Gould. Many of the less common species in the pond (see Table 1, Station 11) undoubtedly come from the fossil shelly layer mentioned above.

Although many of the species listed may have dropped off the rock walls of the pond, many also probably live on the organic debris and algae coating the muddy bottom, as suggested by a comparison of the list of these species with the list of molluscan-algal associations of Warmke and Almodóvar (1963). The abundance of *Ctena orbiculata* in the pond may reflect stress conditions. Jackson (1970, p. 586) found that lucinids are tolerant of stagnant conditions involving the presence of hydrogen sulfide and, unlike most other bivalves, are able to feed on microbial populations present on plant detritus.

Other Localities

Hungry Bay. Hungry Bay (Station 14), on the south shore of Bermuda Island, is very shallow, less than 1 m. deep at low tide, with a bottom of coarse sand with broad-bladed marine grass and coral fragments. The small alga, *Pedina,* is also abundant, and it is in this shallow area that we found many small (5 mm) *Chione.* At the entrance to the bay and out to a depth of about 8 m (Station 15), the maximum depth of this dive, the bottom is rock with a thin algal covering broken here and there by the tooth marks of large parrot fish. Pot holes up to 1 m. deep and some deep channels have been scoured out of the rock, and the turbulence of the area has left few rocks small enough to overturn. Under the few that could be overturned, *Barbatia domingensis* was common. *Malleus candeanus* was seen far be-

FIGS. 16, 17. *Right valve and hinge (x 15) of* Erycina *sp. aff.* E. linella *Dall, USNM 708134, Bermuda Sta. 24, length 6.2 mm.*

FIG. 18. *Right valve of* Carditopsis smithi *(Dall), scanning electron micrograph, USNM 708135, Bermuda Sta. 11, height 1.7 mm.*

FIG. 19. *Prodissoconch of* Carditopsis smithi *(Dall), scanning electron micrograph, USNM 708136, Bermuda Sta. 11, length 0.39 mm.*

FIG. 20. *Alvania didyma (Watson), scanning electron micrograph, USNM 708137, Bermuda Sta. 21, height 2.1 mm.*

FIG. 21. Alvania platycephala *Dautzenberg and Fischer, scanning electron micrograph, USNM 708138, Bermuda Sta. 11, height 2.4 mm.*

FIG. 22. Caecum delicatulum *Verrill and Bush, scanning electron micrograph, USNM 708139, Bermuda Sta. 11, height 2.9 mm.*

FIG. 23. Cerithiopsis cynthia? *Bartsch, USNM 708140, Bermuda Sta. 24, height 5.0 mm.*

FIG. 24. Triphora mirabilis *(C. B. Adams), USNM 708141, Bermuda Sta. 24, height 9.0 mm.*

FIG. 25. Pusia variata? *(Reeve), USNM 708142, Bermuda Sta. 21, height 18 mm.*

FIG. 26. Finella dubia *(Orbigny), USNM 708143, Bermuda Sta. 1, height 3.3 mm.*

FIG. 27. Aesopus stearnsi *Tryon, USNM 708144, Bermuda Sta. 21, height 4.9 mm.*

FIG. 28. Thala foveata *(Sowerby), USNM 708145, Bermuda Sta. 24, height 4.4 mm.*

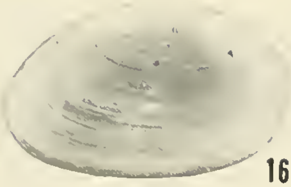
FIG. 29. Pyrgocythara candidissima *(C. B. Adams), USNM 708146, Bermuda Sta. 39, height 4.7 mm.*

FIG. 30. Odostomia didyma *Verrill and Bush, scanning electron micrograph, USNM 708147, Bermuda Sta. 11, height 1.8 mm.*

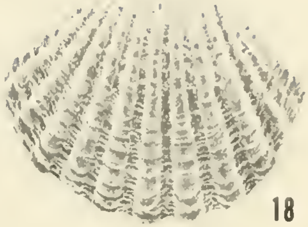
FIG. 31. Mitrolumna biplicata *(Dall), USNM 708148, Bermuda Sta. 39, height 3.9 mm.*

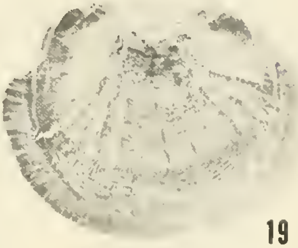
FIG. 32. Odostomia nioba *Dall and Bartsch, scanning electron micrograph, USNM 708149, Bermuda Sta. 21, height 2.5 mm.*

FIG. 33. Turbonilla heilprini *Bush, scanning electron micrograph, USNM 708150, Bermuda Sta. 11, height 2.8 mm.*

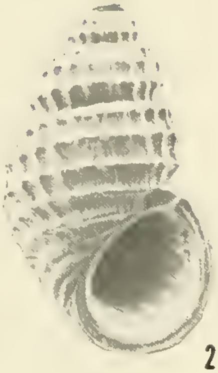

16


17


18


19


20


21


22


23


24


25


26


27

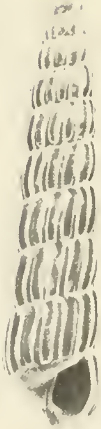

28


29


30


31


32


33

Bermuda Marine Mollusks
(explanation on opposite page)

neath the overhangs of pot holes and channels, whereas *Chama* was common atop the bare rock surface.

Ely's Harbor. Almost the entire area of Ely's Harbor was surveyed for the presence of scallops by towing divers behind the boat, but no living specimens were found. In the north half of the harbor (Station 31), the bottom in the center is soft, barren mud or silt with some coral-covered rocks. Peripheral areas are sandy and grassy with scattered clusters of *Arca zebra.*

North Lagoon. The bottom features and fauna at Station 27, north of St. George's Island, are very similar to those in the *Oculina* Zone of Harrington Sound (Neumann, 1965; see preceding notes) with the dominant mollusks being *Arca zebra, Pododesmus rudis, Vermicularia, Spondylus,* and *Chama.* Many dead *Chlamys imbricata,* not found in Harrington Sound, were present at this station, but no living individuals could be found after an intensive search.

Outer Platform. The deepest areas sampled lie well outside of the breaker zone: Station 21 (depth, 37 m), Station 24 (depth, 34 m) and Station 39 (depth, 51 m). The bottom at these stations consists of patches of barren coarse carbonate sand, generally ripple marked, with intervening patches of coral and algae. The sand at Station 39 consists almost entirely of the tests of the foraminifer, *Amphistegina gibbosa,* and the bottom is strewn with maroon algal nodules. Bulk samples of the sand yielded a profusion of small shells, particularly gastropods such as *Euchelus guttarosea, Zebina browniana,* various cerithiopsids, *Triphora mirabilis, Trivia quadripunctata,* various columbellids and marginellids, and *Williamia krebsii.* Small bivalves are also common, particularly *Arca imbricata, Barbatia domingensis,* fragmented *Comptopallium antillarum, Spondylus, Lima lima, Chama sarda, Trigoniocardia media,* and *Gouldia cerina.* The bivalve *Ventricolaria rugatina,* previously unknown from Bermuda, increases in both size and abundance from Station 24 to the deepest station (Station 39).

In addition to the small mollusks, the tiny brachiopod, *Argyrotheca bermudana* (Dall, 1911), is common in the sand at Stations 24 and 39. Presumably these specimens, like the many byssate and cemented bivalves that are also found in the sediment, have become detached from living sites among and beneath small corals.

The fact that 15 out of 17 new records listed in Table 1 are from the three outer-platform stations is a striking indication of how little is known about the Bermudian molluscan fauna from these depths.

TABLE 1. List of species of shell-bearing Mollusca collected in Bermuda, with references to illustrations and collecting stations. The order of families follows that of Moore (1969) for the bivalves and Taylor and Sohl (1962) for the gastropods. Taxa are alphabetically arranged within each family. Station numbers in bold-face type indicate living specimens; other specimens are represented by shells only. Species not previously known from Bermuda are preceded by an asterisk (*). Specimens that document the list are deposited in the collections of the Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D. C.

Species	Illustration	Stations
BIVALVIA		
Anadara notabilis (Röding, 1798)	Warmke and Abbott	3, **5**, **10**, **13**
Arca imbricata Bruguière, 1789	Warmke and Abbott	12, **18**, 21, 24, **27**, 39
Arca Zebra (Swainson, 1833)	Warmke and Abbott	**2**, **3**, **5**, 6, **7**, **9**, **10**, **13**, **27** **29**, **31**, **33**, **34b**, **35**, 39
Barbatia (Arca) domingensis (Lamarck, 1819)	Warmke and Abbott	11, **12**, **15**, **18**, 21, 24, **27**, 39
**Barbatia (Fugleria) tenera?* C. B. Adams, 1845	Warmke and Abbott	39
Barbatia sp.	—	24
Arcopsis adamsi (E. A. Smith, 1888)	Warmke and Abbott	6, 24
Brachidontes sp.	—	
Lithophaga bisulcata (Orbigny, 1842)	Warmke and Abbott	**2**, **7**

Species	**Illustration**	**Stations**
Modiolus americanus Leach, 1815	Warmke and Abbott	**5**, 37
Musculus lateralis (Say, 1822)	Warmke and Abbott	16, **37**
Pinna carnea Gmelin, 1791	Warmke and Abbott	**29**
Pinctada imbricata Röding, 1798	Warmke and Abbott (as *P. radiata*)	2, 5, 10, 13, 16, 37, 38
Pteria colymbus (Röding, 1798)	Warmke and Abbott	16, 28
Isognomon radiatus (Anton, 1839)	Warmke and Abbott	15, 25
Isognomon sp.	–	24
Malleus (Malvufundus) candeanus (Orbigny, 1842)	Boss and Moore	**15**, **23**, 24, **25**, **26**
Aequipecten acanthodes (Dall, 1925)	**Our Figs. 3, 4**	27, 39
Argopecten gibbus (Linnaeus, 1758)	Warmke and Abbott	3, **5**, 6, **10**, **13**
**Argopecten noronhensis* (E. A. Smith, 1885)	**Our Figs. 5-8**	39
**Chlamys benedicti* Verrill and Bush, 1897	Warmke and Abbott	24, 39
Chlamys imbricata (Gmelin, 1791)	Warmke and Abbott	16, **18**, 24, 25, 26, 27, 28, 29, 39
**Chlamys multisquamata* (Dunker, 1864)	**Our Figs. 9-11**	39
**Comptopallium antillarum* (Récluz, 1853)	Warmke and Abbott	24, 39
**Pecten chazaliei* Dautzenberg, 1900	Warmke and Abbott	24, 39
Pecten ziczac (Linnaeus, 1758)	Warmke and Abbott	2, **3**, **5**, **10**, 12, **13**, 31, 34b, 36, 37, 38
Spondylus americanus Hermann, 1781	Warmke and Abbott	4, 16, 21, 24, **27**, 28, 38, 39
Anomia simplex Orbigny, 1842	Warmke and Abbott	3, **5**, 6, **7**, **10**, **13**, 37, **38**
Pododesmus rudis (Broderip, 1834)	Warmke and Abbott	**2**, **5**, 24, **27**
Lima Lima (Linnaeus, 1758)	Warmke and Abbott	**12**, 21, 24, **27**, **28**
**Limaria hyalina* (Verrill and Bush, 1898)	**Our Figs. 14, 15**	39
**Neopycnodonte cochlear* (Poli, 1795)	Stenzel; **Our Figs. 12, 13**	39
Lopha folia (Linnaeus, 1758)	Warmke and Abbott	3, 5, **10**, **12**, **13**
Anodontia schrammi (Crosse, 1876)	Abbott	3, 5, 20
Codakia orbicularis (Linnaeus, 1758)	Warmke and Abbott	12, 29, 37
Ctena orbiculata (Montagu, 1808)	Warmke and Abbott	6, **11**, 16, 21, 24, 39
Parvilucina costata (Orbigny, 1842)	Warmke and Abbott	5, 6, 16
Erycina sp. *aff. E. linella* Dall, 1899	**Our Figs. 16, 17**	24
Lasaea adansoni (Gmelin, 1791)	Verrill and Bush	11
Carditopsis smithi (Dall, 1896)	**Our Figs. 18, 19**	11
Chama congregata Conrad, 1833	Bayer	**2**, 3, 6, **7**
Chama macerophylla Gmelin, 1791	Bayer	11, **27**
**Chama sarda* Reeve, 1847	Bayer	21, 24, 39
Chama sp.	–	15
Pseudochama radians (Lamarck, 1819)	Warmke and Abbott	**5**, **10**, **27**
Crassinella lunulata (Conrad, 1834)	Warmke and Abbott	16, 24, 39
Laevicardium laevigatum (Linnaeus, 1758)	Warmke and Abbott	2, 16, 20, 28
Laevicardium sp.	–	6, 24, 39
Papyridea semisulcata (Gray, 1825)	Warmke and Abbott	17
Trigoniocardia media (Linnaeus, 1758)	Warmke and Abbott	24, 39
Ervilia concentrica (Holmes, 1860)	Davis	24
Florimetis intastriata (Say, 1826)	Warmke and Abbott	3, 5, 37
Macoma tenta Say, 1834	Warmke and Abbott	6

Species	Illustration	Stations
Strigilla mirabilis (Philippi, 1841)	Boss (1969)	26
Tellina (Acorylus) gouldii Hanley, 1846	Boss (1966)	16, 24
Tellina (Angulus) paramera Boss, 1964	Boss (1968)	24
Tellina (Laciolina) laevigata Linnaeus, 1758	Warmke and Abbott	5, 10, 24, 25
Tellina (Laciolina) magna Spengler, 1798	Boss (1966)	10, 37
Tellina (Scissula) similis Sowerby, 1806	Warmke and Abbott	24
Tellina (Tellina) radiata Linnaeus, 1758	Warmke and Abbott	25
Tellina (Tellinella) listeri Röding, 1798	Warmke and Abbott	10, 37, 38
Semelina proficua (Pulteney, 1799)	Warmke and Abbott	16
Tagelus divisus (Spengler, 1794)	Warmke and Abbott	11
Coralliophaga coralliophaga (Gmelin, 1791)	Warmke and Abbott	24, 27
Macrocallista maculata (Linnaeus, 1758)	Warmke and Abbott	3, 5, 13
Chione cancellata (Linnaeus, 1767)	Warmke and Abbott	11, 14
Gouldia cerina (C. B. Adams, 1845)	Warmke and Abbott	1, 2, 6, 16, 21, 24, 39
Pitar fulminata (Menke, 1828)	Warmke and Abbott	1, 6, 16
**Ventricolaria rugatina* (Heilprin, 1887)	Abbott	21, 24, 39
**Corbula (varicorbula)* sp.	-	39
Gastrochaena hians (Gmelin, 1791)	Warmke and Abbott	24
GASTROPODA		
Diodora dysoni (Reeve, 1850)	Warmke and Abbott	17
Diodora sp.	-	5
Emarginula pumila (A. Adams 1851)	Warmke and Abbott	24
Acmaea pustulata (Helbling, 1779)	Warmke and Abbott	24, 39
Lepeta? sp.	-	24
Euchelus guttarosea Dall, 1889	Warmke and Abbott	21, 24, 39
Synaptocochlea picta (Orbigny, 1842)	Warmke and Abbott	24
Astraea phoebia Röding, 1798	Warmke and Abbott	24, 39
Truncatella caribaeensis Reeve, 1842	Warmke and Abbott	11
Alvania didyma (Watson, 1886)	Our Fig. 20	21, 24
Alvania platycephala Dautz. and Fischer, 1896	Our Fig. 21	11
Cingula? sp.	-	24
**Microdochus floridanus* Rehder, 1943	Warmke and Abbott	11
Rissoina bryerea (Montagu, 1803)	Warmke and Abbott	24
Rissoina sp. aff. *R. bryerea* (Montagu, 1803)	-	39
Rissoina cancellata Philippi, 1847	Warmke and Abbott	11
Rissoina fischeri Desjardin, 1949	Warmke and Abbott	11, 24
Zebina browniana (Orbigny, 1842)	Warmke and Abbott	21, 24, 39
Vitrinella species A	-	11
Vitrinella species B	-	24, 39
Vitrinella species C	-	39
**Spirolaxis exquisita* (Dall and Simpson, 1901)	Warmke and Abbott	24
Vermicularia knorrii (Deshayes, 1843)	Warmke and Abbott	24, 27, 39
Vermicularia spirata Philippi, 1836	Gould (1969)	11
Siliquaria squamata Blainville, 1827	Gould (1966)	24
Caecum delicatulum Verrill and Bush, 1900	Our Fig. 22	11
Caecum plicatum Carpenter, 1858	Warmke and Abbott	11, 24, 39
Caecum sp.	-	11
Modulus modulus (Linnaeus, 1758)	Warmke and Abbott	11, 16, 39

Species	Illustration	Stations
Finella dubia (Orbigny, 1842)	**Our Fig. 26**	1
Alaba incerta (Orbigny, 1842)	Warmke and Abbott	24
Cerithium litteratum (Born, 1778)	Warmke and Abbott	5, 10, 11, 13, 24, 39
Cerithium variabile (C. B. Adams, 1845)	Warmke and Abbott	11
Cerithiopsis ara Dall and Bartsch, 1911	Dall and Bartsch	21
Cerithiopsis cynthia? Bartsch, 1911	**Our Fig. 23**	21, 24, 39
Cerithiopsis rugulosum (C. B. Adams, 1850)	Clench and Turner	24
Cerithiopsis vicola Dall and Bartsch, 1911	Dall and Bartsch	11
Cerithiopsis species B	-	24, 39
Cerithiopsis species C	-	24
Cerithiopsis species D	-	21, 39
Triphora mirabilis (C. B. Adams, 1850)	**Our Fig. 24**	21, 24, 39
Triphora species B	-	24, 39
Triphora species C	-	39
Triphora species D	-	21
Triphora species E	-	21
Bermudaclis bermudensis (Dall and Bartsch, 1911)	Dall and Bartsch (1911)	11
Strombus costatus Gmelin, 1791	Warmke and Abbott	34b, 37
Trivia quadripunctata (Gray, 1827)	Warmke and Abbott	16, 21, 24, 39
Cypraea cinerea Gmelin, 1791	Warmke and Abbott	39
**Cypraea spurca acicularis* Gmelin, 1791	Warmke and Abbott	26
Cypraea sp. (*Bulla* stage)	-	24
Natica sp.	-	39
**Aspella elizabethae* McGinty, 1940	McGinty	17
Murex (Favartia) cellulosus Conrad, 1846	Warmke and Abbott	27
**Pusia variata?* (Reeve, 1845)	**Our Fig. 25**	21, 24
Aesopus stearnsi Tryon, 1883	**Our Fig. 27**	21, 24, 39
Anachis catenata (Sowerby, 1844)	Warmke and Abbott	11, 24
Columbella mercatoria (Linnaeus, 1758)	Warmke and Abbott	15, 21, 25
Mitrella lunata (Say, 1826)	Warmke and Abbott	21, 24
**Nassarina monilifera* (Sowerby, 1844)	Warmke and Abbott	21, 24
Colubraria swifti (Tryon, 1881)	Warmke and Abbott	14, 18
Colubraria testacea Mörch, 1877	Warmke and Abbott	39
Nassarius albus (Say, 1826)	Warmke and Abbott	11, 20, 24, 39
Thala foveata (Sowerby, 1874)	**Our Fig. 28**	24
Latirus brevicaudatus (Reeve, 1847)	Warmke and Abbott	39
Hyalina avena (Kiener, 1834)	Warmke and Abbott	11, 21, 24, 39
Hyalina lactea (Kiener, 1841)	-	39
Persicula lavalleeana (Orbigny, 1842)	Warmke and Abbott	11
Persicula? species A	-	24
Persicula? species B		39
Mitra nodulosa (Gmelin, 1791)	Warmke and Abbott	21, 24
Glyphoturris quadrata rugirima (Dall, 1889)	Warmke and Abbott	39
Mitrolumna biplicata (Dall, 1889)	**Our Fig. 31**	39
Pyrgocythara candidissima (C. B. Adams, 1845)	**Our Fig. 29**	39
Conus bermudensis Clench, 1942	Clench	12, 29, 37
Odostomia didyma Verrill and Bush, 1900	**Our Fig. 30**	11
Odostomia nioba Dall and Bartsch, 1911	**Our Fig. 32**	21
Turbonilla heilprini Bush, 1899	**Our Fig. 33**	11

Species	Illustration	Stations
Turbonilla pupoides (Orbigny, 1842)	Warmke and Abbott	24, 39
Bulla striata (Bruguiére, 1792)	Warmke and Abbott	5, 11
Atys sp.	-	39
Haminoea succinea (Conrad, 1846)	Warmke and Abbott	11
Haminoea sp.	-	24
Retusa candei Orbigny, 1841	Warmke and Abbott	11
Williamia krebsii (Mörch, 1877)	Warmke and Abbott	24, 39
Laemodonta cubensis (Pfeiffer, 1854)	Clench (1964)	11
Pedipes mirabilis (Mühlfeldt, 1816)	Clench (1964)	11
Pleurobranchus sp.	-	39
SCAPHOPODA		
Cadulus quadridentatus (Dall, 1881)	Warmke and Abbott	24
POLYPLACOPHORA		
Radsiella rugulata (Sowerby, 1832)	Keen	39

NOTES ON TAXA AND THEIR HABITS

Bivalvia

Arcidae

The similarity of living habits of *Arca imbricata* and *Arca zebra* have been emphasized by Stanley (1970, p. 122), who also stated that both prefer shallow subtidal habitats. Our collections indicate, however, that in Bermuda *Arca imbricata* is more common in open marine situations than in protected sounds (see Table 1). The only co-occurrence of living specimens was in the North Lagoon at Station 27, where conditions similar to those in the *Oculina* Zone of Harrington Sound exist on the open platform.

Arca zebra is perhaps the most conspicuous mollusk in the shallow inshore waters of Bermuda. It is especially abundant in Harrington Sound, where it can be found at depths from about 1.5 m to 17 m within the Shallow Sandy Zone and *Oculina* Zone of Neumann (1965). Secreting a strong, pedestal-like byssus, *Arca zebra* attaches to the top or sides of any hard object, most commonly to shells, rocks, or other debris on the sandy bottom. Subsequently, other individuals attach to one another, resulting in clusters or knots which themselves form a substrate for epifauna. Each individual *Arca* raises itself on its byssus while filtering but quickly lowers itself when sensing a passing shadow. *Arca zebra* does not colonize the rocky shore, nor does the species attach to corals far above the bottom. At Station 29, *Arca zebra* clusters have formed on the old concrete pilings of the abandoned causeway, but these clusters are subtidal and close to the bottom.

In contrast to its inshore abundance, the paucity or absence of *Arca zebra* from the outer shallow waters of Bermuda is striking. It is usually uncommon in small bays with free access to the open sea and is not common in the shallow waters within the breaker zone of the south shore. The only outside area at which *Arca zebra* was found in abundance is Station 27 in an area of abundant *Oculina* on a silty mud bottom, very similar to the *Oculina* Zone of Harrington Sound.

In a study of *Barbatia domingensis* on the Bermuda Platform, Bretsky (1967) found that this species is most abundant in turbulent environments and least abundant in protected bays and sounds. Its most common site of byssal attachment is beneath corals, less commonly beneath rocks. The strong representation of *B. domingensis* in our collections from the open platform confirms Bretsky's observations, and in view of these habitat preferences only the occurrence of the species in Walsingham Pond (Station 11) is unexpected. The pond specimens are all immature and possibly indicate that larvae forced into the pond through crevices are unable to reach maturity.

Pteriidae, Isognomonidae, and Malleidae

Among the Pteriacean bivalves *(Pteria, Pinctada, Isognomon,* and *Malleus),* only *Pteria colymbus* lives off the bottom, attached by a strong, clasping byssus to the flexible, waving arms of gorgonaceans. At all stations where living individuals were observed *Pinctada radiata* attaches to shells or rocks on the sandy bottom, generally with the plane of commissure nearly horizontal or somewhat inclined to the substrate. Whereas *Pteria* was observed only in open-marine areas, *Pinctada* is common in bays and sounds.

Isognomon radiatus was observed living only at two open-marine stations (Stations 15 and 25), where individuals were byssally attached between large rocks. According to Stanley (1970, p. 136), nestling beneath or between rocks with weak byssal attachment is the usual living habit of the species. Orientation relative to the attachment surface is variable, although generally the distal portions of the shell are erect and project into the water rather than lie flat against the attachment surface.

Malleus candeanus is a rare species throughout the West Indies and Florida but occurs in abundance at Bermuda. The taxonomy, distribution and living habits of the species have been described by Boss and Moore (1967), and Yonge (1968) has given a detailed account of the functional morphology of the very similar Pacific species, *M. regula.* Although Boss and Moore did not observe living specimens, they concluded that *Malleus candeanus* lives attached to hard substrates, particularly in the crevices of coral or coralline rock. Our underwater observations confirm this habit. At all localities observed, specimens were found tightly byssally attached to the sides and undersurfaces of large rocks, particularly where there are large crevices or small caves between rocks, or beneath overhanging ledges of coral. At Station 26, *Malleus* was particularly common on the high; steep side of a large patch reef. All localities were in open marine areas generally deeper than 6 meters and with considerable current or surge flowing between the rocks.

The elongate, distal portion of the shell of *Malleus* projects from the attachment surface. This portion of the shell is thin and composed entirely of fragile prismatic calcite. Although it is frequently fractured during attacks by nibbling predators, Yonge (1968, p. 387) has pointed out that prismatic calcite can be rapidly regenerated by the highly retractible mantle, which remains uninjured.

Pectinidae

Both *Comptopallium antillarum* (Récluz, 1853) and *Pecten chazaliei* Dautzenberg, 1900, have not been previously reported from Bermuda. Shells and fragments of both were recovered from sediment samples taken on dives deeper than 30 m. (Stations 24 and 39). *Comptopallium antillarum* is a common species in the Caribbean and tropical Western Atlantic, where living specimens have been found at depths ranging from 3 m. to 70 m. and where, in shallow waters, they are commonly attached among *Halimeda* algae. The previously known geographic range of the species extends from off Colon, Panama and Barbados northward to Great Abaco, Bahamas. *Pecten chazaliei* is known to live at depths ranging from 18 to 230 m. in an area ranging from off Brazil, through the Caribbean and eastern Gulf of Mexico, and up the North American coast as far north as Cape Fear, North Carolina (depth, 73 m.).

Aequipecten acanthodes (Dall, 1925) was originally described as being "less inflated, wider, and with less prominent spines" than *Aequipecten muscosus* (Wood, 1828) [= *Pecten exasperatus* Sowerby, 1843]. Although the type locality of Dall's species was never given, the syntypes (USNM 333367) are from "Santa Lucia, northwest Cuba, depth 2 to 4 fathoms". The Bermuda specimens listed in Table 1 bear a closer resemblance to the Cuban forms than to *A muscosus* from the Florida coast. The larger of the two syntypes of *A. acanthodes* is illustrated in Figures 3 and 4.

The occurrence of *Argopecten gibbus* within a nearly land-locked sound is unusual. Along the North American coast, the species is found only in open marine waters generally within a depth range of 9 to 365 meters (Waller, 1969, p. 37), whereas bays and sounds harbor populations of *Argopecten irradians* and *Argopecten nucleus.*

As observed by Neuman (1965, pp. 999, 987), Harrington Sound "does not exhibit extremes in either dilution or evaporation", and regardless of the almost complete isolation of the sound, "tidal exchange through the narrow inlet is sufficient to maintain near-normal oceanic temperature and salinity." In addition there is some exchange of water through caves and the porous limestone surrounding the sound. As emphasized by De Laubenfels (1950,

p. 159), the small amount of land area surrounding Harrington Sound in comparison to the large size of the sound itself, coupled with the porous bedrock, permits little land runoff and allows for greater constancy of oceanic conditions. In contrast, sounds located along the North American coast commonly exhibit extremes of both salinity and temperature, favoring species adapted to variation of these conditions.

In Harrington Sound, *Argopecten gibbus* rests on the bottom with its right valve on or slightly within the sediment. The majority of the largest individuals lie free, without byssal attachment, although many mature individuals attach a weak byssus to dead shells and coral fragments. The species is sluggish and rarely begins to swim when approached by a diver or when handled. When swimming begins, it is an irregular motion with rapid adductions of the valves and short flights of no more than a meter. Like all free-living scallops, *A. gibbus* has an overturning reaction when placed with its left valve downward. Generally the animal rests motionless for a time varying from a half minute to three minutes. Then the valves gape broadly, the vela become rigid, and with one or two claps the scallop rotates on either its hinge axis (10 out of 18 trials) or on an axis perpendicular to the hinge and parallel to the plane of commissure. Generally the smaller individuals (those of about 25 or 30 mm in height in our test sample) begin the righting reaction sooner than larger individuals (those 50 to 60 mm in height).

Two valves and numerous fragments of *Argopecten gibbus* were found in the Subthermocline Zone near Shark Hole, Harrington Sound (Station 6, Fig. 2). The larger of the two nearly complete valves is a typical representative of the species, with a thick shell and moderate convexity. It is indistinguishable from individuals living in the Shallow Sandy Zone, and because its auricles are chipped as though bitten, the shell may have been dropped or dragged into this zone by a predator.

The smaller of the two valves is strikingly different from any of the specimens found elsewhere around the Bermuda Islands. Its shell is exceedingly thin with very low curvature and radial plicae of low amplitude. Its disk flanks are very low and, on the posterior side, there is no sharp demarcation between the disk flank and posterior auricle, which lacks radial costae. Dark, brownish red pigment produces mottling on the valve exterior and a more uniform dark hue on the interior of the valve in areas outside of the pallial line. Sculptural details, such as the fine, concentric lamellae on the exterior and ridged cardinal crura on the interior, and the aragonitic myostraca are well-enough preserved to suggest that the thinness of the shell is not entirely due to solution. Most of the fragments recovered exhibit the same thinness and pigmentation as the smaller of the two whole valves, and according to G. R. Clark, II (personal communication) such specimens are common from drill cores of sediments within the Subthermocline Zone. The thin shells are within the range of variation exhibited by *Argopecten gibbus* and most closely resemble fossil specimens from early Pleistocene deposits in southern Florida (see Waller, 1969, pp. 65, 66).

The thin specimens may be the offspring of shallow-water populations which have entered the Subthermocline Zone as larvae during maximum overturn of the water. Subsequent growth may then have been modified by the unusual conditions present in the subthermocline environment. Alternatively, the subthermocline *Argopecten* may in fact be fossils introduced into Harrington Sound some thousands of years ago at a time when populations throughout the Sound were of this morphology. These hypotheses can be tested, the former through culturing of *Argopecten gibbus* within the Subthermocline Zone, the latter through radiocarbon dating of shells and observation of Bermuda fossils both from within and outside of Harrington Sound.

Argopecten noronhensis (E. A. Smith, 1885) was originally described from the coast of Brazil, where it was dredged by the *H. M. S. Challenger* from a depth of 46 m off Fernando Noronha. Since Smith's original description, there have apparently been no further reports on the occurrence of the species outside of Brazilian waters. However, collections in the U. S. National Museum contain numerous specimens from Barbados (depths, 46 to 183 m), Antigua (220 m), the Virgin Islands and Puerto Rico (73 to 256 m), and Cat Cay, Bahamas (550 m). All of these specimens were found dead with only the shells remaining on bottoms of coarse sand or coral rubble. Living specimens have been taken by the *R/V Oregon* off St. Lucia (66 to 75 m), south of Saba Banks (91 to 110 m), and off

Tortola, Virgin Islands (49 m). *Argopecten noronhensis* is not known to occur in the western Caribbean or in the Gulf of Mexico. In Bermuda fragments of *A. noronhensis* were recovered from sediment samples taken on our deepest dive, at a depth of 51 m (Station 39). The species is illustrated in Figures 5-8.

Although not well-known because of its small size (generally less than 15 mm), *Chlamys benedicti* Verrill and Bush, 1897, is the most widespread and numerous *Chlamys* in the Western Atlantic region. According to data with specimens examined thus far, the species ranges from the coast of South America off Surinam northward to a point southeast of George's Bank and is also widespread in the northern and eastern Gulf of Mexico. Shells of *C. benedicti* have been found from beach level down to 2,480 m, but living specimens are known only from about 2 to 806 m. Out of 86 records of living specimens, 75% are within the 46 to 90 m range. At many localities the species is associated with coral debris and sponges, and preserved specimens indicate that, like all *Chlamys, C. benedicti* is byssally attached. At Bermuda, fragments and one small valve of *Chlamys benedicti* were recovered from sediment samples taken at Stations 24 (34 m) and 39 (51 m).

Despite an intensive search for living *Chlamys imbricata,* only one live individual only 17 mm in height was found (Station 18). It was byssally attached with its right valve upward against the undersurface of a hemispherical head of dead coral at a depth of 7 m. The scallop voluntarily released its byssal attachment when the coral was overturned and, by clapping its valves, slid along the coral surface.

In a bucket on the boat, the specimen quickly attached itself with a new byssus to a clump of coral. However, after a few hours in a laboratory aquarium, the specimen detached itself from the same clump of coral, moved up and out of a small glass bowl in the bottom of the aquarium, and reattached to the lower umbo of an *Argopecten gibbus* on the bottom of the same aquarium. On the basis of only a few trials with this one immature specimen, *C. imbricata* seems to have only a weak overturning reaction, generally not beginning to right itself for several minutes after being overturned and then righting with a single clap and rotation about the hinge line. The specimen was observed to swim with its commissure inclined and left valve uppermost, taking off from the bottom at a steep angle with very rapid valve adductions.

Bermuda is the northernmost occurrence of this species, which on the North American coast occurs no further north than Miami. In the south, *C. imbricata* is known only from the Caribbean, where it has been found as far south as Payardi Island, Panama.

Chlamys multisquamata (Dunker, 1864) is the rarest of the Western Atlantic *Chlamys.* Originally described from Havana Bay, Cuba, the species was subsequently redescribed as *Pecten effluens* by Dall (1886) on the basis of two immature valves dredged from 230 m. off Havana. Since this time, additional specimens have been found at Barbados (USNM, 46 to 110 m); Dominica (Nat. Marine Fish. Service, Lab. at Pascagoula, Miss., 62 to 110 m); Puerto Rico (USNM, 73 to 91 m); Cuba (USNM, 550 m); Bahamas (USNM, 90 to 550 m); off Palm Beach, Florida (F. M. Bayer Collection, 24 to 30 m); and Bonaine, Dutch West Indies (S. D. Abbott , 17 m. in crevice, on coral heads). At Bermuda, unmistakable fragments of the species were recovered from sediment samples taken on the deepest dive (Station 29, 51 m). According to data accompanying the Palm Beach specimen, the species was living among rocks and between the shells of *Spondylus.* Morphologically, *Chlamys multisquamata* resembles several Indo-Pacific species that live in coral crevices (see Waller, 1972). The Western Atlantic species is illustrated in Figures 9-11.

Living *Pecten ziczac* was found only in the Shallow Sandy Zone of Harrington Sound, although shells of the species are common in other bays such as Ely's Harbor and inner Port Royal Bay. The living habits of *P. ziczac* are as described by Stanley (1970, p. 140). The scallops live with their right valve buried in the sediment to the level of the commissure; a thin layer of sediment covers the upper flat valve; and the only portion visible from above is the ring of extended tentacles.

Pecten ziczac is more adept at swimming and does so more readily than *Argopecten gibbus.* Although the latter would not swim when sensing the approach of a diver, *Pecten* would occasionally do so. Other specimens would begin swimming when lifted from the sediment. The animal takes off at a steep angle and then levels out in flights of about 5 seconds duration or longer. Adduction frequency is fairly rapid, generally about two claps per second, and flight distances average slightly more than 1 m.

Like *Argopecten, P. ziczac* has a distinct righting reaction but because of the flatness of its left valve, righting is accomplished with great difficulty. Studies of three specimens in an aquarium indicated that righting begins one or two minutes after overturning. Rotation is about an axis parallel to the hinge line, generally requiring three or four claps of the valves during rotation.

The ability of *Pecten ziczac* and many other scallops to excavate a shallow depression in the sediment has been described by Waller (1969, p. 17) and Stanley (1970, p. 140).

Anomiidae

Collections of *Anomia simplex* and *Pododesmus rudis* from Harrington Sound suggest differences in habitat between the two species. *Anomia* is most abundant in the Shallow Sandy Zone where it attaches to shells and other debris on the sandy substrate. *Pododesmus,* on the other hand, is most abundant in the *Oculina* Zone, where it attaches to *Oculina* and avoids contact with the bottom. In areas on the North American coast, Stanley (1970, p. 144) has observed that *A. simplex* generally occurs attached to pebbles and debris on a firm substrate where there is a moderate current flow.

Limidae

Lima lima attaches with a strong byssus beneath rocks in open marine areas and avoids bays and sounds.

Gryphaeidae and Ostreidae

The listing of *Neopycnodonte cochlear* is based on a single, eroded right valve from the deepest station (Station 39, 51 m.; Figs. 12, 13). The specimen is roughly circular in form, measures 13 mm in diameter, and clearly displays the vesicular shell structure and outer prismatic layer (Fig. 12) that Stenzel (1971, p. 1105) considers to be characteristic of the genus. According to Stenzel there is only one living species in the genus, which has a worldwide distribution in tropical and subtropical oceanic waters ranging in depth from 27 to 1,500 m.

The familiar *Ostrea frons* of the West Indian region has been relegated to the genus *Lopha* and to the synonymy of *Ostrea folium* Linnaeus by Stenzel (1971, pp. 1024, 1158). The elongate, clasping form associated with *Ostrea frons* is one of two ecomorphic end members within the species. Although commonly attributed to growth while attached to mangrove roots (Warmke and Abbott, 1954, p. 173), this ecomorph is generally the result of attachment to gorgonacean corals in subtidal habitats. In Harrington Sound (Station 13), the species also cements itself to shells lying on the bottom, in which case it secretes clasps only where the oyster shell overlaps the edge of the shell to which it is attached. As with all oysters, the shape of the attachment surface profoundly affects the shape of the oyster, and those attached to shells are less crenulated and less elongate than those found on gorgonaceans.

Condylocardiidae

Viviparity is common in the superfamily Carditacea (Dall, 1902, p. 696), and *Carditopsis smithi* is no exception. One of the dead but tightly closed specimens from Walsingham Pond yielded three articulated prodissoconchs, one of which is illustrated in Figure 19. Large, sculptured, saucer-shaped prodissoconchs, of this type are generally associated with viviparity in several taxonomic groups, as in the genera *Condylocardia* (Bernard, 1897, p. 170) and *Philobrya* (Bernard, 1896, p. 9).

Chamidae

Certain species of Bermudian chamids are separated in open marine and partially enclosed environments. *Pseudochama radians* lives in abundance in the Shallow Sandy Zone of Harrington Sound and also occurs in the *Oculina* bed at Station 27 in association with well-developed *Chama macerophylla.* Another common chamid in Harrington Sound is *Chama congregata,* which is most abundant in the *Oculina* Zone. *Chama sarda* was found only well off-shore, where it was abundant at the three stations deeper than 30 m.

The shells of *Chama macerophylla* found on the bottom of Walsingham Pond have extremely heavy and deep left valves and resemble the *Chama bermudensis* described by Heilprin (1889, p. 141) from Harrington Sound. Because these have crenulated inner margins and lack an exterior sulcus, they cannot be considered a subspecies of *Chama sinuosa* Broderip as in Bayer (1943, p. 122).

In Table 1 the Chamidae have been placed near the Carditidae rather than near the Lucinidae following the convincing evidence of relationships presented by Kennedy, Morris, and Taylor (1970).

Crassatellidae

Following the study of Harry (1966), both *Crassinella parva* (C. B. Adams, 1845) and *C. guadalupensis* (d'Orbigny, 1846) are considered to be junior synonyms of *C. lunulata* (Conrad, 1834).

Veneridae

The Western Atlantic species of *Gouldia* are highly variable and inadequately described. It is curious that *G. cerina* (C. B. Adams, 1845), *G. bermudensis* (E. A. Smith, 1885), *G. insularis* (Dall and Simpson, 1901), and *G. foresti* Fischer-Piette and Testud, 1967, were all described without adequate published comparison to other known species. There is no adequate basis for separating *G. cerina, G. bermudensis,* and *G. foresti* without an extensive quantitative study of geographical variation; *Gouldia insularis* appears somewhat more distinct, characterized by its rounded form and high degree of inflation.

None of the numerous *Gouldia* from the Subthermocline Zone of Harrington Sound were alive when collected. All show some deterioration of their aragonitic shells and lack preserved ligaments, although some have traces of pigment remaining (see Notes on Habitats).

Gastropoda

Rissoidae

Alvania platycephala was first described and illustrated by Dautzenberg and Fischer (1896, p. 63, plate 19, figs. 12, 13) on the basis of specimens taken from a depth of 1,385 meters in the Azores. The first Bermudian record is that of Verrill and Bush (1900, p. 539), who identified the species from "shell sand" taken from waters less than 15 m deep. Their identification was apparently based on Dautzenberg and Fischer's illustration, and the specimens themselves were evidently not compared. The species was subsequently reported by Piele (1926, p. 77) from an unknown site and by Gould (1968, p. 4) from Walsingham Pond. These specimens, shown here in Figure 21, bear an even closer resemblance to the illustration of Dautzenberg and Fischer than the rather poor line drawing of Verrill and Bush would indicate. The species was found by us only in Walsingham Pond (Station 11), where it is abundant.

A second species of *Alvania,* also reported by Piele (1926, p. 77), is *A. pagodula* (Bucquoy, Dautzenberg, and Dollfus, 1884), originally described from the Mediterranean and Adriatic. Piele's specimens were more likely *Alvania didyma* (Watson, 1886), which in the present study was taken at depths exceeding 30 m. (Stations 21 and 24, Fig. 20).

Turritellidae

Gould (1968, p. 4) recognized *Vermicularia spirata* Philippi, 1836, as the most common mollusk in Walsingham Pond and later (Gould, 1969) studied the ecology and functional significance of uncoiling in the species. In Bermudian waters *V. spirata* cements itself to a variety of hard substrates but is particularly common in association with the branching coral, *Oculina.* In Walsingham Pond there is no development of *Oculina,* and, as noted by Gould, fewer than 1 percent of the largest *Vermicularia* present show uncoiling. Instead, individuals live in burrows with their apertures projecting slightly above the mud.

Specimens of *Vermicularia* from stations on the open Bermuda Platform have all been identified here with *V. knorri* (Deshayes, 1843) only because their early whorls are white, rather than tan or brown as in *V. spirata.* This is a character that some workers believe is genetically significant. However, there are no differences in whorl profile or sculpture other than those imposed by differing rates of uncoiling, a process shown by Gould to be environmentally controlled, and it is possible that further study will place *V. knorri* in the synonymy of *V. spirata.*

Caecidae

Caecum plicatum Carpenter, 1858, is a senior synonym of *Caecum termes* Heilprin, 1889, reported by Piele (1926, p. 78) to be the most common *Caecum* in Bermuda and by Gould (1968, p. 4) to be the most common in Walsingham Pond.

Buccinidae

All living *Colubraria swifti* observed in Bermuda (Table 1) were beneath rocks in open marine areas, commonly associated with *Barbatia domingensis.*

TABLE 2. Collecting stations grouped according to general environment or ecological zone. Ecological zones in Harrington Sound follow Neumann (1965).

Description	Stations
Harrington Sound, Shallow Sandy Zone	3, 5, 9, 10, 13
Harrington Sound and North Lagoon, *Oculina* Zone	2, 7, 27
Harrington Sound, Subthermocline Zone	1, 6
Watsingham Pond, muddy bottom	11
Bays and sounds other than Harrington Sound	14, 17, 20, 29, 30, 31 33, 34b, 35, 36, 37, 38
Open platform, sand pockets and patch reefs, 5 to 18 m	12, 15, 16, 18, 23, 25, 26, 28
Open platform, sand pockets, 34 to 51 m	21, 24, 39

Polyplacophora

Ischnochitonidae

Radsiella rugulata (Sowerby, 1832) is a senior synonym of *Ischnochiton boogii* Haddon, 1886 (Keen, 1971, p. 869), which in turn is a senior synonym of *Ischnochiton bermudensis* Dall and Bartsch, 1911.

ACKNOWLEDGMENTS

The field portion of this study was carried out at the Bermuda Biological Station for Research, St. George's West. I am grateful to the staff of the Station, particularly Dr. Wolfgang Sterrer, Director, and Mr. Brunell Spurling, skipper of the *Micmac*. Dr. Porter M. Kier, Chairman of the Department of Paleobiology, Smithsonian Institution, kindly permitted his assistant, Mr. Thomas F. Phelan, to accompany me as a companion diver. Both Mr. Phelan and Miss Ellen P. Broudy, my research assistant, ably assisted in the field study. Additional help in Bermuda was received from Dr. J. D. Herkes, Dr. David Pawson, and Mr. Arthur Guest.

Assistance in identification was received from Mr. Russell Jensen and Dr. R. T. Abbott, Delaware Natural History Museum; Dr. D. R. Moore, University of Miami; Dr. K. J. Boss, Harvard University; Dr. Ruth Todd, U. S. Geological Survey, and Drs. J. P. E. Morrison, H. A. Rehder, J. Rosewater, and G. A. Cooper, Smithsonian Institution, and Mr. W. G. Lyons, Florida Department of Natural Resources, St. Petersburg. I am grateful to Dr. F. M. Bayer, University of Miami, for the loan of a specimen of *Chlamys multisquamata*, and to Mr. H. R. Bullis, Jr., National Marine Fisheries Service, for permission to study his collections in Pascagoula, Mississippi. Dr. D. R. Moore, Dr. R. T. Abbott, and Mr. R. Jensen read the manuscript and gave many helpful suggestions. Mr. Larry Isham, artist for the Department of Paleobiology, drafted the maps.

Funding for travel and field study was through the Department of Paleobiology, Smithsonian Institution, and funding for all other aspects of the work was through grants to the author from the Smithsonian Research Foundation.

LITERATURE CITED

Abbott, R. Tucker. 1954. American seashells: Princeton, Van Nostrand Co., 541 p., 40 pls., 100 figs.

Adams, C. B. 1845. Synopsis Conchyliorum Jamaicensium, etc. Proc. Boston Soc. Nat. Hist., Jan. 1, 1845, 17 p.

Bayer, F. M. 1943. The Florida species of the family Chamidae. The Nautilus, 56 (4): 116-124, pls. 12-15.

Bernard, Félix. 1896. Études comparatives sur la coquille des lamellibranches. *Condylocardia*. Jour. Conchyliologie, 44: 169-207, 5 figs., pl. 6.

Bernard, Félix. 1897. Études comparatives sur la coquille des lamellibranches. II. Les genres *Philobrya et Hochstetteria: Ibid.* 45: 5-47, 7 figs., pl. 1.

Boss, Kenneth J. 1966. The subfamily Tellininae in the Western Atlantic. The genus *Tellina* (Part I). Johnsonia 4 (45): 217-272, pls. 127-142, 3 tables.

Boss, Kenneth J. 1968. The subfamily Tellininae in the Western Atlantic. The genera *Tellina* (Part II) and *Tellidora*. *Ibid.* 4 (46): 273-344, pls. 143-163.

Boss, Kenneth J. 1969. The subfamily Tellininae in the Western Atlantic. The genus *Strigilla. Ibid.* 4 (47): 345-368, pls. 164-171.

Boss, Kenneth J. and Donald R. Moore. 1967. Notes on *Malleus (Parimalleus) candeanus* (d'Orbigny) (Mollusca: Bivalvia). Bull. Mar. Sci. 17 (1): 85-94, 2 figs.

Bretsky, Sara S. 1967. Environmental factors influencing the distribution of *Barbatia domingensis* (Mollusca: Bivalvia) on the Bermuda Platform. Postilla, Peabody Museum of Nat. Hist., Yale Univ., no. 108, 14 p., 2 figs., 2 tables.

Britton, Joseph Cecil. 1970. The Lucinidae (Mollusca: Bivalvia) of the western Atlantic Ocean. Washington, D. C., George Washington Univ., unpublished Ph.D. dissertation, 566 p., 23 pls., 7 tables.

Clench, William J. 1942. The genus *Conus* in the Western Atlantic. Johnsonia 1 (6): 40 p., 15 pls.

Clench, William J. 1964. The genera *Pedipes* and *Laemondonta* in the Western Atlantic. *Ibid.*, vol. 4, no. 42, p. 117-127, pls. 76-79.

Clench, William J. and Ruth D. Turner. 1950. The Western Atlantic marine mollusks described by C. B. Adams. Occasional Papers on Mollusks, Mus. of Comparative Zool., Harvard Univ. 1 (15): 233-403, pls. 28-49.

Dall, William Healey. 1886. Reports on the results of dredging . . . by the U. S. Coast Survey Steamer "Blake". Report on the Mollusca, Part 1 - Brachiopoda and Pelecypoda. Bull. Mus. Comparative Zool. 12 (6): 173-318, 9 pls.

Dall, William Healey. 1889. A preliminary catalogue of the shell-bearing marine mollusks and brachiopods of the southeastern coast of the United States, with illustrations of many of the species. Bull. U. S. Natl. Mus., no. 37, 232 p., 95 pls.

Dall, William Healey. 1902. Synopsis of the Carditacea and of the American species: Proc. Acad. Natural Sci. Phila. 54: 696-716.

Dall, William Healey. 1925. Notes on the nomenclature of some of our east American species of *Pecten* with descriptions of new species. Nautilus, vol. 38, no. 4, p. 112-120.

Dall, William Healey and Paul Bartsch. 1911. New species of shells from Bermuda. Proc. U. S. Natl. Mus. 40 (1820): 277-288, pl. 35.

Dall, William Healey and Charles Torrey Simpson. 1901. The Mollusca of Puerto Rico. U. S. Fish Commission Bull. 1: 351-524, pls. 53-58.

Dautzenberg, P., and H. Fischer, 1896. Compagnes scientifiques de S. A. le Prince Albert 1 de Monaco. Dragages effectivés par l'*Hirondelle* et par la *Princess-Alice*, 1885-1895. Mem. de la Soc. Zool. de France 9: 1-104, pls. 15-22.

Davis, J. D., 1967. *Ervilia concentrica* and *Mesodesma concentrica.* Clarification of synonymy. Malacologia 6 (1-2): 231-241, 1 fig., 2 pls.

De Laubenfels, M. W. 1950. An ecological discussion of the sponges of Bermuda. Trans. Zool. Soc. London 27: 155-201, 4 figs.

Fischer-Piette, E. and A.-M. Testud. 1967. Mollusques Lamellibranches: Veneridae. Résultats scientifiques de campagnes de la "Calypso", Fascicule 8, no. 13, p. 205-220, 4 pls.

Gould, Stephen Jay. 1966. Notes on shell morphology and classification of the Siliquariidae (Gastropoda). The protoconch and slit of *Siliquaria squamata* Blainville: Amer. Mus. Novitates, no. 2263, 13 p., 7 figs., 2 tables.

Gould, Stephen Jay. 1968. The molluscan fauna of an unusual Bermudianpond: A natural experiment in form and composition: Breviora, no. 308, 13 p., 2 figs., 2 tables.

Gould, Stephen Jay. 1969. Ecology and functional significance of uncoiling in *Vermicularia spirata:* An essay on gastropod form. Bull. Marine Sci. 19 (2): 432-445, 3 figs., 1 table.

Harry, Harold W. 1966. Studies on bivalve molluscs of the genus *Crassinella* in the Northwestern Gulf of Mexico: Anatomy, Ecology and Systematics. Publ. Inst. Marine Sci., Texas 11: 65-89, 17 figs.

Heilprin, Angelo. 1889. On some new species of Mollusca from the Bermuda Islands. Proc. Acad. Nat. Sci. Philadelphia for 1889, p. 141, 142, pl. 8.

Jackson, Jeremy B. C. 1970. The ecology and paleoecology of near shore tropical Lucinacea (Bivalvia). Geol. Soc. America Abstracts, 2 (7): 586-587.

Keen, Angeline Myra. 1971. Sea shells of tropical west America, 2nd Edition. Stanford, California, Stanford Univ. Press., 1,064 p., 22 pls.

Kennedy, William James, N. J. Morris and John D. Taylor. 1970. The shell structure, mineralogy and relationships of the Chamacea (Bivalvia). Palaeontology 13, part 3, p. 379-413, 6 figs., pls. 70 - 77.

McGinty, Thomas L. 1940. New land and marine Tertiary shells from southern Florida. The Nautilus 53 (3): 81-84, pl. 10.

Moore, Raymond C. (Editor). 1969. Treatise on invertebrate paleontology, Part N, vols. 1 and 2, mollusca 6, bivalvia: Univ. of Kansas and Geol. Soc. Amer., 951 p., illustr.

Neumann, A. Conrad. 1965. Processes of recent carbonate sedimentation in Harrington Sound, Bermuda. Bull. Marine Sci. **15**: 987-1035, 8 figs., 1 table.

Piele, A. J. 1926. The Mollusca of Bermuda. Proc. Malac. Soc. London **17** (2 and 3): 71-98.

Smith, Edgar A. 1885. Report on the Lamellibranchiata. Report on the scientific results of the voyage of the *H. M. S. Challenger* during the years 1873-76, Zoology 13 (35): 341 p., 25 pls.

Stanley, Steven M. 1970. Relation of shell form to life habits in the Bivalvia (Mollusca). Geol. Soc. Amer. Mem. **125**, xiii + 296 p., 48 figs., 40 pls.

Stenzel, H. B. 1971. Oysters: *in* Raymond C. Moore (Editor), Treatise on invertebrate paleontology, Part N, vol. 3, Mollusca 6, Bivalvia, p. 953-1224, 153 figs.

Taylor, Dwight W. and Norman F. Sohl. 1962. An outline of gastropod classification. Malacologia **1** (1): 7-32, 2 figs.

Verrill, A. E. and Katherine J. Bush. 1900. Additions to the marine Mollusca of the Bermudas. Trans. Connecticut Acad. Sci. **10**: 513-544, pls. 63-65.

Waller, Thomas Richard. 1969. The evolution of the *Argopecten gibbus* stock (Mollusca: Bivalvia), with emphasis on the Tertiary and Quaternary species of eastern North America. Paleont. Soc. Mem. 3 (Jour. Paleont. 43 (5), suppl.), 125 p., 13 figs., 7 pls., 43 tables.

Waller, Thomas Richard. 1972. The Pectinidae (Mollusca: Bivalvia) of Eniwetok Atoll, Marshall Islands. Veliger **14**(3): 221-264, 22 figs., 8 pls., 13 tables.

Walton, Anthony W. 1969. Walsingham Pond: A brief study of its sediments and water chemistry. Reports of Research, 1968 Seminar on organism-sediment interrelationships, Bermuda Biol. Sta. for Research, Special Publ. no. 2: 41-50, 3 figs.

Warmke, Germaine L. and R. Tucker Abbott. 1961. Caribbean seashells. Narberth, Pennsylvania, Livingston Publ. Co., 346 p., 44 pls., 34 text-figs.

Warmke, Germaine L. and Luis R. Almodővar. 1963. Some associations of marine mollusks and algae in Puerto Rico: Malacologia **1** (2): 163-177, 1 fig., 10 tables.

Yonge, C. M. 1968. Form and habit in species of *Malleus* (including the "hammer oysters") with comparative observations on *Isognomon isognomon* Biol. Bull. **135** (2): 378-405, 13 figs., 1 table.

BOOK REVIEW

SHELLS AND SHELL COLLECTING. By S. Peter Dance. 128 pp., 110 photos, 30 in color. Index. Hamlyn Publ., London, N. Y., Toronto. $4.95.

This is one of the more attractive of the recent rash of popular books on conchology. It is well-written, accurate and illustrated by excellent photographs. It is an interesting introduction to the major groups of mollusks, shell shapes and colors, the history of shell collecting, rare shells, and man's use of mollusks as food, money and objects of art. Peter Dance has included several accounts new to the popular literature, and has illustrated a number of land and marine shells that previously had not been published in books for the layman. Missing from this otherwise excellent book on shell collecting are instructions on how to collect shells and how to clean and preserve them. The art director has reversed the negative on the first double-page spread, thus creating sinistral *Nucella* dogwinkles. For its low price, this book is a worthwhile purchase.

R. Tucker Abbott
Delaware Museum of Natural History

EVIDENCE FOR SPAWNING BY *GONATUS* SP. (CEPHALOPODA: TEUTHOIDEA) IN THE HIGH ARCTIC OCEAN

Richard Edward Young
Department of Oceanography
University of Hawaii, Honolulu, Hawaii 96822

ABSTRACT

A specimen of the squid, Gonatus *sp., was captured through an ice hole at 79° 58' N. lat., 170° 23' E. long. (about 500 miles north of Wrangel Island, Siberia) whose condition suggests it had spawned just before its capture on March 30, 1962. The emaciated condition is described in specimens of other Californian female* Gonatus *that presumably had spawned just before capture, and a brief review is given of the records of the degeneration and fatal effects from spawning by females in other genera of squid and octopods.*

The cephalopod fauna of the high Arctic Ocean is poorly known; pelagic cephalopods have been reported only on a few occasions. Berry (1925) described from seal stomachs a small collection of cephalopod beaks, one of which taken at 70°13'N, 140°50'W, probably belongs to a squid. MacGinity (1955) recorded a juvenile and adult *Cirroteuthis* sp. (finned octopods) that were dip-netted near shore and 3 specimens of *Gonatus "fabricii"* (72, 63, 59 mm mantle length) that had washed ashore at Pt. Barrow, Alaska. Voss (1967), in a footnote, mentioned the capture of *Cirrothauma* (finned octopod) in the high Arctic. The locality of this capture is 86°N, 173°E (Roper and Brundage, 1972). Nesis (1971a) found 2 specimens of *Gonatus "fabricii"* (175 and 87 mm Mantle Length) in an ice hole at 87°24.2'N, 132°01.5'E and one specimen of *G. "fabricii"* (130 mm ML) in an ice hole at 80°13.3'N and 143°01'E. He further reports that *Gonatus* is abundant at the border of the Arctic Basin and the Greenland Sea, particularly young specimens ranging from 30-71 mm ML. The only pelagic cephalopods known from the high Arctic Ocean, therefore, are members of the squid family Gonatidae and two species of finned octopods.

The squid reported here was captured from ice island Arlis II (Arctic Research Laboratory Ice Station No. 2) in the high Arctic Ocean on March 30, 1962. The squid, alive at the time of capture, was found floating head downward in a hole cut through the ice for hydrographic and plankton studies.

DESCRIPTION

Since the identity of this specimen is of considerable importance but impossible to determine to species at present due to the condition of the animal, a brief description is presented (Fig. 1 & 2). The pen is 210 mm in length. The mantle and fins are gelatinous and flaccid. A well-developed conical "tail" is present posterior to the conus of the pen. In preservation in 70% ethanol the fins measure 102 mm in total length and 145 mm in total width. The fins extend posteriorly along the "tail."

The funnel is large and reaches to the level of the midpoint of the eyes. The funnel locking-cartilages bear simple straight grooves (Fig. 2, F). The dorsal pad of the funnel organ has an inverted V-shape, the anterior half of each limb has low ridges along the lateral margin (Fig. 2, G). A small anterior papilla is present. The ventral pads are small and nearly teardrop-shaped with the blunt end anterior. A large funnel valve is present.

The head is short and bears large eyes with a distinct sinus on the anterior margin of each eyelid. A nuchal crest with three indistinct pairs of nuchal folds occurs on the head. "Olfactory" lobes lie on the second pair from the funnel on each side. The nuchal cartilage, which is long and slightly rounded at either end, bears a median ridge containing a central groove.

The arms are gelatinous and relatively short (Arm I = 73 mm, III - 97 mm, IV = 98 mm). A weakly developed aboral keel is present on each arm III and large lateral keels are present on each arm IV. All arms bear very broad, thick, gelatinous trabeculae that are joined by thick, poorly defined protective membranes which converge and conceal the hooks in the distal portion of the arms. The arm tips are not attenuate. The armature of arms I-III consists of two alternating rows of small hooks (Arm I = 42 hooks, II = 41 hooks, III = 44 hooks). The marginal and terminal rows of suckers are absent and only small grooves indicate their former presence. Suckers are absent from arms IV (Fig. 2, B). The tentacles have been lost except for rounded stubs.

The specimen is a female. Oviducal and nidamental glands are slightly swollen (lengths: 28 mm and 14 mm respectively). The ovary is rather small but still contains many elongate immature ova and a few scattered, larger sperical ova of various sizes, the largest of which measures about 1.5 mm in diameter.

The radula (Fig. 2, C) contains only five teeth in a transverse series. The rachidian tooth has a short central cusp and two small lateral cusps. The first lateral teeth are absent. The second laterals have broad bases each with a rather blunt medial cusp. Marginal plates are absent. The beaks (Fig. 2, D) are heavily pigmented. The lower mandible shows a faint ridge on the lamella. Many sperm reservoirs are attached to the inner wall of the buccal membrane.

Although the generic boundaries in the family Gonatidae appear to be somewhat indistinct (Okiyama, 1969; Fields & Gauley, 1971; Nesis, 1971b), this specimen clearly belongs within the genus *Gonatus sensu stricto* as indicated by the presence of a tail extending beyond the gladius, tentacle stubs and a radula with only five teeth.

DISCUSSION

The following evidence suggests that the specimen has recently spawned:

1. The specimen had mated as indicatod by the presence of sperm reservoirs (discharged spermatophores) embedded in the buccal membrane.
2. The nidamental and oviducal glands are of intermediate size (i. e. these glands are larger than would be expected in immature specimen but much smaller than would be expected in a gravid specimen.
3. The ovary is almost totally depleted of mature ova.
4. The specimen has undergone degeneration as indicated by the gelatinous nature of the muscular tissues and the loss of suckers from all arms, as well as the loss of the tentacles.

The features which typify spent females are not well-known. In order to confirm the above list as characteristic of spent females of the family Gonatidae, I have examined the extensive collections of cephalopods at the University of Southern California for females that appear to have recently spawned. Four species of *Gonatus* are found in the waters off southern California; females of three species were found which appear to have spawned.

Gonatus pyros Young, 1972. Two specimens, 135 mm pen length (P. L.) and 130 mm pen length, easily identified by the presence of a large oval photophore on the ventral surface of each eye, showed extreme signs of degeneration. In consistency they are flaccid and gelatinous which contrast strongly with the muscular condition of immature specimens. Tentacles are absent except for small stubs. All arm suckers are absent; small pockets or slight puckerings of the skin on the gelatinous trabeculae mark the spots where the suckers had once been. The nidamental glands in both specimens are considerably larger (30 and 25 mm) than one would expect to find in a large immature specimen. The oviducal glands are fairly large (22 and 16 mm). In both cases the ovary is small and filled with small, deteriorated eggs. In one specimen a mature egg which was presumably dislodged from the oviducal gland during dissection was found in the mantle cavity. No other eggs were found in the oviducal glands or oviducts. The mature egg, oval in shape, measures 3 mm long by 1.7 mm at the widest point. The deteriorating eggs are slightly more than .5 mm in length. A number of sperm reservoirs were found attached to the buccal membrane. Clusters of small oval vesicles also were found in the buccal membrane; broad funnel-shaped ducts connected the clusters to the oral surface of the buccal membrane (one funnel per cluster). Presumably these are organs for storing sperm. All of the vesicles examined appear to be empty.

Gonatus berryi Naef, 1923. A single female (185 mm P. L.), tentatively identified as this species on the basis of the massive size of the arms, showed evidence of having spawned. In most respects the features of this specimen are the same as in *G. pyros.* The consistency is gelatinous; suckers are absent; the ventral arms are completely bare and the tentacles are absent. The buccal membrane lacks sperm reservoirs but most of the membrane is missing. Nidamental and oviducal glands are somewhat enlarged (35 mm and 25 mm respectively). (For comparison, nidamental and oviducal glands of an immature specimen (103 mm P. L.) measured 5 and 4 mm respectively). The ovary is small but has a large number of small, elongate immature ova. Interspersed among these cells are a number of spherical, pale orange ova in various stages of maturity, the largest of which is about 3.5 mm in diameter.

Gonatus onyx Young, 1972. One presumably spent female has tentatively been identified to this species, primarily on the basis of body proportions. This specimen is somewhat different than the others; the tissues are much firmer and more muscular but still not as muscular as in an immature specimen of this species. Both tentacles are missing and suckers are absent from the dorsal three pairs of arms. The ventral arms are bare except for a few suckers at the arm bases. The nidamental and

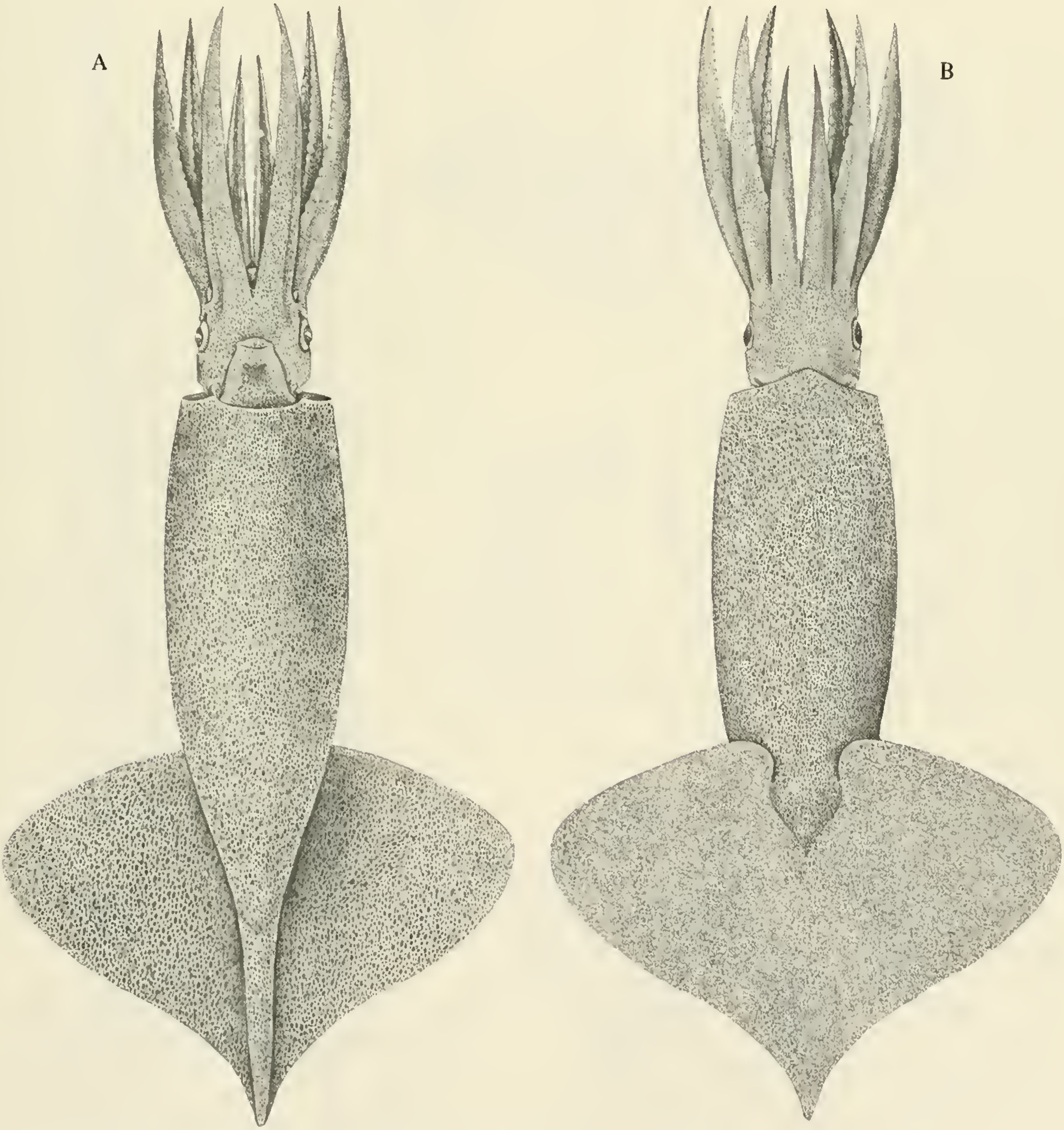


FIG. 1. Gonatus *sp. from the Arctic Ocean. A, Ventral view; B, Dorsal view.*

oviducal glands are somewhat enlarged (34 mm and 22 mm respectively). A small portion of the buccal membrane is missing; the remaining portion is strewn with sperm reservoirs and some of these are attached to the bases of the arms. The ovary is somewhat larger than in the other species and is packed with long (about 1 mm in length), slender immature eggs with a few larger orange, sperical, partically mature eggs (1 mm diam.) interspersed. Apparently a larger percentage of the eggs of this specimen failed to mature completely before spawning.

These three species of *Gonatus* correspond rather closely in their appearance with the specimen from the Arctic Ocean. All show similar signs of degeneration, and comparable conditions of the ovary, oviducal and nidamental glands; and several have sperm reservoirs still attached to the buccal membrane. The evidence strongly suggests that all of these specimens are spent females.

Relatively little information is in the literature regarding the degeneration effects related to spawning in squids. Fields (1965) showed that the mantle of spent females of *Loligo opalescens* decreased greatly in thickness and girth and he concluded that the mantle is the chief site for storing food reserves consumed during the spawning period. He also noted that oviducal and nidamental glands decreased greatly in size after spawning but were still relatively larger than these glands in immature females. In an immature female (ML 87 mm) he found that the nidamental gland was 0.6% of the total body weight. In a mature female (ML 151 mm) the nidamental gland was 22.8% of the body weight while in a spent female (ML 151 mm) the figure was 5%.

McGowan (1954) observed a mass mortality of the squid *Loligo opalescens* following copulation and spawning. He noted that in the dead and dying squid that the mantles were thin and limp. Sasaki, 1913 (according to Hamabe, 1963) found that in the squid, *Watasenia scintillans,* males die after mating in off-shore waters while females die after spawning in coastal waters. Hamabe (1963) noted that the cuttlefish *Sepia esculenta* apparently dies after spawning. For *Todarodes pacificus,* Hamabe (1963) found that in females with a reduced number of eggs in the ovary the mantle was thin and flabby, the liver was reduced in size and firmness and the stomach walls were thin and flabby. These animals had large numbers of eggs in the oviducts and Hamabe assumed that they had not yet spawned but were about to do so.

It has been thought for many years that *Octopus* dies after brooding its eggs (Nixon, 1969). Recently W. Van Heukelem (in press) has noted rather rapid degenerative changes occurring in the muscles of female octopods in aquaria upon completion of the brooding period and just prior to death.

The evidence suggests that degeneration and death following spawning by female squid is a common if not universal phenomenon, and that the same situation occurs in octopods although delayed to the end of the brooding period (See also discussion in Arnold, in press).

Presumably the Arctic specimen had spawned and was about to die when captured. Spawning therefore probably occurred near March 30 and about 79°58' N lat. and 170°23'E long., the time and place of capture. This point is over water 2655 m deep in the Hyperborean Basin of the Arctic Ocean. No information is available on the amount of time which passes from spawning to hatching in any gonatid. It is also not known whether gonatids lay pelagic or benthic egg masses. Nesis (1971a) estimates that the young specimens of *Gonatus* from the northern Norwegian Sea hatched in April or May.

ACKNOWLEDGMENTS

I thank the following people for reading and commenting on the manuscript: J. Arnold, Pacific Biomedical Research Center; M. Nixon, University College London; M. Okiyama, Japan Sea Reg. Fisheries Res. Lab. Niigata; W. VanHeukelem and J. McMahon, University of Hawaii. The squid was collected through a program supported by NONR 228(19), NR 307-270 Office of Naval Research contract with the University of Southern California - work being pursued now under Dr. Hector Fernandez: contract NOOO14-67-A-0269-0013 NR 307-270. I also thank Mrs. Constance McSweeny for preparing the illustrations.

LITERATURE CITED

Arnold, J. M. 1972. Cephalopoda, Decapoda. In: *Reproduction of Marine Invertebrates.* Giese, A. and J. Pierce, edit., Academic Press, In press.

Berry, S. S. 1925. The Cephalopoda collected by the Canadian Arctic Expedition, 1913-18. Rept. Can. Artic Exped. 1913-18, 8(B): 3-8.

Fields, G. 1965. The structure, development, food relations, reproduction, and life history of the squid *Loligo opaleseens* Berry. Fish Bull. 131, 1-108.

Fields, W. G. and V. A. Gauley. 1971. Preliminary description of an unusual gonatid squid (Cephalopoda: Oegopsida) from the North Pacific. Jour. Fish. Res. Bd. Canada 28(11): 1796-1801.

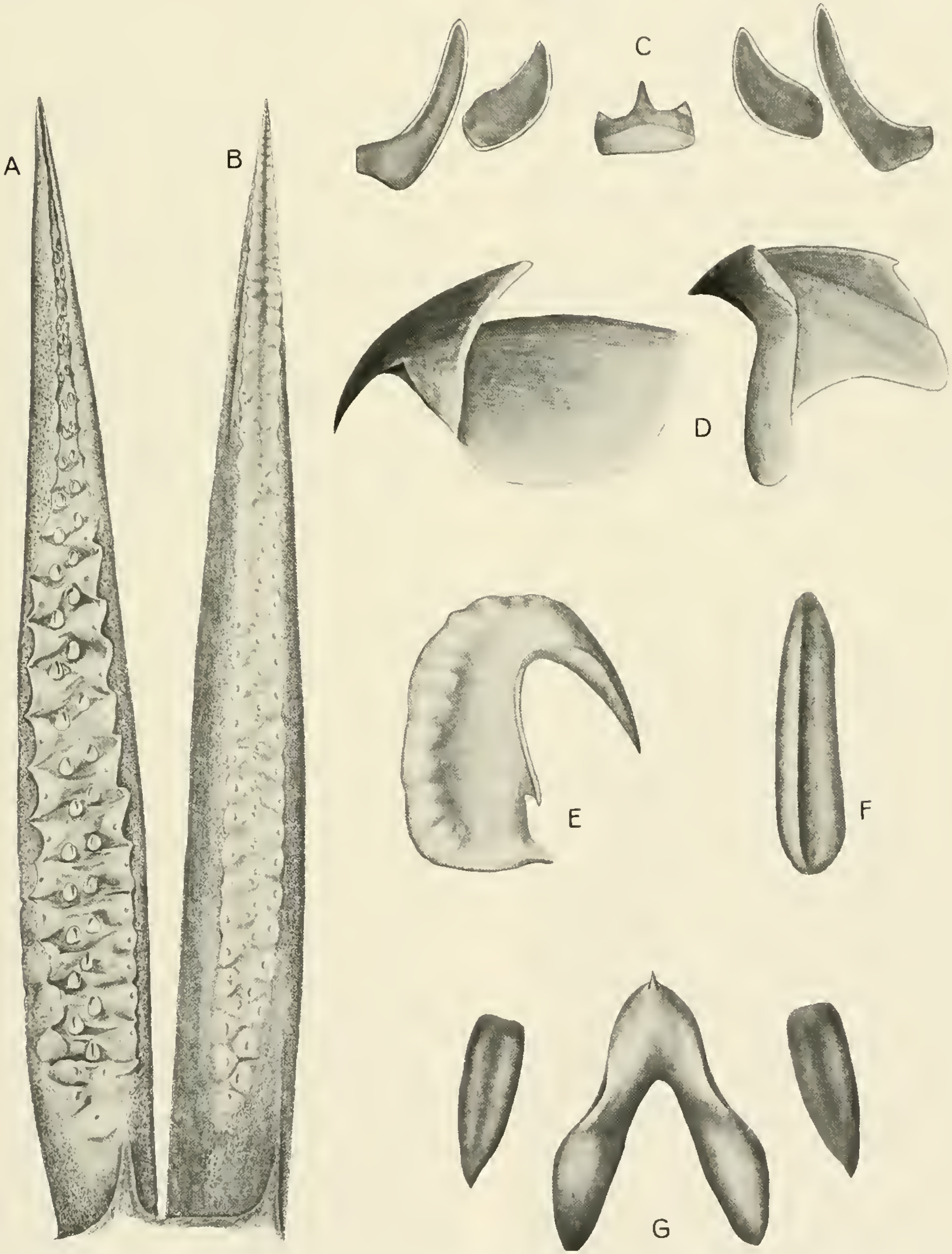


FIG. 2. Gonatus *sp. from the Arctic Ocean. A, Left third arm; B, Left ventral arm; C, Radula; D, Beaks; E, Large arm hook; F, Funnel-locking cartilage; G, Funnel organ.*

Hamabe, M. 1963. Exhaustion process of the genital organs of common squid, *Ommastrephes sloani pacificus.* Bull. Japan Sea Reg. Fish. Res. Lab. 11: 1-11 [in Japanese].

MacGinitie, G. E. 1955. Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. Smithsonian Misc. Coll. 128(9): 1-201.

McGowan, J. A. 1954. Observations on the sexual behavior and spawning of the squid *Loligo opalescens* at La Jolla, California. Calif. Fish Game **40**: 47-54.

Naef, A. 1923. Die Cephalopoden. Systematik. Fauna u. Flora Neapel, Monogr. 35, I(1): 149-863.

Nesis, K. N. 1971a. The squid *Gonatus fabricii* at the center of the Arctic Basin. Hydrobio. Jour. 7(1): 93-96 [in Russian].

Nesis, K. N. 1971b. The family Gonatidae - abundant squids of the North Pacific (their distribution, ecology, system and phylogeny). Fourth Meeting of Investigation of Molluscs, Academy of Sciences, U. S. S. R., Zoological Institute, pp. 63-65 [in Russian].

Nixon, M. 1969. The lifespan of *Octopus vulgaris* Lamarck. Proc. Malac. Soc. London 38: 529-540.

Okiyama, M. 1969. A new species of *Gonatopsis* from the Japan Sea, with the record of a specimen referable to *Gonatopsis* sp. Okutani, 1967 (Cephalopoda: Oegopsida, Gonatidae). Pub. Seto Mar. Biol. Lab. 17(1): 19-32.

Roper, C. F. E. and W. L. Brundage, Jr. 1972. Cirrate octopods with associated deep-sea organisms: new biological data based on deep benthic photographs. Smithson. Contr. Zool. No. 121: 1-46.

Sasaki, N. 1913. Ecology of hotaru-ika *(Watasenia scintillans* (Berry)). Zool. Mag. 30(302): 581-590.

Van Heukelem, W. 1972. Life span of *Octopus cyanea* Gray. Jour. Zool. (London), in press.

Voss, G. L. 1967. The biology and bathymetric distribution of deep-sea cephalopods. Studies in Tropical Oceanography, Miami 5: 511-535.

Young, R. E. 1972. The systematics and areal distribution of the cephalopods from the seas off southern California. Smithson. Contr. Zool., No. 97: 1-159.

BOOK REVIEW

SEA SHELLS OF TROPICAL WEST AMERICA. Marine Mollusks from Baja California to Peru. Second Edition. By A. Myra Keen; with assistance by James H. McLean. xvi + 1064 pp., 4000 illus., 22 pages in color. Index. Stanford University Press, Stanford, Calif. 1971. $29.50.

It seems almost superfluous to recommend this classic compendium to both professional and amateur students of the tropical West American marine mollusk fauna. The second and greatly enlarged edition is the labor of love of A. Myra Keen and a number of her able associates, such as James H. McLean who undertook the herculean task of organizing the section on the Turridae and most of the Archaeogastropoda. Twila Bratcher and Robert Burch contributed the revision of the Terebridae; Eugene Coan and Barry Roth, the Marginellidae; and Spencer Thorpe, the chitons.

Over 3,325 species are included, most of which are well-illustrated and accompanied by succinct descriptions, ranges, and synonyms. The updated bibliography is one of the most complete ever assembled for the mollusks of a major marine province. The index, a measure of the magnitude of the book, contains over 7,000 scientific entries. A bonus comes to the users of the book in the form of a good glossary, a geographical guide to and a series of maps of the area, and tables for fathom-meter-feet conversion.

A very welcome addition is a fairly full treatment of the known nudibranchs, thanks to the efforts of Jame Lance. This rapidly growing subfield of malacology has been greatly stimulated by the inclusion of these shell-less orphans of conchology.

Twelve new plates of stunning color photographs of 72 living mollusks add to the beauty and usefulness of this remarkable faunal guide.

In the face of such a huge, meticulous and detailed documentation, one cannot resist repeating Dr. Keen's quote from another woman writer, George Eliot: "Why, you might take up some light study - conchology now; I always thought that must be a light study."

R. Tucker Abbott
Delaware Museum of Natural History

SHORT PAPERS

RANGE EXTENSIONS OF *CORBICULA MANILENSIS* (PHILIPPI) IN THE ATLANTIC DRAINAGE OF THE UNITED STATES

Samuel L. H. Fuller
and
Charles E. Powell, Jr.
Academy of Natural Sciences of Philadelphia
Philadelphia, Pennsylvania 19103, U. S. A.

ABSTRACT

Corbicula manilensis *(Philippi) is newly recorded from the Savannah, Pee Dee, and Delaware river systems in the Atlantic drainage of the United States.*

In a recent issue of this journal, Sickel (1973, *The Nautilus,* 87 (1): 11-12) discussed the appearance of *Corbicula manilensis* (Philippi) in the Altamaha river system of Georgia, where this Asian species was first detected in 1971. According to the age of Sickel's oldest material, establishment of *Corbicula* in this system had probably occurred as early as 1968. "It will be only a matter of time [Sickel concluded] before *Corbicula* moves northward to inhabit the remainder of the Southern Atlantic Slope region." To the probable detriment of the native Atlantic drainage benthos, that time is come.

Several living *Corbicula* were taken 20 September 1972 by Dr. Selwyn S. Roback and one of us (SLHF) from the Savannah River, about 9 miles northeast of Milhaven, Screven County, Georgia. The specimens lived in shifting sand on a bar at the mouth of an enormous slough; none was found at depths greater than about 1 foot of water. Visits to this locality in 1971 had failed to produce *Corbicula,* but this material falls into at least two size classes, and, at 20.0 mm in length, the largest individual may have been in its second year of life.

During the previous week (12 September), Mr. C. Kirkland Dunlap, Jr., and one of us (SLHF) had found one living *Corbicula* and several "gapers" in the Pee Dee River, about 3 miles southeast of Society Hill, Darlington County, South Carolina. At this point the Pee Dee floor is chiefly of hard clay, with pockets of sand, which drifts in from springs along the river margin. The living specimen was found on bare clay in a few inches of water. The largest individual (a gaper) measures 28.5 mm in length, shows extensive erosion at the beaks, and appears to have reached at least two years of age.

During September and October, 1972, one of us (CEP) found *Corbicula* at numerous localities in the Delaware River between Philadelphia, Pennsylvania, and Trenton, New Jersey. The species was common in no more than 18 inches of water on a variety of substrates, primarily muds and fine gravels. The largest individual collected is 16.5 mm in length and appears to have been in its second year.

Thus *Corbicula* has now invaded the Savannah, Pee Dee, and Delaware river systems, in each case probably as early as 1971. Sickle argued persuasively that the species reached the Altamaha system from the Apalachicola river system of the eastern Gulf of Mexico drainage by means of man's inadvertent carriage overland. We, on the other hand, have no evidence which would incriminate any given vehicle in the rapid and far-reaching dispersal of *Corbicula* recorded here.

●

STREAM POLLUTION REPORTED 104 YEARS AGO

"In the Erie Canal, *Anodonta Lewisii* Lea, formerly very abundant, is now quite scarce, probably on account of chemical contamination from the gas works and armory at Ilion, a mile and a half west from Mohawk" [N.Y.]. -- James Lewis, M.D., Amer. Jour. Conch., vol. 4, p. 245, 1869.

●

JUNE A. M. U. MEETING PLANS COMPLETE

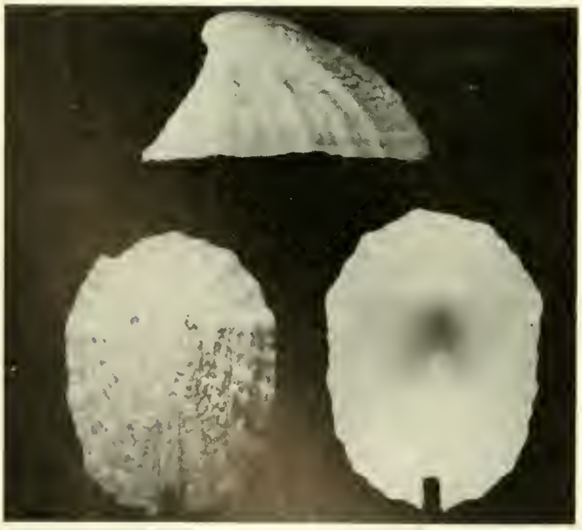
Delaware will be the site of the 39th Annual Meeting of the American Malacological Union from Monday, June 25, through Thursday, June 28, 1973. The main meetings will be held at the new air-conditioned conference center on the campus of the University of Delaware, Newark, Del. On Tuesday there will be a guided tour of the Delaware Museum of Natural History, with special films and additional A. M. U. papers being given there. Prospective new A. M. U. members are also welcome, and are asked to send their annual dues ($4.00 per person and $1.00 for an additional family member) to obtain registration and dormitory reservation forms from Mrs. Marian S. Hubbard 3957 Marlow Court, Seaford, New York 11783.

EMARGINULA DENTIGERA HEILPRIN, 1889, A LITTORAL MOLLUSK

Margaret C. Teskey
P. O. Box 273
Big Pine Key, Florida 33043

From more than sixty shallow water stations in the Florida Keys, both reef and shore, no specimen of *Emarginula* was collected until a colony was discovered in 1972 at the north (Gulf) end of Big Pine Key. Here the live mollusks cling to slab limestone rubble that was pushed into the water to form a narrow, sloping shore when a bordering road was constructed two years ago. They occur occasionally at tide line but are most abundant at the two-foot depth. Density of population may be judged by the fact that on about fifty feet of shore, one hundred specimens were taken by one collector in less than an hour. Only *Acmaea pustulata* (Helbling) is more numerous at the site.

Identification was made by Dr. R. Tucker Abbott who remarked (*in litt.*) that although *Emarginula dentigera* has been considered an ecological form of *E. pumila* A. Adams (Farfante, 1947), he is inclined to recognize it as a valid species. *E. pumila* is reported as extremely variable in size and shape; The Big Pine Key shells are remarkably uniform, high-spired and somewhat narrow. Adults vary little from a length of 6 to 7 mm., width 4 mm., height 3 mm. The apical whorls form a definite hook at about 2/3 of the posterior length of the shell; color chalky-white or stained green; interior glossy; sculpture of 18 to 26 radial ribs of varying size and of numerous, smaller concentric threads, giving a slightly cancellate appearance.



FIGS. Emarginula dentigera *Heilprin, 1889, from Big Pine Key, Monroe Co., Florida. X5.*

Emarginula dentigera Heilprin, 1889, was originally described from Bermuda, as was its synonym, *E. pileum* Heilprin, 1889.

LITERATURE CITED

Farfante, Isabel Perez, 1947. Johnsonia, 2, (24): 107-109.

Heilprin, A. 1889. On Some New Species of Mollusca from the Bermuda Islands, Proc. Acad. Nat. Sci. Phila. for 1889: 141-142, pl. 8, figs. 6 and 7.

●

New Council of Systematic Malacologists

On November 17, 1972, a group of 11 American malacological systematists, representing some of the leading mollusk collections in the country, gathered at the Academy of Natural Sciences of Philadelphia to form a "Council of Systematic Malacologists." The purposes of this organization are 1) to prepare recommendations concerning standards and techniques of collection management for malacological resources; and 2) to define the goals and priorities of malacology. Working subgroups were appointed to prepare recommendations concerning:

1) Compatible EDP (electronic data processing) and curatorial programs for use by malacologists in collection management and research;

2) Articulation of national goals for malacological research;

3) Coordination of specimen acquisition policies for malacological collections;

4) Preparation of position papers outlining priority programs for malacology.

Membership to the Council is open to all professional persons in the Americas who use or manage systematic malacological resources. Further information may be obtained from the Chairman of the Steering Committee, Dr. Alan Solem, Dept. of Zoology, Field Museum of Natural History, Chicago, Ill. 60605. It is hoped that other institutions and their managerial malacologists will be added to the initial participants: Acad. Nat. Sci. Phila.; Delaware Mus. Nat. Hist.; Field Mus. Nat. Hist. (Chicago); Los Angeles Co. Mus. Nat. Hist.; Mus. Comp. Zool. at Harvard; National Mus. Canada (Ottawa); Nat. Mus. Nat. Hist. (Wash., D.C.); Ohio State Univ. Mus.; Nat. Hist. Mus. San Diego; Mus. Zool., Univ. Mich.

INFORMATION FOR SUBSCRIBERS

The *annual subscription* rate for *The Nautilus* is $7.00 for individuals and $12.00 for institutions (domestic or foreign). Subscriptions may be commenced in January when a new volume begins. Send check or money order to "The Nautilus" to Mrs. Horace B. Baker, Business Manager, 11 Chelten Road, Havertown, Pa. 19083.

Back issues from volume 72 to date are obtainable from the Business Manager. Volumes 1 through 71 (if available) may be obtained in reprint or original form from Kraus Periodicals, Inc., 16 East 46th Street, New York, N.Y. 10017.

Advertising rates may be obtained from the Business Manager or Editor.

CONTRIBUTORS

Manuscripts: Authors are requested to follow the recommendations of the *Style Manual for Biological Journals,* which may be purchased from the American Institute of Biological Sciences, 2000 "P" Street, N.W. Washington, D.C. 20036. Manuscripts should be typewritten and doublespaced; original and one copy are required, to facilitate reviews. Tables, numbered in arabic, should be on separate pages, with the title at the top. Legends to photographs should be typed on separate sheets. Explanatory terms and symbols within a drawing should be neatly printed, or they may be pencilled in on a translucent overlay, so that the printer may set them in 8 pt. type. There is a charge of 50 cents per word for this extra service. All authors or their institutions will be charged 50 cents per line of tabular material and taxonomic keys. The publishers reserve the right, seldom exercised, to charge $32 per printed page.

An *abstract* should accompany each paper.

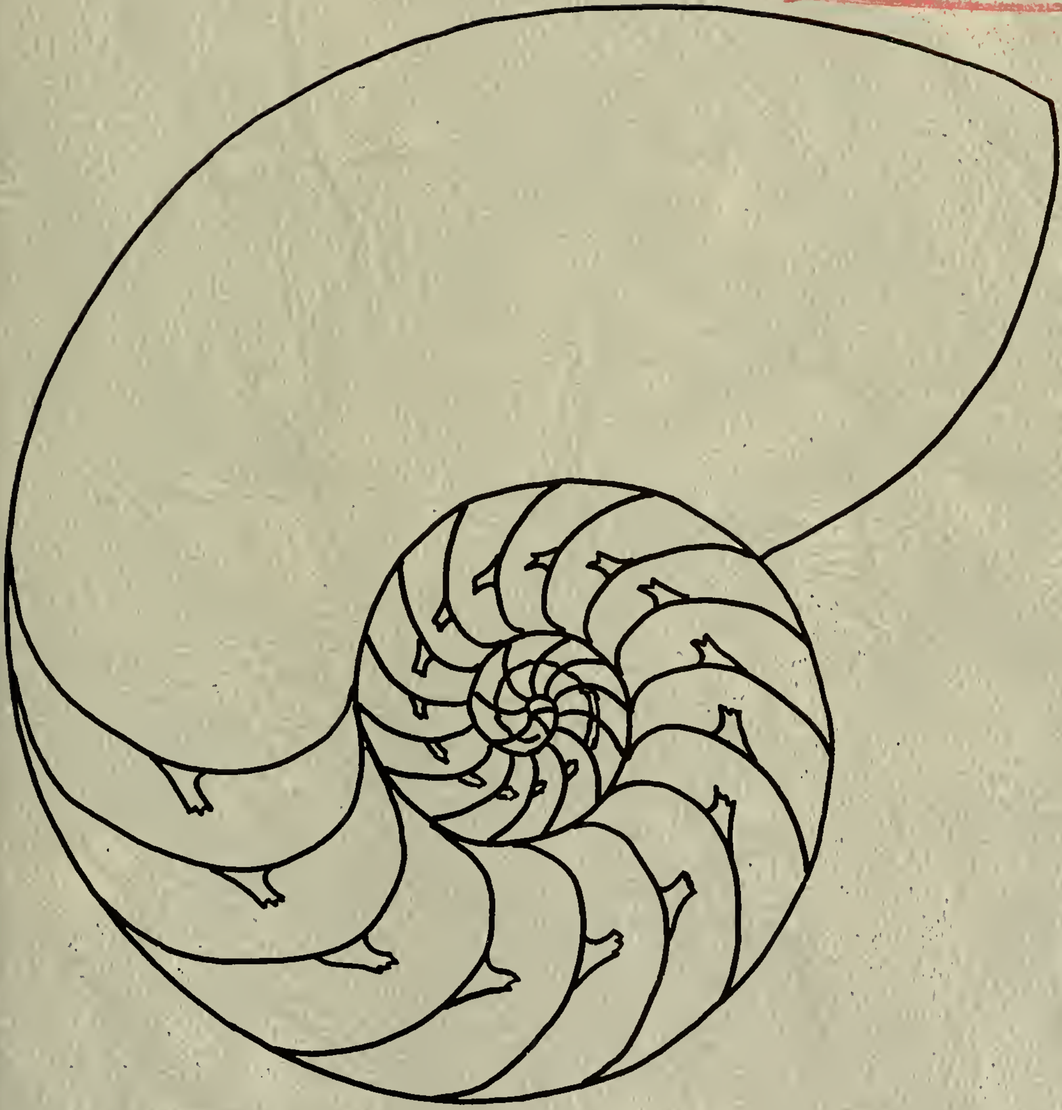
Reprints and covers are available at cost to authors. When proof is returned to authors, information about ordering reprints will be given. They are obtained from the Economy Printing Co., Inc., R. D. 3, Box 169, Easton, Maryland 21601.

JULY, 1973

THE NAUTILUS

Vol. 87

No. 3



A quarterly
devoted to
malacology and
the interests of
conchologists

Founded 1889 by Henry A. Pilsbry. Continued by H. Burrington Baker.
Editors: *R. Tucker Abbott and Charles B. Wurtz*

EDITORIAL COMMITTEE

CONSULTING EDITORS

EDITORS

OFFICE OF PUBLICATION
Delaware Museum of Natural History
Kennett Pike, Route 52
Box 3937, Greenville, Delaware 19807

Second Class Postage paid at Wilmington, Delaware

Subscription Price: $7.00 (see inside back cover)

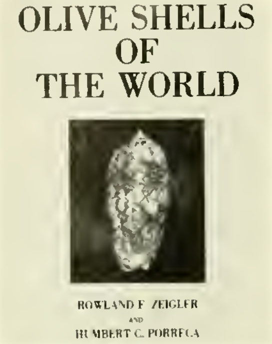
THE
NAUTILUS

Volume 87, number 3 -- July 1973

CONTENTS

The Shell Cabinet

Successor to:
Richard E. Petit
and
John Q. Burch


OLIVE SHELLS
OF
THE WORLD

ROWLAND F. ZEIGLER
AND
HUMBERT C. PORRECA

SPECIMEN SHELLS

NATURAL HISTORY
BOOKS

International Directory of Conchologists - $3.00
A current worldwide list of 2,000 people interested in mollusks and in exchanging shells. Gives addresses and interests. Available only from The Shell Cabinet.

Olive Shells of the World by Zeigler and Porreca - $12.95
13 full-page color plates illustrating over 150 species and named varieties. The only current treatment of the popular family. Clothbound. Available from your book store or directly from us.

Other Recently Published Shell Books Available
Post Office Box 29, Falls Church, Virginia 22046

Limited Edition

A Rare Collector's Item . .

**SWAINSON'S
EXOTIC CONCHOLOGY**

now available at a startlingly low price!
Now only *$13.75* (formerly $30.00)

The few remaining copies of this unusual facsimile have been purchased by the Delaware Museum of Natural History and are now made available practically at cost to all libraries, scientists and amateur conchologists. 48 beautiful, colored plates, representing a faithful reproduction of Swainson's 1834 and 1841 classic, together with the original text and a modern analysis by R. Tucker Abbott and Nora McMillan. Handsomely bound, gilt-edged on 3 sides and in full 9 x 12 inch page size. A useful and rare work belonging in the library of every lover of mollusks. Both available from your favorite book dealer or directly from the

Delaware Museum of Natural History
Box 3937, Greenville, Delaware 19807, U.S.A.

INDO-PACIFIC
MOLLUSCA

MONOGRAPHS OF THE MARINE MOLLUSKS OF THE WORLD WITH EMPHASIS ON THOSE OF THE TROPICAL WESTERN PACIFIC AND INDIAN OCEANS

The most technical and most beautifully illustrated journal now being published on Recent and Tertiary marine mollusks. Over 20 professional malacologists are currently contributing. Edited by R. Tucker Abbott. Among the groups treated are Strombidae, Cassidae, Tridacnidae, Turridae, Littorinidae, Phasianellidae, and, soon to come, Patellidae, Harpidae and Mitridae.

Issued to date in looseleaf form with three sturdy, permanent binders — 1100 pages, 810 plates (31 in full color). Limited number of complete sets left, $91.90 U.S. (foreign: $94.00), postage paid. Any number of extra binders available at $6.00.

Published by

The Delaware Museum of Natural History, Box 3937, Greenville, Delaware 19807 U.S.A.

OBSERVATIONS ON *OCTOPUS JOUBINI*: FOUR LABORATORY REARED GENERATIONS[1]

Ronald F. Thomas and **Lee Opresko**
University of Miami, Rosenstiel School of Marine and
Atmospheric Science, Miami, Florida 33149

ABSTRACT

Four consecutive generations of Octopus joubini *Robson were reared in the laboratory. Spawning occurred at 4-5 months after hatching. At 27-29°C, development of the eggs was completed in 34-42 days. Fiddler crabs (*Uca *spp.) were used almost exclusively for food, although other animals were also presented to the octopods. Results indicate that there are probably two generations of* O. joubini *per year in the field.*

INTRODUCTION

Few laboratory studies have been carried out on the life history of octopods. Discussion of hatching and rearing of the fry of sepioid squids were presented by Choe and Oshima (1963), Choe (1966), Schroder (1969a, b) and Boletzky et al. (1971). The loliginid squids *Sepioteuthis sepioidea* and *Doryteuthis plei* were discussed by LaRoe (1971). Wolterding (1971) reared *Octopus briareus* from egg to maturity and Arnold *et al.* (1972) have reared *Euprymna scolopes.*

Owing to their accessibility and relative hardiness in aquaria, some shallow water octopods, and particularly species of *Octopus,* have been studied. *Octopus vulgaris* was used extensively by J.Z. Young in his classic series of experiments on learning and behavior. Nixon (1969) studied the rate of growth of *O. vulgaris* kept in the laboratory. Boletzky (1969) studied the early development of *O. vulgaris, O. joubini* and *O. briareus.* In the same year Boletzky and Boletzky reported on the first success in raising *O. joubini* to maturity in the laboratory. From one brood of about 50 eggs collected in the field, one female survived to maturity and spawned about 5½ months after hatching.

Octopus joubini is a species of small octopus which is found in shallow waters along the west coast of Florida and the northwestern Caribbean. Its small size (about 10 cm. in total length at maturity) makes it well-suited for laboratory culture. The present paper reports on four generations of *O. joubini* reared in laboratory. Observations on culture, feeding, brooding and life span are given.

METHODS AND MATERIALS

This study was begun in February 1971 and is still in progress. The octopods were maintained in aquaria of 5-, 10-, and 20-gallon capacities and

FIG. 1. *Adult male* Octopus joubini *in aquarium. Natural size. Photo by Dennis Opresko.*

---

[1] Contribution No. 1592 from the University of Miami, Rosenstiel School of Marine and Atmospheric Science. This work was supported in part by National Science Foundation grant GB-24994X.

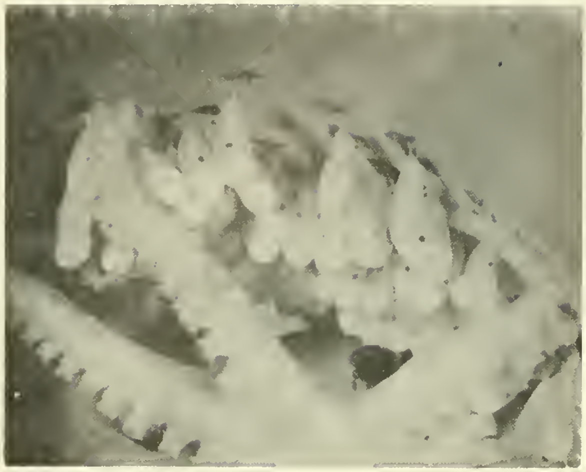


FIG. 2. *Eggs being brooded by female* O. joubini *on inside of empty flower pot. x 1½. Photo by Dennis Opresko.*

supplied with running sea water piped from Biscayne Bay. The bay water was first passed through settling tanks and was then filtered through a series of gravity-fed compound filters containing layers of $CaCO_3$ pebbles and sand and glass wool. With this system, adequate water quality and aeration for the survival of the octopods was maintained. Additional aeration was provided by means of a mechanical pump as a safeguard against water stagnation due to possible blockage of the filters and subsequent loss of water flow.

The initial brood and female were obtained from inside a bottle found in shallow water of about 1-2 meters at Key Biscayne, Miami, Florida. The newly-hatched animals were supplied refuge by astro turf floating on the water-surface. After 4 weeks, flower pots, rocks and shells were provided for the animals. Mature females would readily deposit eggs in the flower pots. *Octopus joubini* attaches each egg individually to the substrate. After hatching, the attachment point of the egg on the substrate can be seen as a dark spot; this permitted the estimation of the size of the brood.

For the first several days after hatching, the octopods were still receiving nourishment from the internal yolk sac and would not feed. During the following 2 to 3 weeks, the juveniles would not accept live *Uca* as food and were individually fed daily. A segment of a *Uca* appendage placed in contact with the octopus was usually seized and eaten. After several weeks, the young animals accepted live *Uca* of appropriate size.

The water level was kept several inches below the tops of the aquaria to discourage animals from crawling out of the tanks. This method was found to be successful for this species.

OBSERVATIONS

At an early age *O. joubini* selected a home site, either in a flower pot or in a rock crevice. Seven adult octopods, each provided with a suitable refuge and placed together in a 20-gallon aquarium, did not display any territorial aggressive behavior. Under these conditions no deaths in any aquaria were considered to be caused by other octopuses.

The animals consumed a considerable amount of food (*Uca*). The young octopods successfully attacked crabs equal to or larger than themselves. They were strongly nocturnal, remaining in crevices during the day and searching for food at night. If a light were turned on at night while an octopus was feeding, it would drop the partially consumed crab and return to its den. It would later attack another *Uca* rather than continue to feed on the dead, half-eaten crab.

In table 1, temperatures in the aquaria are given. Small fluctuations of aquarium temperatures (from 1-2°C) tended to reflect those of the room rather than those of the field, but in general, aquarium temperatures were comparable to those in the field.

F_1 GENERATION

The F_1 generation hatched on 13 February 1971. The newly hatched animals grew slowly, probably because of an inadequate supply of food. The most critical stage in rearing *O. joubini* occurs between 2 and 21 days of age, since the animals would not attack live food. Consequently this is the time during which the highest mortality occurred. Later mortalities usually occurred when the sea water system became blocked and additional aeration was not used. As the water in the tank began to foul, the animals responded by leaving their dens and moving to the water surface.

Three F_1 females laid eggs 4½ months after hatching, all within several days of each other.

Thus the maturation of laboratory-raised *O. joubini* was sufficiently rapid to allow two generations to be completed within a year.

One female laid about 40 eggs. The length of these eggs (7.6 mm.) did not differ significantly from measurements reported in the literature (8.0-8.5 mm.) by Boletzky (1969).

Once the eggs were laid, the female remained with them until they hatched. Her arms continuously swept over the eggs to remove detritus that settled on them. She would not leave the eggs to feed. If a crab entered the octopus' den while she was brooding eggs, she would generally attack and consume it. Due to the high density of crabs in each tank, females were able to feed while brooding. Although it is generally believed that the female octopus dies soon after the eggs hatch, this did not always occur in the laboratory, probably due to the availability of food during brooding.

At 27-30°C, hatching occurred within 34-42 days, usually at night. Near the time of hatching, mechanical stimulation caused by examining the eggs resulted in premature hatching of some eggs. Although these octopods hatched prematurely, they were still able to survive.

The females did not lay a second brood of eggs. After the eggs hatched both males and females showed a reduction in feeding intensity (the animals now fed sporadically rather than regularly). At about 6 months of age the F_1 males and females began to die. The mortality rate steadily increased so that by 8 months of age about 50% adult mortality was attained. Old, dying *O. joubini* typically stopped feeding and abandoned their dens. They often sat on the floor or sides of the aquarium, slowly coiling and uncoiling their arms in an uncoordinated manner.

F_2 GENERATION

Eggs were laid by F_1 females on 23 June 1971. The F_2 generation hatched between 34 and 42 days later. Growth of these animals was similar to that stated for the F_1 generation. Egg laying by F_2 females began at the end of November, indicating that this generation reached maturity in about 4 months. The water temperature in the aquaria during the development of the F_2 generation was 27-29°C, about 1-3°C higher than the temperature during the development of the first generation.

TABLE 1. *Temperature values (°C) measured in the aquaria.*

Date	Temp (°C)
21 July 1971	28.9
28 July	28.2
3 August	29.0
10 August	27.8
16 August	27.1
24 August	29.0
31 August	27.8
7 September	26.7
11 September	27.0
20 September	27.0
24 September	27.0
30 September	27.0

FIG. 3. *Young* O. joubini *in typical posture. x 2. Photo by M. Wolterding.*

TABLE 2. *Dates of hatching of* Octopus joubini *eggs laid 23 June 1971. Water temperatures: 27-29°C.*

Date	No. eggs hatched
27 July	8
28	5
29	4
30	8
31	1
1 August	1
2	1
3	0
4	0
5	4
6	2

F_3 GENERATION

Approximately 95 eggs were laid by one of the F_2 females. Hatching of these eggs began on 26 December 1971. At the end of six weeks, 52 young were still alive. This generation was raised very successfully, and about 42 animals reached maturity, with 15 females laying broods of eggs.

The size of the F_3 animals was quite small (average mantle length of 5 males: 26.7 mm.; of 5 females: 21.9 mm.). We feel that stunting occurred as a result of crowded conditions in the aquaria. Inadequate food may have been a contributing factor during the early growth period. Egg-laying began at 4½ months (15 May 1972) even in the small females, although the number of eggs per brood was low. It is interesting to note that *O. joubini* in Biscayne Bay, Florida, were also observed to have eggs at the same time as the F_3 females (James Espy, personal communication).

F_4 GENERATION

These octopuses began to hatch on 20 June 1972 and hatching continued to the middle of July. A culture of brine shrimp *(Artemia salina)* was established and maintained in an attempt to replace the individual feeding of each juvenile octopus. For this experiment, octopuses between 1 and 7 days old were supplied with brine shrimp of various sizes, excluding newly hatched brine shrimp. The brine shrimp were placed in the tank with the octopus at 4:00 PM daily and the running water was turned off. The *Artemia* were observed to swim slowly around the tank, during which time they often came in contact with an octopus. Many times brine shrimp were seen to crawl under the octopus. Instead of seizing the brine shrimp, the octopus blanched, inked and swam away. Brine shrimp held with forceps and presented to the octopus were rejected. One octopus, presented with brine shrimp in this manner, accepted the food after many trials and was later observed to capture live *Artemia.* This procedure unfortunately met with little success and it became necessary to resume the hand feeding.

The number of F_4 juveniles that hatched could not be accurately estimated because many were able to hide in the rocks that were provided for the adults. About 70 were isolated and placed in separate aquaria of 3- to 5-gallon capacity. One month after the initial hatching occurred 15 of the largest F_4 *O. joubini* were placed in a single 20-gallon aquarium and were fed exclusively with live *Uca* spp. The small individuals which remained in the 3- to 5-gallon aquaria were fed pieces of *Uca* appendages and were also provided with suitably-sized live *Uca.*

DISCUSSION

Boletzky & Boletzky (1969) were able to raise one female *Octopus joubini* to maturity. This animal laid eggs 5½ months after hatching. The present study confirms the rapid development of this species of octopus. Mangold-Wirz (1963) found that females of *Eledone cirrosa, E. moschata, Octopus vulgaris* and *Pteroctopus tetracirrhus* reached sexual maturity at about 18-24 months, while *Bathypolypus sponsalis* matured at 8-17 months.

According to Boletzky (1969), at 24-25°C the eggs of *O. vulgaris* hatch in 25 days, *O. joubini* in 30 days, and *O. briareus* in 50 days. In this study, hatching of *O. joubini* began at about 34 days, thus agreeing with Boletzky's findings.

As is typical with most octopods, the female of *O. joubini* diligently cares for the eggs until they hatch. Brooding behavior weakens the female and she generally dies soon after the eggs hatch, but death appears to be delayed if she is able to feed during brooding.

The rapid maturation of *O. joubini* in the laboratory suggests that there are two generations annually. Thus in certain parts of the range it is likely that there is both a summer and a winter population of this species. This species of small octopus with its short life span provides an opportunity to study development in the laboratory and to establish techniques for cephalopod maintainance. An important problem, water quality, can be minimized by a running sea-water system with filtering equipment. With running sea-water, additional aeration is unnecessary but is advisable in the event that the water flow is temporarily blocked.

Feeding presents the other major problem in the culture of benthonic octopods. At the present time, suitable live food for the young juveniles has not been found. Gammarid and caprellid amphipods and various other amphipods as well as numerous isopods were offered to the juveniles but were rejected by them. This was found to be the case for *Artemia salina*, except with one *O. joubini*. The largest and probably oldest (7 days old) F_4 juvenile which was offered brine shrimp did finally attack *Artemia*. Even though the octopus accepted them as food, the fact that the smaller *O. joubini* would not eat brine shrimp prevents this method from being used on newly hatched *O. joubini*. *Artemia* seems to be more suitable for octopods with planktonic larvae and has been used in rearing *O. vulgaris* (Boletzky, personal communication).

The method of feeding with *Uca* described here is time consuming and inefficient, contributing to most of the mortalities at this stage of growth. In areas where *Uca* is abundant, it provides a satisfactory and easily obtainable source of live food for the larger animals.

ACKNOWLEDGMENTS

We wish to thank Mr. Dennis Opresko and Mrs. Irene Thomas for their help in maintaining the animals and for their assistance in the preparation of the manuscript. We also wish to thank Mr. D. Opresko for photographing the animals. Dr. Won Tack Yang provided helpful suggestions in the culture of marine organisms and also provided the stock of live *Artemia*. We especially wish to thank Dr. Gilbert L. Voss for his support and encouragement during this study and for his critical reading of the manuscript.

LITERATURE CITED

Arnold, J.M., C. T. Singley and L. D. Williams-Arnold 1972. Embryonic development and post-hatching survival of the Sepiolod squid *Euprymna scolopes* under laboratory conditions. The Veliger **14**(4): 361-364.

Boletzky, S. von 1969. Zum Vergleich der Ontogenesen von *Octopus vulgaris, O. joubini*, und *O. briareus*. Rev. Suisse Zool. **76**: 716-726.

Boletzky, S. von & M. V. von Boletzky 1969. First results in rearing *Octopus joubini* Robson, 1929. Verh. naturf. Ges. Basel **80**: 56-61.

Boletzky, S. von, M. V. von Boletzky, D. Frosch, & V. Gatzi 1971. Laboratory rearing of Sepiolinae (Mollusca: Cephalopoda). Mar. Biol. **8**: 82-87.

Choe, S. 1966. On the eggs, rearing, habits of the fry, and growth of some Cephalopoda. Bull. Mar. Sci. **16**: 330-348.

Choe, S. & Y. Oshima 1963. Rearing of cuttlefishes and squids. Nature **197**: 307.

LaRoe, E. T. 1971. The culture and maintainance of the loliginid squids *Sepioteuthis sepioidea* and *Doryteuthis plei*. Mar. Biol. **9**: 9-25.

Mangold-Wirz, K. 1963. Biologie des Cephalopodes benthiques de la Mer Catalane. Vie et Milieu (Suppl.) **13**: 1-285.

Nixon, M. 1969. The lifespan of *Octopus vulgaris* Lamarck. Proc. malac. Soc. London **38**: 529-540.

Schroder, W. 1969a. Observations made during the breeding of cuttlefish (*Sepia officinalis* L.). Drum and Croaker **69**: 9-15.

Schroder, W. 1969b. Notes concernant Cephalopoda et la reproduction de la seich commune. Zool. Anvers. 34th year (3).

Wolterding, M. 1971. The rearing and maintainance of *Octopus briareus* in the laboratory with aspects of their behavior and biology. M.S. thesis, Univ. of Miami, 120 pp.

OXYLOMA DEPRIMIDA, A NEW SPECIES OF SUCCINEIDAE (PULMONATA)

Dorothea S. Franzen
Illinois Wesleyan University
Bloomington, Illinois 61701

ABSTRACT

Oxyloma deprimida, *a new species of Succineidae (Pulmonata) is described from Utica, LaSalle County, Illinois, (type locality) and near Canton Lake, NE of Canton, Fulton County, Illinois. The nuclear whorl of the shell is depressed, hence, the species name* deprimida. *The habitat of* O. deprimida *is on cattails generally 3 to 5 ft. above the wet ground or water level. The snails mature in the fall and not in the summer as does* O. retusa, *a sympatric species. Anatomical features include a broadly based penial appendix and an albumengland which is smaller than the prostate gland.*

The search for succineas in the state of Illinois has resulted in the recognition of a hitherto undescribed species, *Oxyloma deprimida,* new species.

Description of Holotype: The amber-colored, ovate, imperforate shell, composed of three inflated whorls, is thin, fragile, shiny, and marked only by fine striae. The nuclear whorl is depressed (Fig. 1, upper right), rough and pitted (Fig. 1, lower left). The whorls increase rapidly in size from the nuclear to the body whorl. The suture is sharply incised resulting in a slight shouldering along the upper border of the whorl. The peristome of the ovate aperture is sharp and continuous over the surface of the body whorl in the form of a thin, white callus (Fig. 2, left). The narrow, white columella follows the inner border of the peristome (Fig. 2, left). The dimensions of the shell are: height, 12.45 mm.; width, 7.6 mm.; height of aperture, 9.85 mm.; width of aperture, 5.7 mm. The ratios of the several dimensions are shown in Table I.

The surface of the head and the body wall are cream-colored and coarsely and irregularly tuberculate. The pigmentation of the anterior dorsal portion of the head consists of black blotches arranged in five, indistinctly defined, longitudinal bands that form a shield-shaped pattern (Fig. 2, right). They converge medially between the posterior tentacles and then spread apart continuing as two bands towards the mantle. The shield pattern is flanked on either side by a pigmented band, narrow anteriorly, but broadening at the base of the posterior tentacles as it continues to the mantle. On

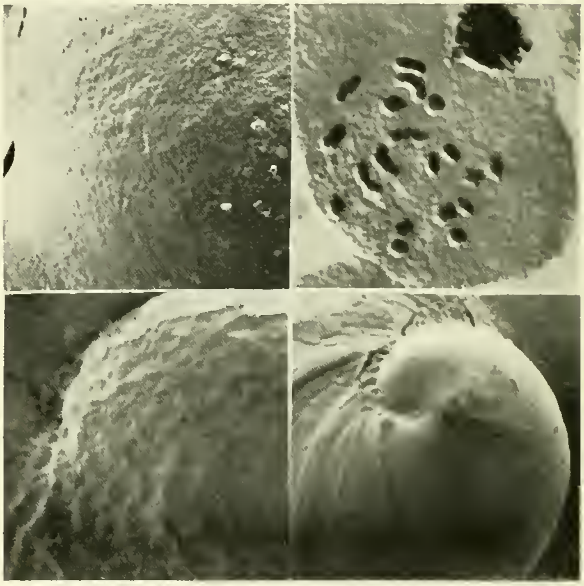


FIG. 1. **Upper left,** *Chromosomes of an ovotestis smear of* Oxyloma deprimida *from the type locality. Enlarged.* **Upper right,** *Scanning-electron-photomicrograph showing the nuclear whorl of* Oxyloma deprimida *of a shell from the type locality. Enlarged.* **Lower left,** *Scanning-electron photomicrograph of the nuclear whorl of* Oxyloma deprimida *of a shell from the type locality, showing surface detail. Enlarged.* **Lower right,** *Scanning-electron-photomicrograph of the nuclear whorl of a shell of* Succinea luteola, *showing surface detail. Enlarged.*

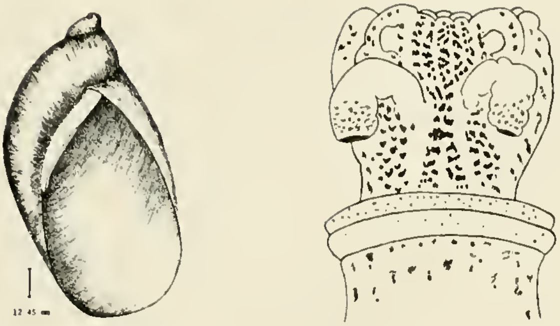


FIG. 2. *Drawings of the holotype of* Oxyloma deprimida. **Left**, *shell drawn to scale as indicated.* **Right**, *head and anterior portion of mantle. Enlarged.*

the lateral body wall flecks of light pigmentation form a broad band that tapers and diminishes posteriorly. The mantle collar is lightly pigmented on the upper and outer surface and more heavily pigmented on the anterior and inferior surface. The pigmentation of the anterior portion of the mantle occurs as widely-spaced blotches (Fig. 2, right). The anterior border of the nephridium is outlined by a narrow, broken, black band whereas the posterior border is outlined by a broader, darker band. Sparse, scattered patches of pigment occur on the remainder of the body. The genital aperture, crescent-shaped, 2 mm. in length, surrounded by a white, tumid lip, is situated on the anterior right-hand side of the body. A pedal groove, continuous from the labial palp to the posterior tip of the body, separates the foot from the lateral body wall; the pedal groove is paralleled dorsally by a less-pronounced, suprapedal groove. Shallow, vertical grooves incise the pedal and suprapedal grooves and the broad, pigmented band. These vertical grooves produce a series of shallow scallops along the margin of the pedal groove especially when the animal is in a somewhat contracted state.

Holotype: catalogue no. FMNH 176002; paratypes nos. FMNH 176003, FMNH 176004, and FMNH 176005, Molluscan Collection, Field Museum of Natural History, Chicago, Illinois. Additional paratypes are in the private collection of the author.

The author has examined shells of succineas of the collection in the Natural History Museum, University of Illinois. A shell identified by Frank Collins Baker (1939) as *Succinea retusa peoriensis* Wolf and which Pilsbry (1948) identified as *Oxyloma decampi peoriensis* (Walker), as indicated below, is herein identified as *Oxyloma deprimida,* new species.

Synonymy —

Succinea retusa peoriensis Wolf. Frank Collins Baker, 1939. Fieldbook of Illinois Land Snails, Manual 2, Natural History Survey Division, p. 126, Fig. E, left-hand figure only.

Oxyloma decampi peoriensis (Walker), Henry A. Pilsbry, 1948. Land Mollusca of North America, Vol. 11, Pt. 2, p. 785, Fig. 420, b, left-hand figure only.

Known geographic distribution and habitat: 1. Type locality: Field No. D.S.F. 350; NE¼ SW¼ S 9, Twp. 33 N, R 2 E, Utica (N. Utica), LaSalle County, Illinois, about ½ mile east of the crossing of Illinois Highway 178 over the Rock Island and Pacific railroad tracks, between the Rock Island and Pacific railroad tracks and Clark Run Creek. The habitat is the shore of a water-filled pit on the northern edge of Clark Run Creek that supports cattails (*Typha* sp.), goldenrod (*Solidago* sp.), and willow (*Salix* sp.). *Oxyloma deprimida* lives on the cattails several feet (2 to 5) above the wet ground and/or above the water level.

An earlier unpublished record of the species taken from "Utica, Illinois" is in the Molluscan Collection of the Field Museum of Natural History, Chicago, Illinois. The shells, catalogue no. 58198, were identified as *Succinea (Oxyloma) decampi* Bryant Walker. They were formerly in the James H. Ferriss collection and identified as *Succinea retusa peoriensis* Wolf.

Locality: 2. Field No. D.S.F. 194; NE¼ SE¼ NW¼ S 19, Twp. 7 N, R 5 E; 3 miles NE of the town square in Canton, Fulton County, Illinois. The habitat is a lowland adjacent to a northeastern arm of Canton Lake where moist ground supports a stand of cattails and willows. *Oxyloma deprimida* lives on this vegetation 3 to 5 feet above the ground, and is not found on the ground where lives *O. retusa* (Lea), a sympatric species. This association does not, however, occur at the Utica locality.

Anatomy of paratypes: The large, coiled, heavily pigmented hermaphroditic duct, coming from the ovotestis, enters the fertilization sac which is connected with the seminal vesicles. The relatively large, twinned, unequal seminal vesicles are coarsely peppered with black pigmentation whereas the inflated fertilization sac is lightly pigmented. The prostate gland is situated immediately anterior to the albumen gland. The acinar prostate gland is covered by a thin, lightly pigmented sheath, and is larger than the albumen gland. The albumen gland, about two-thirds the length of the prostate, is composed of acini which are smaller than those of the prostate gland. The single duct leading from the fertilization sac divides to form two ducts, one leading into the prostate gland and the other forming the oviduct (Fig. 3, F).

The vagina is straight, slightly pigmented, equal to about seven-eighths of the length of the penis, and opens along with the penis into the genital antrum. The oviduct is highly convoluted, slightly pigmented, and enters the distal end of the vagina as does the spermathecal duct. The spermathecal duct loops over the oviduct just prior to its entry into the vagina.

The retractor muscle of the right posterior tentacle passes between the penis and the vagina. The penis is enclosed in a thin, translucent sheath peppered with black pigment in the middle or towards its distal end. The vas deferens may or may not be lightly stippled. As the vas deferens approaches the distal end of the penial sheath it loops ventrally under the penial retractor muscle and enters the penial sheath terminally; then known as the epiphallus, it coils, increases in caliber as it approaches the penis and becomes enlarged just before it merges with the penis subterminally (Fig. 3, A). The penial appendix, because of its broad base, appears to be a terminal extension of the penis rather than an appendix separated from the body of the penis by a constriction. The size and shape of the penial appendix is variable (Fig. 3, A - E).

The ovotestis of many individuals of *Oxyloma deprimida,* from both localities, were squashed and stained with orcein. Examinations of the stained chromosomes in metaphase revealed the haploid number of nineteen to be characteristic of this species (Fig. 1, upper left). This is the same number found in *O. retusa* (Lea), *O. haydeni* (W. G. Binney) and *O. salleana* (Pfeiffer), (Franzen, 1966, p. 67).

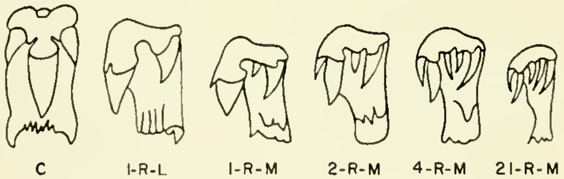


FIG. 4. *Representative teeth of a radula of a snail taken from near Canton Lake; 3 mi. NE Canton, Illinois. C, central tooth; 1-R-L, 1st right lateral; 2-R-M, 2nd right marginal; 4-R-M, 4th right marginal; 21-R-M, 21st right marginal.*

The radula (Fig. 4) is composed of many rows of teeth and numerous teeth to a row. The number of rows in 6 radulae examined, ranged from 90 to 116. The numbers of marginals and laterals of representative rows of 5 radulae are to be noted in Table II. The ratios of marginals to laterals approaches 1:3 and 1:4. This compares with what has been reported for *Oxyloma retusa,*(Franzen, 1963, Table II, p. 89) and for *O. haydeni,* (Franzen, 1964, Table II, p. 78).

The structural details of the individual teeth resemble those of the genus in general (Fig. 4). The central tooth has a broad basal plate which has a lateral basal pointed projection on either side. The pointed mesocone, somewhat variable in length, does not usually extend to the lower margin of the basal plate. A shorter, pointed ectocone flanks the mesocone on either side. The laterals have a large, pointed mesocone which, like that of the central tooth, is usually not as long as the basal plate; the single ectocone, sometimes divided into two — especially of the more lateral teeth — is pointed; a short, pointed endocone may be present. The marginals, smaller than the laterals, have a long, slender basal plate which is characteristic of the genus *Oxyloma* (Quick, 1933:296, Fig. 1, *Oxyloma (Succinea) pfeifferi* Rossm.). Of the cusps of the marginals, the mesocone is the largest, the endocone is small and pointed. The ectocone of about the six medial-most marginals is divided into two unequal cusps of which the lateral-most is the largest, and curved. The ectocone of the more lateral marginals is divided into three cusps of which the outermost is the largest. The ectocone of the marginals nearest the outer side of the radula may be divided into four cusps of which the outermost is short and pointed. The features of the amber-colored jaw are typical of the genus. A prominent median fold projects anteriorly and is flanked on either side by a broadly rounded fold.

The surfaces of the bodies of the paratypes are, as in the holotype, cream-colored and coarsely and irregularly tuberculate. The pattern of pigmentation of the head and body is like that of the holotype although the intensity of pigmentation is variable. The sole of the foot may be lightly or not at all speckled. The most striking variation of pigmentation is that of the mantle. The pattern of the anterior portion may be in the form of black, widely-spaced blotches, as in the holotype, or heavier blotches arranged in indistinctly defined rows connected by less intense stripes of pigment, or the blotches may merge, resulting in an irregular pattern. The amount of pigmentation anterior to the nephridium varies from light to heavy, the latter in the form of a dark area interspersed by fine-lined, light streaks. The intensity of the pigmentation outlining the nephridium is light in some individuals and more intense in others. The pigmentation of the area posterior to the nephridium varies from a few scattered blotches to many patches merging to form a more overall pattern extending to the posterior tip of the animal.

Shell of paratypes: The shell of the mature snail, attaining a height of almost 13.5 mm., is comprised of 2½ to 3 inflated whorls. The surface of the nuclear whorl is rough and pitted (Fig. 1, lower left) but not distinctly malleated as in *Succinea luteola* Gould (Fig. 1, lower right), *S. vaginacontorta* Lee, and *S. campestris* Say.

Dimensions of the three largest shells, number of shells measured, and the median of each series measured, are recorded in Table I. The range of the greatest height of the series of shells included in this study is from 9.8 mm. to 13.46 mm.; and the range of the greatest width is from 6.7 mm. to 8.4 mm. The greatest height of shells obtained from the Canton Lake locality is 11.8 mm.; the greatest diameter is 8.4 mm. (October, 1960); the comparable dimensions of shells of the Utica locality are, greatest height, 13.46 mm., greatest diameter, 8.04 mm. (September, 1967).

Distinctive characteristics of Oxyloma deprimida: The name of the species, *deprimida*, denotes the depressed position of the nuclear whorl (Fig. 1, upper right) as contrasted with the prominent, knoblike nucleus which is characteristic of other known species of the genus. The tip of the nuclear whorl appears to be somewhat "tucked in" under the penultimate whorl.

The epiphallus enters the penis subterminally which produces a terminal extension of the penis, the penial appendix. In *O. deprimida* the base of the penial appendix is broad which makes it appear to be a terminal extension of the penis rather than an appendix distinctly separated from the body of the penis by a constriction as in, for example, *O. haydeni*, (Franzen, 1964, Fig. 1). The epiphallus enlarges as it approaches the penis and merges imperceptibly with it.

The albumen gland is smaller than the prostate gland and is located posteriorly to it. The acini of the albumen gland are distinctly smaller than are those of the prostate.

Oxyloma deprimida lives on cattails and willows generally 3 to 5 feet above the ground and/or the water level, not on the ground nor on objects floating on the water. The last time the type locality was visited (September 28, 1971) the water had receded to the level of the small stream as a

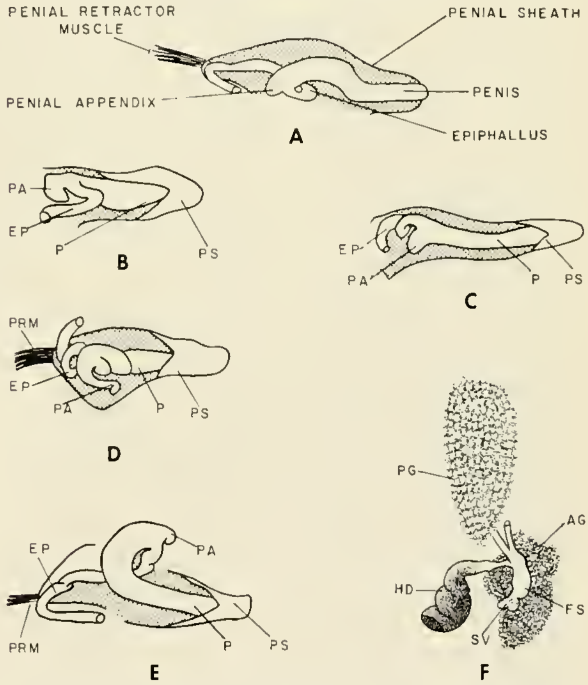


FIG. 3. *Drawings of genital organs of* Oxyloma deprimida: *A - E, penis, penial appendix and epiphallus shown inside of penis sheath cut open. The figures are of snails from the following localities: A, near Canton Lake, 3 mi. NE Canton, Illinois; B, Utica, Illinois; C, Utica, Illinois; D, Utica, Illinois; E, near Canton Lake, 3 mi. NE Canton, Illinois. F, prostate gland and albumen gland of a snail from the Utica, Illinois, locality: PG, prostate gland; AG, albumen gland; FS, fertilization sac; SV, seminal vesicles; HD, hermaphroditic duct.*

TABLE 1. *Dimensions of the shells of* Oxyloma depressa. *The measurements are of the 3 largest shells of each of the 9 series as indicated. In the 4th column of measurements are listed the ratios of the width of the shell over its height. In the last 3 columns are listed the ratios of the height of the aperture over the height of the shell, width of aperture over width of shell, width of aperture over height of aperture.*

	No. of Whorls	Height	Width	Width/ Height	Height of Aperture	Width of Aperture	H. Ap./ H. Shell	W. Ap./ W. Shell	W. Ap. H. Ap.
Holotype	3	12.45 mm	7.6 mm	.610	9.85 mm	5.7 mm	.79	.750	.578
Field # 350	2 3/4	10.74 mm	6.80 mm	.633	8.16 mm	4.88 mm	.760	.718	.598
Type Locality	3	10.24	6.33	.618	7.50	4.50	.732	.711	.600
Utica, Ill.	3 1/8	10.03	6.10	.608	7.38	4.45	.736	.729	.603
Oct. 22, 1966									
Range (32 shells)	2 1/4-3 1/8	6.71-10.74	4.07-6.8	.550-.673	5.13-8.16	3.24-4.88	.710-791	.659-.806	.544-.677
Median		8.85	5.54	.619	6.66	3.99	.759	.718	.598
Field # 350	3	13.46 mm	7.75 mm	.576	9.54 mm	5.66 mm	.709	.730	.593
Utica, Ill.	2 7/8	13.17	8.04	.610	9.94	5.79	.755	.720	.582
Sept. 30, 1967	3 1/8	12.84	7.72	.601	9.61	5.81	.748	.752	.604
Range (74 shells)	2 1/2-3 1/8	8.24-13.46	4.64-8.04	.553-.668	6.06-9.94	3.36-5.89	.709-.798	.681-.795	.549-.651
Median		10.84	6.53	.599	8.11	4.79	.744	.733	.594
Field # 350	3	12.89 mm	7.33 mm	.569	9.52 mm	5.72 mm	.738	.780	.601
Utica, Ill.	3	12.39	7.12	.575	8.49	5.27	.685	.740	.621
Sept. 19, 1970	3	12.26	7.10	.579	8.47	5.30	.691	.746	.626
Range (107 shells)	2 3/4-3 1/4	7.9-12.89	4.90-7.37	.499-.654	6.05-9.52	3.5-5.72	.673-.808	.670-.799	.539-.736
Median		10.88	6.41	.597	8.0	4.76	.737	.741	.600
Field # 350	3	12.45 mm	7.60 mm	.610	9.85 mm	5.70 mm	.791	.750	.579
Utica, Ill.	3	12.30	7.40	.602	9.30	5.80	.756	.784	.624
Sept. 28, 1971	3	12.25	7.25	.592	9.55	5.85	.780	.807	.613
Range (157 shells)	2 1/2-3	7.74-12.45	4.53-7.60	.532-.717	5.88-9.85	3.71-5.85	.674-.883	.679-.852	.570-.663
Median		9.58	5.85	.613	7.29	4.48	.759	.768	.615
Field # 194	3	11.5 mm	8.2 mm	.713	9.1 mm	5.8 mm	.791	.707	.637
Canton Lake, Ill.	3 1/8	11.2	7.8	.696	8.9	5.6	.795	.718	.629
Oct. 6, 1956	3 1/4	11.1	7.8	.703	8.3	5.2	.748	.667	.626
Range (7 shells)	2 7/8-3 1/4	10.8-11.5	7.2-8.2	.661-.759	8.0-9.1	5.1-5.8	.734-.806	.654-.718	.600-.655
Median		11.1	7.8	.703	8.5	5.5	.766	.683	.637
Field # 194	2 7/8	10.3 mm	7.6 mm	.738	8.2 mm	5.4 mm	.796	.711	.659
Canton Lake, Ill.	3	9.6	6.4	.667	7.0	4.4	.729	.689	.629
Sept. 14, 1958	2 7/8	9.2	6.2	.674	7.0	4.4	.761	.709	.629
Range (30 shells)	2-3	4.8-10.3	3.4-7.6	.625-.738	3.7-8.2	2.2-5.4	.719-.852	.629-.809	.579-.684
Median		7.8	5.0	.675	5.8	3.6	.769	.714	.638
Field # 194	2 3/4	11.8 mm	8.4 mm	.712	9.2 mm	5.9 mm	.780	.702	.641
Canton Lake, Ill.	2 7/8	11.4	7.8	.684	8.6	5.3	.754	.679	.616
Oct., 1960	2 7/8	10.9	7.8	.716	8.6	5.7	.789	.731	.663
Range (26 shells)	2 1/4-3	6.6-11.8	4.6-8.4	.678-.807	5.1-9.2	3.3-5.9	.717-.848	.600-.731	.571-.687
Median		9.3	6.7	.710	7.4	4.6	.776	.679	.636
Field # 194	3 1/4	9.8 mm	6.7 mm	.684	7.4 mm	4.7 mm	.755	.701	.635
Canton Lake, Ill.	2 7/8	9.8	6.7	.684	7.3	4.7	.745	.701	.644
Oct., 1964	2 3/4	9.8	6.7	.684	7.4	4.7	.755	.701	.635
Range (16 shells)	2 1/2-3 1/4	7.4-9.8	5.5-6.7	.684-.743	6.1-7.4	3.8-4.7	.740-.824	.652-.737	.597-.667
Median		9.2	6.5	.710	7.0	4.4	.780	.701	.645
Field # 194	3	9.92mm	5.79mm	.584	7.29mm	4.55 mm	.735	.786	.624
Canton Lake, Ill.	3	9.47	6.05	.639	7.23	4.60	.763	.760	.636
Oct., 1966	3	9.46	7.0	.740	7.14	4.24	.755	.606	.594
Range (39 shells)	2-3	6.06-9.92	3.57-7.0	.583-.740	4.44-7.29	2.91-4.60	.609-.792	.606-.825	.564-.752
Median		7.93	4.96	.627	5.90	3.67	.750	.747	.622

result of a period of about a year of low precipitation. The ground of the usually submerged area was wet though not muddy. Even under such conditions *O. deprimida* was not found on the ground. Many of the snails were aestivating on the cattails 2 feet above the ground.

Oxyloma deprimida differs from other species of the genus, at least in the Mississippi Valley, as to the time of year in which it reaches maturity. The mature, fully grown, sexually active adults are to be found from the latter part of September to the early part of October. This is several months later

TABLE 2. *Formulae of representative rows of teeth of* Oxyloma deprimida *new species.*

Station	Slide	No. of Rows of Teeth	Row	M	L	C	L	M
Type Locality Utica, Illinois Field No. 350	A	105	14	7	12	1	13	6
			32	42	12	1	15	37
			77	37	14	1	13	37
	B	110	40	37	12	1	12	37
			87	37	10	1	9	41
	C	100	23	33	12	1	9	26
Canton, Illinois Field No. 194	A	92	23	34	16	1	9	37
			30	40	10	1	10	39
	B	99	65	37	11	1	9	39
			74	39	10	1	10	39

TABLE 3. Comparisons of the medians of ratios of several dimensions of Oxyloma deprimida *with several other species of* Oxyloma *as previously reported (Franzen, 1969, Table III).*

Species	W. of Shell/ H. of Shell	H. Aperture/ H. Shell	W. Aperture/ W. Shell	W. Aperture/ H. Aperture
O. deprimida	59.7% - 71.0%	73.7% - 78.0%	67.9% - 76.8%	59.4% - 64.5%
O. retusa	52.0%	74.4%	80.5%	57.1%
O. haydeni	49.0%	73.0%	85.3%	57.6%
O. salleana	56.3%	78.6%	79.2%	57.6%
O. sanibelensis	47.8%	60.7%	68.8%	55.2%

than the maturation time of *O. retusa, O. haydeni,* and *O. salleana* whose mature adults disappear in the latter part of June or in early July.

ACKNOWLEDGMENTS

National Science Foundation Grants-in-Aid No's. NSF G18000 and NSF GB2715 provided laboratory equipment and supported, in part, the field studies. The author is grateful to Dr. B. V. Hall, Director, Center for Electron Microscopy, Univ. of Illinois, Urbana, and to Dr. James Anderson for the scanning-electron-photomicrographs. Dr. Alan Solem, Field Museum of Natural History, Chicago, Illinois, and Dr. Donald F. Hoffmeister, Natural History Musuem, Univ. of Illinois, Urbana, graciously lent shells of the respective museum collections. Dr. A. Byron Leonard read the manuscript and offered helpful suggestions.

LITERATURE CITED

Baker, Frank Collins. 1939. Fieldbook of Illinois Land Snails, Natural History Survey Division, Manual 2, State of Illinois: 3-166.

Franzen, Dorothea S. 1963. Variations in the Anatomy of the Succineid Gastropod *Oxyloma retusa.* The Nautilus 76 (3): 82-95, Tables I-II, Figs. 1-4.

Franzen, Dorothea S. 1964. Anatomy of the Succineid Gastropod *Oxyloma haydeni.* The Nautilus 77(3): 73-81, Tables I-II, Fig. 1.

Franzen, Dorothea S. 1966. Anatomy of the Succineid Gastropod *Oxyloma salleana* (Pfeiffer). The Nautilus 80(2): 59-69, Tables I-II, Figs. 1-3.

Franzen, Dorothea S. 1969. Structural Characteristics of Succineid Gastropod *Oxyloma sanibelensis.* The Nautilus 82(3): 77-83, Tables I-III, Figs. 1-2.

Pilsbry, Henry A. 1948. Land Mollusca of North America (North of Mexico). Acad. Nat. Sci. Philadelphia Mon. No. 3, Vol. II, Pt. 2: xlvii + 521-1113, 585 figs.

Quick, H. E. 1933. The Anatomy of British Succineae. Proc. Mala. Soc. London 20(VI, Nov.): 295-318 Pl. 23-25, Figs. 1-18, Tables I–V.

LATE EOCENE DISTRIBUTION OF THE PELECYPOD *EXPUTENS* IN SOUTHEASTERN UNITED STATES

David Nicol
Box 14376, University Station,
Gainesville, Florida 32601
and
Graig D. Shaak
The Florida State Museum
University of Florida
Gainesville, Florida 32601

ABSTRACT

The pelecypod Exputens *(Malleidae) was confined to the Tethyan marine province during the Middle and Late Eocene. In Peninsular Florida* Exputens ocalensis *(MacNeil) is found in the two lowest zones of the Crystal River Limestone, which is Late Eocene in age.* Exputens *has also been found in the Ocala Limestone of southwestern Georgia and the Castle Hayne Marl in North Carolina, which shows that at least one Tethyan mollusc lived farther north during the Late Eocene than had previously been supposed.*

The presence of the pelecypod *Exputens* in strata of Late Eocene age in Peninsular Florida has been reported by Palmer, 1957, p. 70; 1967, pp. 189-190; and Palmer and Brann, 1965, p. 143. However, *Exputens* was not mentioned as occurring in Florida by Hertlein and Cox, 1969, in the *Treatise on Invertebrate Paleontology*. Moreover, the type species, *Exputens llajasensis* Clark, 1934, was stated as fixed by original designation. In his original description of *Exputens*, Clark described two new species, *E. llajasensis* and *E. alexi*, but he selected neither species as the type of *Exputens*. The type species was subsequently designated by Vokes, 1939, p. 51, as *E. llajasensis* Clark from Middle Eocene beds from Simi Valley, California.

Palmer, 1957, 1967, has particularly emphasized the fact that *Exputens* was confined to the Tethyan marine province, and it has been reported from Jamaica and southern California as well as Florida. The stratigraphic range of the genus appears to be Middle and Upper Eocene.

MacNeil described *Vulsella ocalensis* in 1934 from specimens collected at the Sumter Rock Quarry about two miles northeast of Sumterville, Sumter County, Florida. Also in the type lot was a specimen collected from a limestone quarry about a mile south of Newberry, Alachua County, Florida. *V. ocalensis* was later allocated to the genus *Exputens*, and the outline of the valves is similar to the type species, *E. llajasensis*. In his original description, MacNeil mentioned the fact that the shell of *V. ocalensis* could be composed of lamellar calcite. In every specimen of *V. ocalensis* we have seen, much of the original shell is preserved, and this leads us to the conclusion that

TABLE 1. The stratigraphic range of Exputens ocalensis *in the Crystal River Formation of Florida.*

CLASSIFICATION OF THE CRYSTAL RIVER FORMATION IN FLORIDA

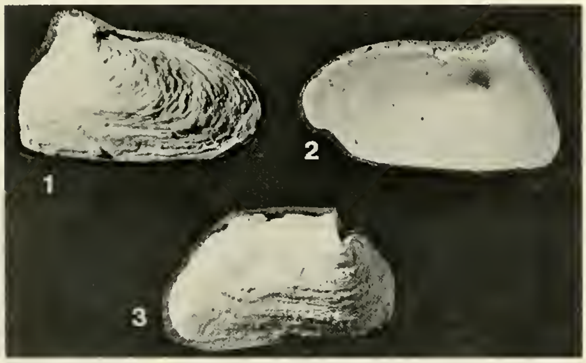
STRATIGRAPHIC	FAUNIZONE	
Crystal River Formation	Lepidocyclina chaperi	
	Asterocyclina - Spirulaea vernani	
	Nummulites vanderstoki - Hemicythere	
	Lepidocyclina Pseudophragmina	↑ Exputens ocalensis ↓
	Spiralaculina newberryensis	

(adapted from Puri, 1957)

the shell was composed mainly of calcite. Except for the Ostreidae and Pectinidae, almost all of the other molluscs are preserved only as internal and external molds and casts in the Crystal River Limestone. The correct orientation of the valves is questionable, but we are assuming that the beaks and the small wing-like projection on the dorsal border are located anteriorly. The location of the beaks varies from nearly a central position to near the anterior end of the dorsal border.

There are more than 40 specimens of *Exputens ocalensis* in the collections at The Florida State Museum, indicating that this species is not rare. On one small piece of limestone, there are seven right valves and some embedded double valves. At some localities the right valve is much more common; at others the reverse is true. This fact indicates selective sorting by currents and wave action.

Exputens ocalensis is most abundant in the lowest zone in which it appears, Puri's (1957) *Spiroloculina newberryensis* faunizone of the Crystal River Limestone. It apparently is found less frequently in the zone above, the *Lepidocyclina-Pseudophragmina* faunizone. It is doubtful that *E. ocalensis* is found in any of the higher zones of the Crystal River (see Table 1). The Tethyan gastropod *Gisortia harrisi* Palmer seems to have about the same stratigraphic distribution as *E. ocalensis* because *G. harrisi* has been found at nearly all localities where *E. ocalensis* has been reported. Thus, some Tethyan molluscs appeared in Florida during the time that the lower part of the Crystal River Limestone was being deposited and after the Avon Park, Inglis, and Williston Formations were laid down.



FIGS. 1, 2, 3. *Exputens ocalensis (MacNeil). The porous material showing around the shells is the limestone matrix. Locality: Limestone quarry west of old U. S. 441 at south edge of Kendrick, Marion County, Florida. N. W. ¼ Sec. 25, T. 14 S., R. 21 E.*

FIG. 1. *Left valve exterior, hypotype Florida State Museum 3481, length 28.1 mm, height 16.6 mm.*

FIG. 2. *Left valve interior, hypotype Florida State Museum 3482, length 27.4 mm, height 14.1 mm.*

FIG. 3. *Right valve exterior, hypotype Florida State Museum 3483, length 25.0 mm, height 14.7 mm.*

Exputens ocalensis has been found in the following counties in surface outcrops in Peninsular Florida: Columbia, Suwannee, Dixie, Gilchrist, Alachua, Levy, Marion, Citrus, and Sumter. *Exputens* has been collected by U. S. Geological Survey geologists in Mitchell and Dougherty Counties in southwestern Georgia in the Ocala Limestone. More surprisingly, they have also collected *Exputens* from the Castle Hayne Marl in Pender and Wayne Counties, which are in southeastern and east-central North Carolina. A specimen from Wayne County is considerably larger than any specimens of *Exputens ocalensis* from Florida and may be a different species. At least one Tethyan mollusc, *Exputens*, lived farther north during the Late Eocene than had previously been supposed.

ACKNOWLEDGMENTS

We are particularly indebted to Mr. Druid Wilson of the U. S. Geological Survey, who showed the senior author specimens of *Exputens* from Georgia and North Carolina. Dr. Katherine V.W. Palmer of the Paleontological Research Institution sent the senior author a list of localities in Florida where *Exputens* has been collected.

LITERATURE CITED

Clark, B. L. 1934. A new genus and two new species of Lamellibranchiata from the Middle Eocene of California. Jour. Paleo. 8 (3): 270-272.

Hertlein, L. G. and L. R. Cox. 1969. Family Malleidae. *in* Treatise on Invertebrate Paleontology (R. C. Moore, editor). Part N, Vol. 1, Mollusca 6, Bivalvia. N326-N332.

MacNeil, F. S. 1934. The pelecypod genus *Vulsella* in the Ocala Limestone of Florida and its bearing on correlation. Jour. Washington Acad. Sci. 24 (10): 428-431.

Palmer, K. V.W. 1957. A new *Gisortia* from the Crystal River Formation, Ocala Group, of Florida, with explanatory notes on the Tethyan influence in the Floridian Middle and Upper Eocene. Jour. Palaeo. Soc. India, Lucknow. D. N. Wadia Jubilee Number. 2: 69-72.

Palmer, K. V.W. 1967. A comparison of certain Eocene molluscs of the Americas with those of the western Tethys. Systematics Assoc. Pub. No. 7. Aspects of Tethyan biogeography. 183-193.

Palmer, K. V.W. and D. C. Brann. 1965. Catalogue of the Paleocene and Eocene Mollusca of the southern and eastern United States. Part I. Pelecypoda, Amphineura, Pteropoda, Scaphopoda, and Cephalopoda. Bull. Am. Paleo. 48 (218): 1-466.

Puri, H. S. 1957. Stratigraphy and zonation of the Ocala Group. Florida Geol. Survey. Geol. Bull. 38: 1-248.

Vokes, H. E. 1939. Molluscan faunas of the Domengine and Arroyo Hondo Formations of the California Eocene. Ann. New York Acad. Sci. 38: 1-246.

RECENT PUBLICATIONS

Cheatum, E. P. and R. W. Fullington. 1971. The Aquatic and Land Mollusca of Texas. Pt. 1. The Recent and Pleistocene Members of the Gastropod Family Polygyridae in Texas ($2.50). Pt. 2 --Pupillidae and Urocoptidae (Gastropoda) in Texas ($4.50). Bull. 1 Dallas Museum of Natural History, P. O. Box 26193, Dallas, Texas, 75226. Illustrated and Useful.

Ladd, Harry S. 1972. Cenozoic Fossil Mollusks from Western Pacific Islands; Gastropods (Turritellidae Through Strombidae). U. S. Geol. Survey Professional Paper 532, 79 pp., 20 pls. Descriptions or citations of 174 species of 18 gastropod families from seven island groups. Excellent.

Britton, J. C. Jr. 1972. Two New Species and a New Subgenus of Lucinidae (Mollusca: Bivalvia), with Notes on Certain Aspects of Lucinid Phylogeny. Smithsonian Contributions to Zoology, no. 129, 19 pp. *Lucina hendersoni* n. sp. from Antigua; *Parvilucina rehderi* n. sp. from Brazil, and *Radiolucina* n. subgenus (type: *amiantus* Dall, 1901).

Sandved,K. B. and R. Tucker Abbott. 1973. *Shells in Color.* 101 pls. in color. 48 pp. accompanying text; bibliography; index. Viking Press, Inc., 625 Madison Ave., N. Y., N. Y., 10022. $12.95. A pretty book, but over-priced.

Wright, C. A. 1971. *Flukes and Snails.* Science of Biology Series no. 4. 168 pp. George Allen and Unwin, Ltd., London. Hardback, about $7.50. Biology of schistosomes and planorbid and bulinid molluscan hosts, mainly in Africa.

Saul, Louella R. 1973. Evidence for the Origin of the Mactridae (Bivalvia) in the Cretaceous. Univ. Calif. Publications in Geol. Sci., vol. 97, 51 pp., 3 pls. $4.00.

Parenzan, Pietro. 1970. Carta d'identità delle conchiglie del Mediterraneo. Vol. 1, Gastropodi, 283 pp., 53 pls. Bio Taras Editrice, paperback $11.00. Useful guide, but many of the 1000 ink drawings are inadequate for identification.

Kensley, Brian. 1973. *Sea-Shells of Southern Africa -- Gastropods.* 236 pp., 910 species illus., some in color. Maskew Miller, Ltd., Cape Town. About $17.00. Contains misidentifications, many out-of-date genera, some wrong author names, non-binomial names, incorrect numbers under the illustrations and a pasted-in errata sheet containing two obsolete names. Recommend waiting for second printing.

Ocean Management, Vol. 1, no. 1. A new international, multi-disciplinary journal dealing with the economics and exploration of oceans. About 500 pp. per year; quarterly. Annual U. S. subscription, $31.00. Elsevier Scientific Journals, P. O. Box 211, Amsterdam, Netherlands.

NOTES ON MOLLUSKS *OSTREA* AND *SIPHONARIA* FROM GEORGIA (U. S. A.)

John N. Kraeuter
University of Georgia Marine Institute[1]
Sapelo Island, Georgia 31327

ABSTRACT

The sponge-dwelling oyster Ostrea permollis *Sowerby, is now known to occur off Georgia at 20 meters depth; and the pulmonate limpet,* Siphonaria pectinata *(Linné) has been found laying eggs on tree stumps on Cabretta Island, Georgia.*

Recent systematic studies have illustrated how much is still to be learned about the marine fauna of Georgia. Darby (1965) described 13 new species from the 24 species of podocopid ostracods he collected. Menzies and Frankenberg (1966) described 11 new species and one new genus of isopods among the 30 species represented in the University of Georgia Marine Institute collections. Malacologists have also reported high numbers of new species in this area. Marcus and Marcus (1967) described three new species and a new subspecies from the 12 opistobranch species present in the above collections. Merrill (1963) and Frankenberg (1966) have reported on small collections of mollusks off Georgia. Merrill and Petit (1965, 1969) compiled 26 and 19 range records for mollusks from South Carolina. They reported a ratio of one range extension for each six species previously reported from the area. Similar ratios are believed to be found in Georgia.

Range modifications for two recently studied species are presented: one, *Ostrea permollis,* Sowerby creates a continuum where a disjunct distribution has been suggested; the other, *Siphonaria pectinata* (Linné), extends the range of this common intertidal pulmonate beyond its northern limit. This paper is preliminary to a more thorough study of the molluscan fauna of Georgia and is intended to alert malacologists to the opportunities available through the study of the Georgia fauna.

After examination of published records and museum specimens, Forbes (1964) concluded that the distribution of the oyster *Ostrea permollis* Sowerby was disjunct between Molasses Reef, Florida (25°1' N, 80°23' W), in 154 m, and Cape Fear, North Carolina (33°50' N, 78°02'40" W), in 15 m. He believes that the absence of its host sponge *Stelletta grubii* (?) Schmidt from the continental shelf in the South Carolina-Florida area has isolated *O. permollis* populations since at least the Sangamon Interglacial.

The discovery of *O. permollis* and its host sponge *Stelletta grubii* (?) in Georgia emphasizes a continuum between the Keys (Molasses Reef) and Cape Fear. The station locations provided by Forbes (1964) are plotted and the two collections from Georgia are included (Fig. 1). The Georgia specimens of *O. permollis* were from 31°22'55" N, 80°52.2' W, Sta. 44 & 45, M. Gray coll., 20 m, 3/7/61, 8 live individuals, and 31°24'15" N, 80°52'35" W, J. Kraeuter, coll., 20 m, 5/23/71, 2 live individuals. These lots are on deposit in the

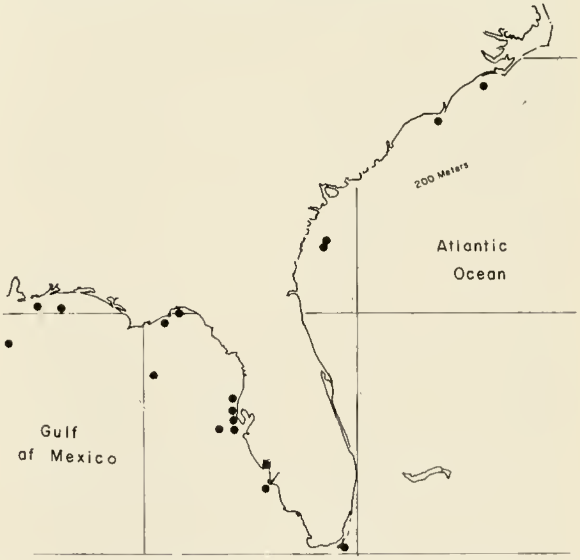


FIG. 1. *Distribution of* Ostrea permollis *after Forbes (1964) with Georgia data added.*

---

[1] Contribution No. 267 from the University of Georgia Marine Institute.

collections of the University of Georgia Marine Institute, Sapelo Island. In both cases spiculation on the sponge fragments from the shells typify spicules figured by de Laubenfels (1953). The spicules measured (terminology from de Laubenfels, 1953):

1. Oxeas	350 - 437 μ x 10 - 21 μ
2. Plagiotriane	392 - 432 μ x 11.7 - 40 μ (across head)
3. Anatriaene	392 - 422 μ x 11.7 - 38 μ (across head)
4. Eutylaster	6 - 8 μ across
5. Oxyeuaster	5 - 8 μ across

The eutylasters were much more numerous than the oxyeuasters and the former did not seem to have as rough a termination as illustrated by de Laubenfels (1953).

The presence of the host sponge and the commensal oyster in Georgia indicates that the lack of populations between Molasses Reef and Cape Fear is not due to disjunct distributions, but is due to either (1) lack of collections in offshore waters or (2) lack of substrate for the sponge, or (3) a combination of these factors.

The extreme narrowness of the continental shelf near Miami obviously limits the number of possible sites; however, submerged reefs or outcrops have been found in North Carolina (Menzies *et al.*, 1966) and this reef is similar to those of the Gulf of Mexico (Parker, 1956). A reef off Georgia has been described by Hunt, Woolsey and Henry (1971), and other reefs or "live bottom habitats" have been listed by Struhsaker (1969) for South Carolina, Georgia, northeast Florida and central Florida. It seems probable that as these areas are sampled more extensively, fewer gaps will exist in offshore distribution patterns.

Siphonaria pectinata, an intertidal pulmonate limpet, has its reported northern range as eastern Florida (Abbott, 1954) or Fernandina, Florida (Voss, 1959). Dr. Erik Rasmussen has found it with egg masses on tree stumps in the surf of Cabretta Island, Georgia, adjacent to Sapelo Island. He has been kind enough to let me record its northern limit and breeding during January 1972. This reproductive time is very close to that found for the same species in south Florida by Nancy Voss (1959). She correlated the northern limit of *S. pectinata* with the 55°F isochryme on a worldwide basis. Sapelo Island is not much beyond the previous record of Fernandina, but the presence here of *S. pectinata* suggests the northern distributional limit may be controlled by lack of suitable substrate on the exposed sandy shores of the mid-Atlantic region. The large numbers and breeding individuals found at Cabretta seem to indicate that *S. pectinata* could survive even farther north.

Historically, Dall (1927) has provided the most conspicuous source of molluscan data for the north Georgia to Florida area. In this one paper he listed 332 species of which he considered 213 to be new. Thus, the area between 30°44' N, 79°26' W (948 m) and 30°58' N, 79°38' W (678 m) provided data which seems to be primarily responsible for the major faunal separation at the Georgia-north Florida boundary found by Fischer (1961) in his analysis of diversity gradients of the U. S. East coast. The magnitude of Dall's paper can best be appreciated by comparing Fischer's pelecypod and gastropod distributions. Fischer (1961) was not able to demonstrate a clear, faunal discontinuity of pelecypods in the north Florida-Georgia area. It appears from his data, however, that perhaps ten species have their northern latitudinal limits at this point. Conversely, the gastropods have approximately 160 species reaching their northern latitudinal limits at the Georgia-Florida boundary - a clear faunal break. Dall's paper listed only 41 pelecypods, four new species, but he catalogued 277 gastropod species of which 200 were new. It appears that the gradual loss of species with latitude as described by Fischer (1961) for the lamellibranchs may come closer to distributional reality than that of the sharp zoogeographic boundary illustrated by the Gastropoda.

The obvious influence of one major work such as Dall's and the records of *Ostrea permollis* and *Siphonaria pectinata* demonstrate the need for more thorough ecologic and systematic work in the Georgia-north Florida area. The importance of hard substrates as limiting factors in marine distributional patterns along the East coast of the United States is also emphasized.

The critical reading and suggestions given by Drs. Dirk Frankenberg and William Shaw are gratefully acknowledged.

LITERATURE CITED

Abbott, R. T. 1954. American Seashells. D. Van Nostrand Co., Inc., New York, 541 pp.

Dall, W. H. 1927. Small shells from dredgings off the southeast coast of the United States by the United States fisheries steamer "Albatross" in 1885 and 1886. Proc. U. S. Nat. Mus. 74(18): 1-134.

de Laubenfels, M. W. 1953. Sponges from the Gulf of Mexico. Bull. Mar. Sci. Gulf and Caribbean 2(3): 511-557.

Darby, D. G. 1965. Ecology and taxonomy of Ostracoda in the vicinity of Sapelo Island, Georgia. National Science Foundation project GB-26. Report No. 2, 59 pp. University of Michigan.

Fischer, A. G. 1961. Latitudinal variations in organic diversity. Amer. Sci. 49: 50-75.

Forbes, M. L. 1964. Distribution of the commensal oyster, *Ostrea permollis,* and its host sponge. Bull. Mar. Sci. Gulf and Caribbean 14(3): 453-464.

Frankenberg, D. 1966. Southern limit of *Nassarius trivittatus.* The Nautilus 79(3): 89-90.

Hunt, J. L., Jr., J. R. Woolsey, Jr. and V. J. Henry, Jr. 1971. Geological investigation of a submerged reef off Sapelo Island, Georgia. Abstract Volume, Second National Coastal and Shallow Water Research Conference, 268 pp.

Marcus, E. and E. Marcus. 1967. Some opisthobranchs from Sapelo Island, Georgia, U. S. A. Malacologia 6(1-2): 199-222.

Menzies, R. J. and D. Frankenberg. 1966. Handbook on the common marine isopod Crustacea of Georgia. University of Georgia Press, 93 pp.

Menzies, R. T., O. H. Pilkey, B. W. Blackwelder, D. Dexter, P. Huling and L. McCloskey. 1966. A submerged reef off North Carolina. Int. Rev. ges. Hydrobiol. 51(3): 393-431.

Merrill, A. S. 1963. Mollusks from a buoy off Georgia. The Nautilus 77(2): 68-70.

Merrill, A. S. and R. E. Petit. 1965. Mollusks new to South Carolina. The Nautilus 79(2): 58-66.

Merrill, A. S. and R. E. Petit. 1969. Mollusks new to South Carolina: II. The Nautilus 82(4): 117-122.

Parker, R. H. and I. R. Curray. 1956. Fauna and bathymetry of banks on the continental shelf, northwest Gulf of Mexico. Bull. Amer. Assoc. Petrol. Geol. 40: 2428-2439.

Struhsaker, P. 1969. Demersal fish resources: Composition, distribution, and commercial potential of the continental shelf stocks off southeastern United States. Fishery Industrial Res. 4(7): 261-300.

Voss, N. A. 1959. Studies on the pulmonate gastropod *Siphonaria pectinata* (Linnaeus) from the southeast coast of Florida. Bull. Mar. Sci. Gulf and Caribbean 9(1): 84-99.

BOOK REVIEW

A SHELLER'S DIRECTORY of Clubs, Books, Periodicals, and Dealers. By Tom Rice. Third Edition, 1972. 64 pp., paperback. Of Sea and Shore Publications, P. O. Box 33, Port Gamble, Wash. 98364. $1.00.

There is no handier guide to shell dealers, shell clubs and popular literature than this greatly improved and neatly printed booklet. 88 shell clubs are listed, including some new ones, such as the Whitsunday Shell Club (of Queensland) and the Wilmington Shell Club of Delaware. There is an imposing list of shell and book dealers, and a useful and complete list of periodicals dealing with mollusks.

R. Tucker Abbott
Delaware Museum of Natural History

BOOK REVIEW

THE MOLLUSKS OF THE ARID SOUTHWEST WITH AN ARIZONA CHECK LIST. By Joseph C. Bequaert and Walter B. Miller. Tucson: University of Arizona Press, pp. 271, maps. $8.00.

A seasoned veteran wise in the ways of traditional systematics and a younger well-versed in newer techniques of study have combined to summarize the mollusks of an important faunal area where both have had extensive field experience. The result is a massive, but somewhat disappointing, compilation of literature citations and locality records. This book will be a fundamental information source for all who are interested in the molluscan fauna of the arid southwestern United States. When combined with the descriptions and illustrations in Pilsbry's 1939-1948 "Land Mollusca of North America", the student of this region now has better bibliographic and identification tools than for any equivalent area of the United States.

The book presents first a general zoogeographic analysis, then a species by species analysis of distribution for the terrestrial species, and concludes with an annotated check list of the Arizona land and fresh water mollusks. The last two sections contain very extensive duplication of data and could have been condensed to good effect. The locality lists give no clear indication in most cases as to whether the cited record is based on literature compilation or previously unreported material.

Throughout the book there are many changes proposed in synonymy and species limits. The changes in *Sonorella* are taken from Miller's unpublished thesis, while those proposed in other genera generally are not documented. It is quite useful to know the opinion of the authors concerning the rank and relationships of the many named forms in such genera as *Ashmunella, Holospira, Gastrocopta, Chaenaxis* and *Vertigo,* but presentation of their evidence for changes would have been preferable.

In the systematic portion of this work there seems to be only a few errors and omissions. Work in Europe indicating the presence of sibling species or species complexes in such groups as *Cionella, Pupilla, Columella* and *Vertigo,* has not been alluded to in their discussions. This is an important omission, since "circumpolar" representatives of these genera occur in Arizona. The section on foreign desert dwellers (pp. 98-102) is cursory. The genus *Sculptaria* is misclassified in the Endodontidae rather than the Corillidae. More important, the Australian bulimulid *Bothriembryon* is called a desert genus, while in reality it is characteristic of the at least seasonally moist forested areas of Southwest Australia.

The most disappointing portion of the book is the discussion on zoogeography. It is concerned with the classic and rather sterile problem of delimiting faunal area boundaries (pp. 7-10) and descriptive spatial accounts of each species (pp. 14-98). It accepts as axiomatic the now generally discredited idea that the center of diversity for a genus represents its center of origin (p. 20). Dynamic aspects of biogeography are virtually ignored, with a discussion of *Sonorella* (p. 21) talking of "genetic drift" and "invasion of new territory", whereas the area involved apparently still is undergoing progressive drying. Consequent restriction of ranges and increased colony isolation is a more probably recent history. Despite the advances in theoretical and experimental biogeography in recent years, questions of species diversity and species-area relationships are not discussed, although the mollusk-inhabited mountains of Arizona form ideal "islands" in a zoogeographic sense.

In summary, the authors are to be congratulated on producing an encyclopaedic work of great usefulness. I shall make continual reference to it. Unfortunately, it is not the significant work in terms of new ideas or syntheses that could have been hoped for from the mixing of diverse talents. That it is a mix and not a blend can be inferred from divergent views of shell versus anatomy. On page 15, the absence of generic or specific shell characters is called exceptional, while on page 100 the shell is called untrustworthy for generic or even family placement. Given the difficulties of mollusk collecting in Arizona and the massive data gathering needed to produce the present volume, it is perhaps unfair of me to want something more than usefulness.

Alan Solem, Curator of Invertebrates
Field Museum of Natural History
Chicago, Illinois 60605

OBSERVATIONS BY POLARIZED LIGHT ON THE RADULA OF *APLEXA MARMORATA*

Maria Luiza S. Mello and **Marlene T. Ueta**
Instituto de Biologia, Universidade Estadual de Campinas,
13100 Campinas, São Paula, Brazil

INTRODUCTION

Many ultrastructural aspects of mollusc radulae have been recently pointed out by scanning electron microscope studies (Runham, 1969; Thomas, 1971; Kohn et al., 1972). However, nothing concerned with the organizational state of the macromolecules which make up the radula teeth has been yet established.

In the present paper observations with polarized light were performed in radulae subjected to some special histochemical procedures as an approach to the discovery of the molecular arrangement of the structure.

MATERIAL AND METHODS

Specimens of *Aplexa marmorata* (Guilding, 1828) (Pulmonata, Physidae) were collected in a small artificial tank of a country house in Campinas, São Paulo, Brazil. The animals were killed in hot water (nearly 70°C), removed from their shells, fixed in 70% ethanol and dissected. After being extracted from their bulbs, some radulae were treated with a 10% KOH aqueous solution for 24 hours. They were washed, stained, dehydrated in ethanol and mounted in Canada balsam.

The following staining solutions were used: 1. Congo Red saturated solution in 96% ethanol (Barth, 1958); 2. Orange G saturated solution in 70% ethanol (Barth, 1958); 3. Xylidine-Ponceau at pH 1.7 (Vidal, 1972); 4. Toluidine Blue at pH 4.0 (Lison, 1960).

At least five radulae were subjected to each staining procedure.

The investigation of anisotropic properties was carried out with a Zeiss Pol-photomicroscope equipped with a MPM photometer and an EMI 6256 photomultiplier. Histophotometric readings were performed in different regions of the teeth of the 1st and 2nd distal rows oriented parallel (d||) and perpendicular (d⊥) to the plane of polarized light. A Plan 40/0.65 objective, 2.0 optovar, 10x projection lens and 2mm measuring diaphragm were used; the area of the specimen measured corresponds to a 2.5 μ diameter. Different wavelengths were provided by a Zeiss monochromator ruler.

The wavelength of the absorption peak was determined for each set of measurements at the visible spectrum. Maxima of linear dichroism (=Δd = d|| - d⊥) and diochroic ratios (d||/d⊥) were also calculated.

The dispersion of the birefringence (DB) was investigated in the same material by determining the optical path differences at several wavelengths with a rotatory analyser and a λ/4 compensator, according to Sénarmont's methods.

RESULTS

The teeth stained strongly with Congo Red and Xylidine-Ponceau and slightly with Orange G and Toluidine Blue.

Anisotropic phenomena are found after staining on the basal portion of the teeth (prop and region A) and on the denticular region (B) (Fig. 2, 3, 6, 7 and 8; Table 1). Some aspects of the linear dichroism (selective absorption of the polarized light) and birefringence are shown in Figures 1 to 10. The absorption values are larger when the different regions analysed are placed parallel to the plane of polarized light (positive dichroism), except when the radula is stained with Toluidine Blue (negative dichroism). When Orange G is used as staining solution the dichroism (Δd) is very weak and only found at the region B (Table 1).

The anisotropical properties are usually less evident at the prop region (Fig. 3 and 7).

The dichroism is stronger in teeth stained with Congo Red (Fig. 2, 3, 4 and 5; Table 1) and in this case the radicular membrane also stains red and displays birefringence.

DB curves were determined but they did not show inflection points within the λ range used under present experimental conditions. However, when the radula is stained with Xylidine-Ponceau the compensated image remains unchanged in directions NE-SO and NO-SE at wavelengths lower than 520nm (Fig. 11 - dotted line).

The dichroism and birefringence values are slightly decreased in KOH-untreated radulae.

DISCUSSION

Optical properties such as those observed in the present work (dichroism and birefringence) indicate that there are oriented macromolecules in the teeth of *Aplexa marmorata* suitable to bind the dyes (Congo Red. Xylidine-Ponceau and Toluidine Blue) in a preferential way and that this level of molecular orientation can be measured. However. from the fact that a precise inflection point has not been found in the DB curves, it can be considered that there is a very complex organization of the stained molecules in the teeth, yeilding inner compensations and a background effect which would also account for the low dichroism values. Mollusc radulae have been reported by

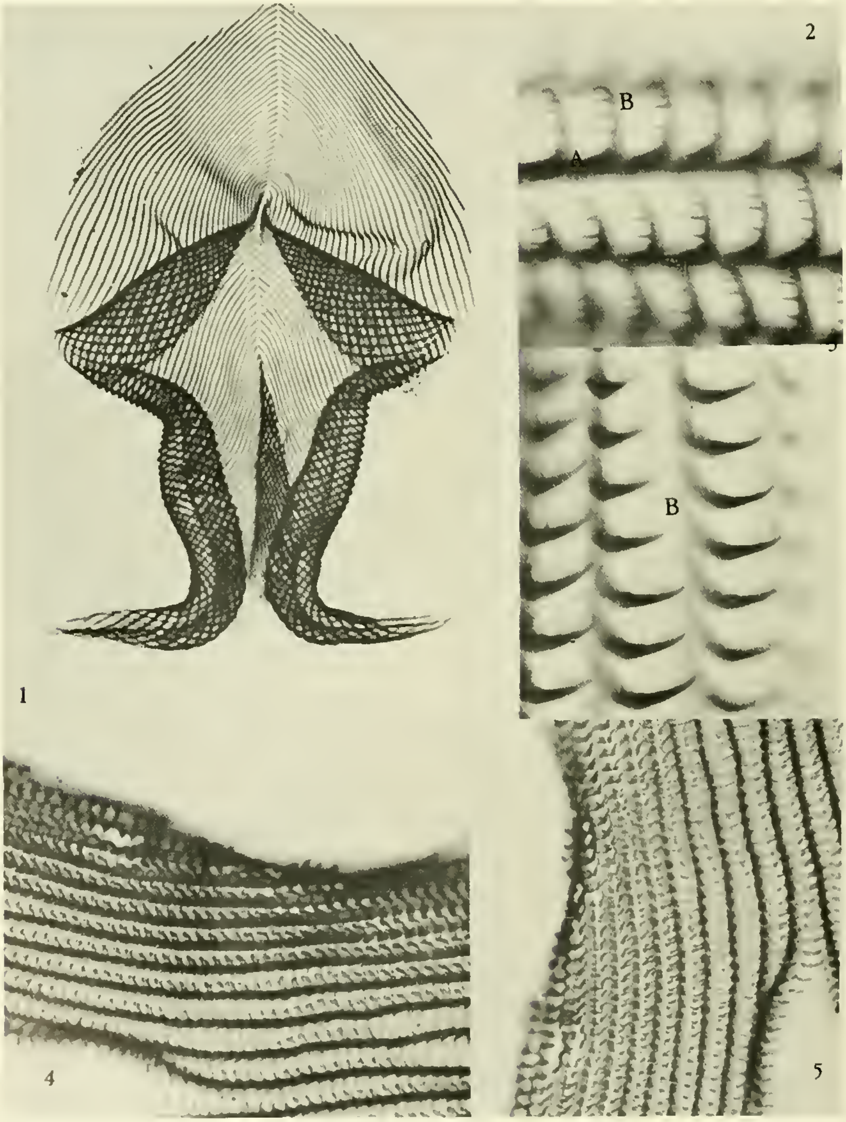


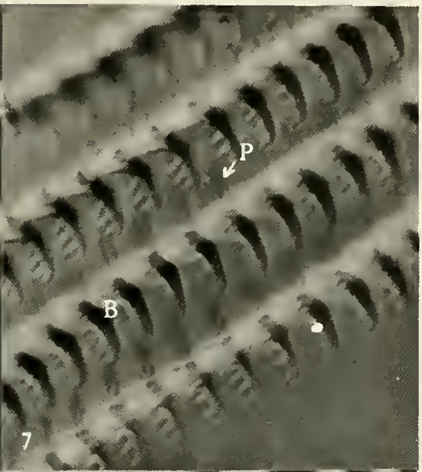
FIG. 1. *A radula stained with Congo Red (510nm). x 48*

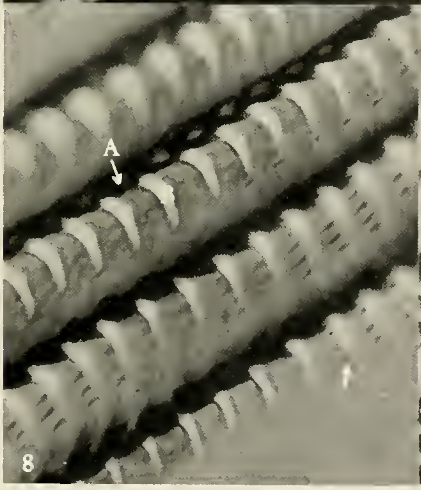
FIG. 2 and 3. *Details from Fig. 1. The tooth region A is oriented parallel (Fig. 2) and perpendicular (Fig. 3) to the plane of polarized light. x 480*

FIGS. 4 and 5. *Idem Fig. 2 and 3 (510nm). x 185* many authors as being composed of chitin; however other components are probably found in the teeth because they stain with Xylidine-Ponceau at pH 1.7 and Orange G which usually attach to protein radicals and also with Toluidine Blue which generally shows dichroism when bound to oriented polyanion substrates. Congo Red also binds to mucins (Conn, 1967). These data suggest that the stained substrate is probably a mucoprotein.

The staining slightly increases after the KOH treatment indicating that it functions as a definite saponification, liberating the anionic groups of the polyanion and allowing them to become reactive. This treatment, in addition, does not remove these groups from their structural complex.

Present data can be considered as a starting point for further demonstration of differences as a function of several physiological states in the teeth. Preliminary observations point out differences of birefringence intensity and dichroism between the apical and basal zones of the radula, which would mean decreasing orientation of the macromolecules as the teeth become older and worn.





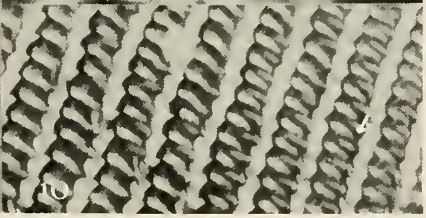


FIG. 6. *KOH-untreated radula stained with Orange G and observed with crossed polarizer and analyser. x 480*

FIG. 7. *The analyser was turned for compensation of region B. x 480 P = prop*

FIG. 8. *Compensation of the region A and of the denticles (arrow). x 480*

FIG. 9. *Congo Red-stained radula as seen with crossed analyser and polarizer. x 500. d = denticles*

FIG. 10. *Idem Fig. 9. Arrow indicates birefringence at the prop region. x 250*

TABLE 1. Polarized light extinction values and dichroism data at the wavelengths of the peaks of the absorption curves (number of measurements = 5).

Dyes	Regions of the teeth	Wave - lengths (nm)	$d\|$ ($\bar{X} \pm S$)	$d\perp$ ($\bar{X} \pm S$)	$\Delta d=d\|-d\perp$ ($\bar{X} \pm S$)	$d\|/d\perp$ ($\bar{X} \pm S$)
Congo Red	Prop	520	.584±.083	.476±.067	.108±.024	1.229±.045
	A	520	.528±.200	.214±.070	.313±.138	2.437±.545
	B	520	.824±.073	.392±.049	.432±.065	2.122±.228
Orange G	Prop	490	.423±.029	.423±.030	.000±.009	.999±.022
	A	490	.696±.088	.700±.089	.003±.007	.993±.014
	B	490	.810±.078	.775±.092	.035±.014	1.049±.055
Xylidine -Ponceau at pH 1.7	Prop	510	.663±.061	.628±.064	.035±.013	1.056±.025
	A	510	.769±.250	.649±.200	-	-
		520	-	-	.131±.057	1.371±.254
	B	520	.854±.087	.805±.087	.049±.022	1.144±.070
Toluidine Blue at pH 4.0	B	520	-	-	-.064±.020	.760±.240
		580	.490±.066	.525±.070	-	-

ACKNOWLEDGMENTS

Authors are indebted to Dr. J. L. Moreira Leme (Museu de Zoologia, Univ. S. Paulo) for the identification of the specimens.

LITERATURE CITED

Barth, R. 1958. Metodos usados em micro-anatomiae histologia entomológica. Mem. Inst. Oswaldo Cruz **56**: 453-471.

Conn, H. J. 1967. Stains and staining. *In* Mc-Clung's Handbook of Microscopical Technique. Hafner Publ. Co., N. Y., pp. 72-111.

Kohn, A. J., J. W. Nybakken and J.-J. Van Mol. 1972. Radula Tooth Structure of the Gastropod *Conus imperialis* Elucidated by Scanning Electron Microscopy. Science **176**: 49-51.

Lison, L. 1960. Histochimie et Cytochimie Animales. Paris, Gauthier-Villars.

Runham, N. W. 1969. The use of the scanning electron microscope in the study of the gastropod radula: the radulae of *Agriolimax reticulatus* and *Nucella lapillus.* Malacologia **9**: 179-185.

Thomas, R. F. 1971. A scanning electron microscope study of the marginal teeth of *Nerita peloronta* Linnaeus. The Nautilus **84**: 118-119.

Vidal, B. C. 1970. Dichroism in Collagen Bundles Stained with Xylidine-Ponceau 2R. Ann. Histoch. **15**: 289-296.

FIG. 11. *Curves of the dispersion of the birefringence.* Γ = *optical path differences (nm)*

A NEW RECORD FOR LIGUUS: THE BOYNTON BEACH COLONY

Alan K. Craig
Department of Geography
Florida Atlantic University
Boca Raton, Florida 33432

ABSTRACT

A new and disjunct northern range limit for Liguus fasciatus *has been found at Boynton Beach, Florida. Coloration indicates affinity with extinct adjacent populations extending southward to Ft. Lauderdale. The relict beach ridge hammock habitat is highly restricted and destined to be destroyed.*

A surprising occurrence of *Liguus fasciatus* in a remnant of beach ridge hammock was noted by university personnel in 1970 in conjuction with routine botanical studies at Boynton Beach, Florida. Subsequent investigation by the writer has confirmed the presence of a small colony existing at the northernmost limit of range under some interesting conditions not previously reported by earlier contributors such as Moore (1921), Pilsbry (1912, 1946), Rhoads (1899), Simpson (1921, 1922), and Young (1960).

From historic accounts (Pierce: 1970) we know tropical hammock vegetation formerly extended in a narrow, almost unbroken band along the crest of beach ridges formed between Ft. Lauderdale and Lake Worth. Further northward hammock vegetation was displaced by a more xeric dune cover consisting of Caribbean pine and palmetto. This habitat effectively precluded any diffusion of *Liguus* in that direction. Mangrove forests and the sawgrass environment of the Everglades created an impassable western boundary for these arboreal snails.

Intense real estate development has destroyed almost every vestige of beach ridge hammock in southeast Florida. The only example remaining survives in an inconspicuous strip (400 x 50 yds.) crowded between U. S. Highway A1A and the Atlantic Ocean (Fig. 1). Thousands of residents and tourists daily pass by this relict habitat as they travel the busy highway or visit the public beach.

The Boynton Beach hammock has developed a canopy 30-40 feet in height dominated by mature gumbo limbo, ficus, and seagrape. Many trees show marked wind shear in response to the prevailing southeast tradewind. In addition, a survey by Austin (1972) has shown the presence of the plants indicated in Table 1. Trees from this group are commonly encountered in a very mature state, with many signs of storm damage and general senility. The hollow trunks, cavities and other damaged areas provide abundant estivation sites for the *Liguus* colony. Shading by the upper storey effectively precludes the growth of most under storey plants although a rather conspicuous layer of leaf mould and litter has accumulated over much of the hammock floor.

A careful analysis of the vegetation indicates that it has been moderately to severely disturbed in the southern half of the hammock so that conditions approaching a natural equilibrium state are restricted largely to the northern half -- amounting to little more than 10,000 sq. yds. total area. The *Liguus* population is further concentrated in a protected microhabitat situated to the leeward of the seagrape stand that occupies the beach ridge crest.

On penetrating the hammock the abundance of empty shells of the carnivorous *Euglandina rosea* is

FIG. 1. *Interior of the Boynton Beach Hammock.*

TABLE 1. Important botanical components of the Boynton Beach Hammock.

Cenchrus tribuloides
Sabal palmetto
Serenoa repens
Smilax bona-nox
Coccoloba uvifera
Yucca aloifolia
Agave decipiens
Hymenocalis latifolia
Salix caroliniana
Ficus aurea
Nectandra coriacea
Capparis cynophallophora
Capparis flexuosa
**Forestiera segregata*
Chiococca alba
Chrysobalanus icaco
Caesalpinia bonduc
Dalbergia ecastophyllum
Pithecellobium keyense
**Zanthoxylum fagara*
Simarouba glauca
**Bursera simaruba*
Cnidoscolus stimulosus
Croton punctatus
**Metopium toxiferum*
Schinus terebinthifolius
Toxicodendron radicans
Krugiodendron ferreum
Eugenia axillaris
Eugenia myrtoides
Ardisia escallonioides
**Mastichodendron foetidissium*
Psychotria nervosa

* - trees frequented by *Liguus*

Source: Austin and Weise (1972)

immediately noticeable. This strictly terrestrial snail is the control predator for the arboreal *Liguus.* One has the impression that any *Liguus* unfortunate enough to be blown from a tree branch probably has little chance of returning to safety if it should fall more than a few feet from a tree trunk. A thorough search of the Boynton hammock has not revealed other terrestrial snails of substantial size that would provide suitable prey for *E. rosea* so I conclude that it subsists almost exclusively upon *Liguus.* Both animals are basically nocturnal and predation has not been witnessed by the writer although it has been reported elsewhere. It is possible that land crabs constitute another significant predator. Their burrows are present in low areas of the hammock and some *Liguus*-shells have been noted with damage suggestive of pincers.

Specimens of *Liguus* from the Boynton Beach hammock have certain physical characteristics that may be especially significant. Adults are often quite elongate (40 mm x 15 mm), exceptionally thin-shelled, and highly porcellaneous on both interior and exterior surfaces. Adult coloration consists of two or more broad golden bands with narrow orange borders on a white background. These colors usually disappear beyond the penultimate whorl. Many specimens disclose an affinity with the variety *L. fasciatus septentrionalis* (Pils.). having three or four fine olivaceous lines superimposed on the gold bands. Although coloration as described is not duplicated by *Liguus* from other locations, we can reasonably assume that a gradation toward olive on white formerly existed in what was once a continuous population extending southward to Ft. Lauderdale. However, the majority of dead shells collected from the ground are weathered to a dull white and often much broken.

Juveniles of a different type appear frequently. These specimens are relatively robust and thick-shelled. Coloration is largely brownish flames similar to *L. marmoratus* but no adults with this coloration have been seen. If *L. marmoratus* does prove to exist in the hammock together with *L. fasciatus* a problem in distribution exists since the former subspecies was never found in hammocks to the south at Yamato, Pompano, and Ft. Lauderdale according to Pilsbry (1946:102). Consequently its disjunct presence at the extreme northern limit of the range under natural circumstances seems quite unlikely. However, artificial implantation of this relatively common variety by some well-meaning conservationist in the past is a likely explanation. The possibility of aboriginal involvement must not be excluded as there is some indirect evidence of Indian presence in the hammock.

Having found *Liguus* in the densely populated locale of Boynton Beach, further efforts were made to seek it in some of the previously known localities listed above by Pilsbry and indicated on his earlier (1912) map. In every case the former hammock habitat was completely destroyed. The search was extended to the inland oak-palmetto hammocks but these likewise proved barren.

Survival of *Liguus* in the Boynton hammock is not by mere accident (that is, beyond preservation of the hammock itself). Nearness to the sea with its ameliorating effect on winter temperatures is an obvious advantage to these cold-sensitive animals. High relative humidity fosters the growth of epiphytic algae and fungi providing abundant forage for tree snails (see Craig 1972 for details). Beach ridge substrate material along this part of the southeastern Florida coast is surprisingly siliceous (Craig *et al.*: 1969), whereas *Liguus* are known to prefer habitats having a rocky, calcareous substrate. In fact, the survival of a *Liguus* colony in an area not having a well-indurated substrate is difficult to demonstrate (with the possible exception of the Cape Sable area). Initially this lack of a rocky floor appeared to be an anomaly of the Boynton Beach site but in the course of investigation an outcrop of calcareous beach ridge rock was found along part of the western side of the hammock. Case-hardening (secondary cementation) of this strata may have a subtle effect on plant food intake of the vegetation and thus be reflected in the shell structure of the tree snails.

At the time this account was being written (Dec., 1971) the Boynton Beach hammock was still intact. It is, however, an extremely valuable tract from the real estate viewpoint and privately owned. Preservation of this unique site to date apparently is due to temporary lack of development funds as construction of a large multi-storied residential building was announced several years ago.

It is unfortunate indeed that no organized effort has been made to save this last remnant of the primeval landscape for the benefit of future generations who can never know the splendid beauty of this forest once it is gone forever.

LITERATURE CITED

Austin, D. F. and J. G. Weise 1972. Annotated checklist of the Boynton Beach Hammock. Jour. Florida Acad. Sci. 35.

Craig, A. K. 1972. Observations on the arboreal snail *Orthalicus floridensis*. Jour. Florida Acad. Sci. 35(1): 15-20.

Craig, A. K., S. Dobkin, R. B. Grimm and J. B. Davidson 1969. The gastropod *Siphonaria pectinata:* a factor in destruction of beach rock. Amer. Zool. 9(3, ed. 2): 895-901.

Moore, C. B. 1921. *Liguus* at Marco, Florida. The Nautilus 34: 139-140.

Pierce, C. W. 1970. Pioneer life in Southeast Florida. Univ. Miami Press, Coral Gables, Florida. 1-264.

Pilsbry, H. A. 1912. A study of the variation and zoogeography of *Liguus* in Florida. Jour. Acad. Nat. Sci. Philadelphia 15: 429-471.

Pilsbry, H. A. 1946. Land *mollusca* of North America (north of Mexico) Acad. Nat. Sci. Phil., Philadelphia, Pennsylvania. 2(1): 1-520.

Rhoads, S. N. 1899. Annotated list of land and fresh-water shells recently collected in the vicinity of Miami, Florida. The Nautilus 13: 43-47.

Simpson, C. T. 1921. Florida West Coast **Liguus.** The Nautilus 35: 66-73.

Simpson, C. T. 1922. A Search for *Liguus*. The Nautilus 35: 66-73.

Simpson, C. T. 1929. The Florida Tree snails of the genus *Liguus* * Proc. U. S. Nat. Mus. 73(Art.30): 1-44.

Young, F. N. 1960. Color pattern variations among snails of the genus **Liguus** on the Florida Keys. Bull. Fla. St. Mus. 5: 259-266.

PISIDIUM HENSLOWANUM (SHEPPARD) IN WESTERN CANADA

Stuart A. Harris
Department of Geography
The University of Calgary, 2920 24 Ave., N.W.
Calgary, Alberta, Canada T2N1N4

ABSTRACT

New localities of Pisidium henslowanum *(Sheppard) are recorded for Alberta, British Columbia, the North-West Territories and Ontario. This species is found in small numbers in boreal North America where there are alkaline oligotrophic to somewhat eutrophic waters of low to moderate salinity. Since it also occurs in post-glacial alluvial deposits over 7000 years old, it does not appear to be introduced species.*

Collections of freshwater mollusca by the writer from Western Canada between 1970 and 1972 have frequently yielded valves identical to *Pisidium henslowanum* (Sheppard) as described by Herrington (1962). Although it has been found in the Upper Pliocene and Early Pleistocene of Idaho (U. S. Geological Survey in Herrington, 1962, p. 41), Herrington (loc. cit.) has concluded that "this species appears to be introduced." Accordingly, it would seem appropriate to list the new occurrences, and re-examine this conclusion. The material is in the collection of the author and a sampling in the Delaware Museum of Natural History, Greenville, Delaware.

NEW LOCALITIES

Alberta

Cardinal Lake, near Peace River; ponds between Cochrane and Calgary; Crimson Lake, near Rocky Mountain House; Elkwater Lake, 26 miles south-east of Medicine Hat; Gull Lake, 10 miles north of Red Deer; beaver pond on Lusk creek along the Kananaskis road, 3 miles south of Seebe; Ma-me-o beach, Pigeon Lake, 40 miles south of Edmonton; Vermilion Lakes at Banff; pond, one-quarter mile inside Waterton National Park; Lake Winnegami, near Peace River (also form *supinum*).

It is also known from the post-glacial alluvial deposits of the area around the Porcupine Hille (Harris and Pip, 1973).

British Columbia

Altrude Lake, Vermilion Pass, Kootenay National Park; Lake Columbia at Canal Flats; Dog Lake, Kootenay National Park; Kootenay Lake.

Manitoba

Lynch's Pt., Lake Manitoba.

North West Territories:

Great Slave Lake at Hay River; latitude 63°9' N., and longitude 122°14' W. in terrace deposits above the MacKenzie River. The last two samples were collected by A. N. Boydell.

Ontario

Lake Bancroft, at Bancroft; Lake Ontario at Hamilton.

GEOGRAPHICAL RANGE

When these localities are added to those listed by Herrington (loc. cit.), and Sterki (1916), it is clear the *Pisidium henslowanum* is a fairly widespread boreal species ranging from the north-east United States almost to the Arctic Circle. It is never very abundant since it composed 3-13% of the valves collected at any particular site. Unless a large collection, say, 100 valves is made, it could easily be missed.

HABITAT AND ECOLOGY

Contrary to the statements in Herrington, this species occurs in ponds (e.g. at Waterton), in creeks (e.g. Lusk Creek, Kananaskis) and in small lakes (e.g., Altrude Lake, Lake Bancroft, Cardinal Lake and Dog Lake) in North America. The fact that it occurs in post-glacial, alluvium beneath

Mazamash (7000 years B.P.) agrees with this interpretation and suggests that it was living in the area long before European man set foot on this continent.

The range of water quality noted so far is pH 7.2-9.4; 91-142 alkalinity ($CaCO_3$ mg/litre); total hardness 101-179 ($CaCO_3$ mg/litre) 138-797 ppm. dissolved salts; dissolved oxygen 7.7-13.4 ppm; bicarbonate 1.97-11.06 meq./litres; chloride 0.02-3.00 meq./litre; nitrate 0.09-0.24 meq./litre; sulphate 0.02-1.25 meq./litre; phosphate 0.004-0.07 meq./litre; potassium 0.01-0.51 meq./litre; magnesium 0.58-14.17 meq./litre; calcium 0.50-2.87 meq./litre; and sodium 0.08-8.70 meq./litre. Thus it favors alkaline waters of low-moderate salinity in zones of calcareous soil and rock. The water may be oligotrophic to somewhat entrophic and is normally characterized by dominance of the bicarbonate anion. Since it occurs in Lake Manitoba, it may also survive where sulphate ions are fairly abundant. Presumably, this explains why it has not been reported from the extremely low salinity waters of central British Columbia and parts of the shield of Northern Ontario. It has yet to be found in the waters with higher salinities in the south-central Prairie Provinces.

LITERATURE CITED

Harris, S. A., and Pip, E., 1973. Mollusca as a means of determining late and post-glacial climatic history in Alberta. Can. Jour. Zool. in press.

Herrington, H. B., 1962. A revision of the Sphaeriidae of North America (Mollusca: Pelecypoda). Museum of Zool; Univ. of Michigan Misc. Paper No. 118, 74 pp.

Sterki, V., 1916. A preliminary catalogue of the North American Sphaeriidae. Ann, Carnegie Mus., **10** (¾), pp. 429-74.

CORBICULA IN SAN FRANCISCO, CALIFORNIA

James T. Carlton
California Academy of Sciences
San Francisco, California 94118

Living specimens of the introduced Asiatic Clam, *Corbicula manilensis* (Philippi, 1844) (the same as *C. fluminea* of authors), were collected on February 24, 1973, from Stow Lake, a small, shallow, artificial body of water in Golden Gate Park, San Francisco, California. While *Corbicula* is well-known from the Sacramento-San Joaquin Delta of central California (and especially in the Delta-Mendota Canal), as well as from the South Bay Aqueduct, this is the first record of this exotic clam on the San Francisco Peninsula. Only two living specimens were found (measuring approximately 17.2 mm and 17.6 mm in length, indicating an age of perhaps one and a half years), but several dead and smaller valves (the smallest 8.5 mm in length) collected at the same time suggest the presence of a reproducing population. The largest dead valve measures approximately 21.7 mm in length. The clams were found in about 12 inches of water on a muddy substrate, along the southeastern shore of the lake. The presence in large numbers of the native mussel, *Anodonta wahlametensis* Lea, 1838, in Stow Lake may provide an opportunity for students to study the effects of the introduction of *Corbicula* on the mussel population.

CYCLOSTREMELLA: A PLANISPIRAL PYRAMIDELLID

Robert Robertson
Academy of Natural Sciences
Philadelphia, Pennsylvania 19103

The genus *Cyclostremella* Bush (1897) was originally placed in the family Vitrinellidae. Thiele (1929) ranked it as a doubtful subgenus of *Daronia* A. Adams in the subfamily Skeneinae (family Trochidae). Defining it conchologically, Donald R. Moore (1966) has proposed the family Cyclostremellidae. One character setting it apart from vitrinellids, trochaceans and most other prosobranchs (except mathildids and architectonicids) is its hyperstrophic protoconch.

The type-species of *Cyclostremella* (by original designation) is *C. humilis* Bush (1897) which is probably the most abundant minute gastropod on the Texas coast, although rarely collected alive (Odé, 1966-1968; Boone, 1969). Mrs. Constance (Hollis Q.) Boone of Houston has kindly sent me two living specimens which she found among polychaete tubes washed ashore at Bryan Beach, Freeport, Texas, on November 26, 1972.

The external body morphology closely resembles that of the five species of east American odostomias (sensu lato) with which I am familiar; the resemblance to *Odostomia dianthophila* Wells & Wells is particularly close. The pair of purplish black eyes is posteromedian to the base of the fairly short tentacles. (Bush also observed that "two large black eyes [are] close together on the top of the head"). The tentacles are ciliated and concave ventrolaterally; the cilia near the tip are longer than the others. A narrow mentum is present and this can extend beyond the anterior end of the foot, which is slightly cleft medially. The operculum is as described and illustrated by Bush and Moore. Behind the head there is some grey speckling. A shallow anal sinus is present both on the shell and the mantle edge. The pigmented mantle organ (? hypobranchial gland) is greenish white anteriorly and bright yellow and brown to the posterior and right. All these characters are in accord with the European pyramidellids studied by Fretter and Graham (1949).

For final proofs of the pyramidellid nature of *Cyclostremella* I squashed each animal under a cover slip. No radula is present (Bush had been unable to find one either). Instead there is an elongate buccal stylet together with an oral sucker at the tip of a long acrembolic proboscis (deeply inverted in the specimens studied). *C. humilis* is hermaphroditic: both oocytes and spermatozoa were observed in the gonad of one of the specimens. The spermatozoa are long-tailed and have corkscrew-shaped heads that are like those of the pyramidellid described and figured by Franzén (1955, fig. 84). Such spermatozoa are unknown among prosobranchs (*ibid.*, pp. 449-450).

No other known pyramidellid approaches *Cyclostremella* in shell shape. Thus spire height per se is not a good familial character. With its low spire, *Cyclostremella* is convergent with the Architectonicidae which have, however, much larger protoconchs (those of *C. humilis* are only 0.28 mm in diameter) and differ conchologically in other ways too.

LITERATURE CITED

Boone, C. 1969. Bring 'em back alive. Texas Conchologist 5(8): 85.

Bush, K. J. 1897. Revision of the marine gastropods referred to *Cyclostrema, Adeorbis, Vitrinella*, and related genera; with descriptions of some new genera and species belonging to the Atlantic fauna of America. Trans. Connecticut Acad. Sci. 10(3): 97-144, 10 figs., pls. 22-23.

Franzén, A. 1955. Comparative morphological investigations into the spermiogenesis among Mollusca. Zoologiska Bidrag fran Uppsala **30**: 399-456, 146 figs., 2 pls., 2 tables.

Fretter, V. and A. Graham. 1949. The structure and mode of life of the Pyramidellidae, parasitic opisthobranchs. Jour. Mar. Biol. Assoc. United Kingdom [ser. 2] 28: 493-532, 12 figs.

Moore, D. R. 1966. The Cyclostremellidae, a new family of prosobranch mollusks. Bull. Mar. Sci. 16(3): 480-484, 6 figs.

Odé, H. 1966. Relative abundance of shells at Galveston. Texas Conchologist 2 (6): [8].

Odé, H. 1967. Some Galveston records of new and unusual shells. Texas Conchologist 3(9): [6-8]

Odé, H. 1968. *Cyclostremella humilis* Bush 1897. Texas Conchologist 5(4): 38-39, 1 fig.

Thiele, J. 1929. Handbuch der systematischen Weichtierkunde. Jena: Fischer 1(1): 1-376, 470 figs.

OBITUARY
G. Bruce Campbell, M.D.
(1934-1973)

G. Bruce Campbell was born October 14, 1934, at Wichita, Kansas, and died suddenly, February 28, 1973, at Victorville, California. He graduated from the school of medicine, Loma Linda University, in 1959, at the top of his class, and interned at the Glendale Adventist Hospital. After one year of residency in neurosurgery at the White Memorial Hospital in Los Angeles, he transfered to a dermatology residency at the same hospital. Since 1970, he had practiced dermatology at Victorville, California. He married Anita Martin in 1955. Besides his widow, he leaves three children.

As a boy, Dr. Campbell was an ardent butterfly collector, and assembled a fine collection from the United States and Cuba. He was also interested in orchid culture and in raising cats for show. While a medical student, he developed a deep interest in marine shells of West Mexico. He made many shore collecting, diving, and dredging trips to Baja California, Guaymas, and Mazatlan. He was the president of the Conchological Club of Southern California in 1962, and the vice-chairman of the American Malacological Union-Pacific Division in 1968. For the past few years, due to health problems, he was inactive with his collection. However, he had recently renewed his interest, and was planning a collecting trip to Panama at the time of his death. He was especially interested in the fossil and recent Typhinae and was compiling data for a monograph of the family. He will be deeply missed by his many friends and especially the writer, since we shared many collecting trips and also shared our professional office. *Trigonostoma campbelli* Shasky, 1964, was named in his honor.

Bibliography of G. Bruce Campbell

1961a. Range extension for *Terebra ornata* Gray, 1834. The Veliger, 3(4): 112.

1961b. Colubrariidae (Gastropoda) of tropical West America, with a new species. The Nautilus, 74(4): 136-142, pl. 10.

1961c. Four new Panamic gastropods. The Veliger, 4(1): 25-28, pl. 5.

1961d. Range extension of *Anatina cyprinus* (Wood 1828). *ibid,* 4(2): 115, 3 text figure.

1962. A new deep-water *Anadara* from the Gulf of California. *ibid,* 4(3): 152-154, pl. 37, 1 text figures.

1963a. Rediscovery of *Terebra formosa* Deshayes, 1857. *ibid,* 5(3): 122.

1963b. A new marine research station at Guaymas, Mexico. *ibid,* 5(3): 122.

1963c. (With Burch, J. Q.) Four new *Olivella* from the Gulf of California. The Nautilus, 76(4): 120-126, pls. 6, 7.

1963d. (With Burch, J. Q.) A new genus for deep-water California naticid. Proc. Malac. Soc. London, 35: 221-225, pl. 5.

1963e. (With Burch, J. Q.) *Shaskyus,* new genus of Pacific Coast Muricidae (Gastropoda). Jour. de Conchyl. 103(4): 201-206, pl. 6.

1964a. New terebrid species from the Eastern Pacific (Mollusca: Gastropoda). The Veliger, 6(3): 132-138, pl. 17.

1964b. (With Keen, A. M.) Ten new species of Typhinae, (Gastropoda; Muricidae). *ibid,* 7(1): 46-57, pls. 8-11, 3 text figures.

1964c. (With Shasky, D. R.) New and otherwise interesting species of mollusks from Guaymas, Sonora, Mexico, *ibid.* 7(2): 114-120, pls. 21, 22, 1 text figure, 1 map.

Names Proposed by G. Bruce Campbell

adairensis Campbell, *Terebra (Strioterebrum)*, 1964
altatae Burch and Campbell, *Olivella (Olivella)*, 1963
anitae Campbell, *Nassarina (Zanassarina)*, 1961
berryi Campbell, *Terebra (Strioterebrum)*, 1961
Calinaticina Burch and Campbell, 1963
churea Campbell, *Terebra (Strioterebrum)*, 1964
clarki Keen and Campbell, *Typhis (Typhinopsis)*, 1964
cortezi Shasky and Campbell, *Crassispira (Striospira)*, 1964
crebriforma Shasky and Campbell, *Clathurella (Lioglyphostoma)*, 1964
Distichotyphis Keen and Campbell, 1964
dushanae Campbell, *Terebra (Strioterebrum)*, 1964
erythrostigma Keen and Campbell, *Siphonochelus (Siphonochelus)*, 1964
fayae Keen and Campbell, *Pterotyphis (Tripterotyphis)*, 1964
hyphalopilema Campbell, *Anadora (Scapharca)*, 1962
imperialis Keen and Campbell, *Typhis (Typhina)*, 1964
ludbrookae Keen and Campbell, *Laevityphis (Laevityphis)*, 1964
mcleani Shasky and Campbell, *Calliostoma*, 1964
myrae Campbell, *Trivia (Pusula)*, 1961
ninfae Campbell, *Terebra (Strioterebrum)*, 1961
nipponensis Keen and Campbell, *Siphonochelus (Siphonochelus)*, 1964
precursor Keen and Campbell, *Typhis (Talityphis)*, 1964
schencki Keen and Campbell, *Laevityphis (Laevityphis)*, 1964
Shaskyus Burch and Campbell, 1963
sphoni Burch and Campbell, *Olivella (Olivella)*, 1963
steveni Burch and Campbell, *Olivella (Olivella)*, 1963
steveni campbelli Burch and Campbell, *Olivella (Olivella), 1963*
teramachii Keen and Campbell, *Typhis (Tyhpina)*, 1964
vemae Keen and Campbell, *Distichotyphis*, 1964
xavieri Campbell, *Columbraria*, 1961

by Donald R. Shasky, 229 Cajon Street
Redlands, California 92373

VIVIPARUS MALLEATUS IN NEW HAMPSHIRE

Frank Perron and **Thomas Probert**
Box 2146, Babcock Hall
University of New Hampshire
Durham, N. H. 03824

A large population of *Viviparus malleatus* (Reeve) was found on May 25, 1972, in the Cocheco River in the town of Rochester, New Hampshire. William J. Clench kindly verified the identification, and we believe that this is the first record of *V. malleatus* in this state. Specimens were deposited in The Ohio State Museum, Columbus, Ohio.

The snails occupy an extensive area of slack water backed up above the Rochester town dam. The substrate is quite sandy, but is covered with a thick layer of algae. It has been noted that the snail population is densest near a large trailer park where concrete septic tanks have been built very close to the river. Finally, these snails share the substrate with *Elliptio complanatus, Alasmidonta undulata, Amnicola limosa,* and *Helisoma anceps.*

Heretofore, this species has been recorded by Abbott (1950) from San Francisco (1891); San Jose, California (1900); Muddy River, Boston Massachusetts, W. J. Clench (1914); Lake Quinsigamond, Worcester, Massachusetts (1917); Fairmount Park, Philadelphia, Pennsylvania (1925); St. Petersburg, Florida (1950); near Niagara Falls, New York (1942). The Delaware Museum of Natural History (R. T. Abbott, *in litt.*) has specimens from Putnam Pond, Fitchburg, Massachusetts, K. and R. Wright, January 1973; Roosevelt Common Pond, Tenafly, New Jersey, Alice D. Barlow, October 1968; Pine Tree Brook, Milton, Massachusetts, Clench and R. D. Turner, May 1957; Central Park, New York City, 1970; Sawmill Lake, High Point Park, N. J., Dorothy Fackert, 1971.

LITERATURE CITED

Abbott, R. Tucker. 1950. Snail Invaders. Natural History **59**(2): 80-85.

INFORMATION FOR SUBSCRIBERS

The *annual subscription* rate for *The Nautilus* is $7.00 for individuals and $12.00 for institutions (domestic or foreign). Subscriptions may begin in January. Send check or money order to "The Nautilus" to Mrs. Horace B. Baker, Business Manager, 11 Chelten Road, Havertown, Pa. 19083.

Back issues from volume 72 to date are obtainable from the Business Manager. Volumes 1 through 71 (if available) may be obtained in reprint or original form from Kraus Reprint Co., Route 100, Millwood, New York 10546.

Advertising rates may be obtained from the Business Manager or Editor.

CONTRIBUTORS

Manuscripts: Authors are requested to follow the recommendations of the *Style Manual for Biological Journals.* which may be purchased from the American Institute of Biological Sciences, 2000 "P" Street, N.W. Washington, D.C. 20036. Manuscripts should be typewritten and doublespaced; original and one copy are required, to facilitate reviews. Tables, numbered in arabic, should be on separate pages, with the title at the top. Legends to photographs should be typed on separate sheets. Explanatory terms and symbols within a drawing should be neatly printed, or they may be pencilled in on a translucent overlay, so that the printer may set them in 8 pt. type. There is a charge of 50 cents per word for this extra service. All authors or their institutions will be charged 50 cents per line of tabular material and taxonomic keys. The publishers reserve the right, seldom exercised, to charge $32 per printed page.

An *abstract* should accompany each paper.

Reprints and covers are available at cost to authors. When proof is returned to authors, information about ordering reprints will be given. They are obtained from the Economy Printing Co., Inc., R. D. 3, Box 169, Easton, Maryland 21601.

MOLLUSK VOUCHER SPECIMENS

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

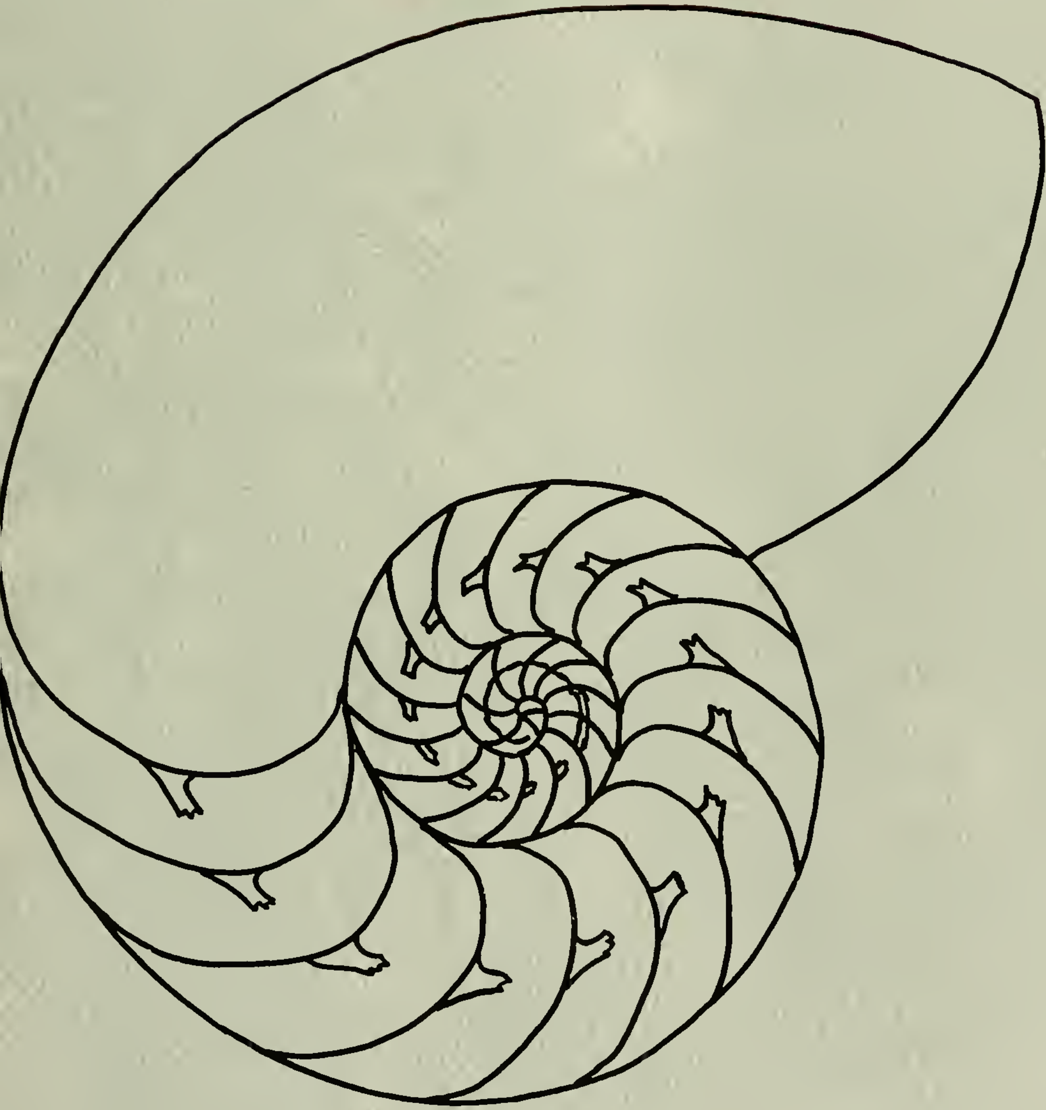
The Delaware Museum of Natural History has extensive, modern facilities and equipment for the housing and curating of voucher specimens. Material should be accompanied by the identification, locality data and its bibliographic reference. There is no charge for this permanent curating service, and catalog numbers, if desired, will be sent to authors prior to publication.

OCTOBER 1973

THE NAUTILUS

Vol. 87

No. 4



A quarterly
devoted to
malacology and
the interests of
conchologists

Founded 1889 by Henry A. Pilsbry. Continued by H. Burrington Baker.
Editors: *R. Tucker Abbott and Charles B. Wurtz*

EDITORIAL COMMITTEE

CONSULTING EDITORS

Dr. Arthur H. Clarke, Jr.
Department of Mollusks
National Museum of Canada
Ottawa, Ontario, Canada K1A-OM8

Dr. William J. Clench
Curator Emeritus
Museum of Comparative Zoology
Cambridge, Mass. 02138

Dr. William K. Emerson
Department of Living Invertebrates
The American Museum of Natural History
New York, New York 10024

Mr. Morris K. Jacobson
Department of Living Invertebrates
The American Museum of Natural History
New York, New York 10024

Dr. Aurèle La Rocque
Department of Geology
The Ohio State University
Columbus, Ohio 43210

Dr. James H. McLean
Los Angeles County Museum of Natural History
900 Exposition Boulevard
Los Angeles, California 90007

Dr. Arthur S. Merrill
Biological Laboratory
National Marine Fisheries Service
Oxford, Maryland 21654

Dr. Donald R. Moore
Division of Marine Geology
School of Marine and Atmospheric Science
10 Rickenbacker Causeway
Miami, Florida 33149

Dr. Joseph Rosewater
Division of Mollusks
U. S. National Museum
Washington, D.C. 20560

Dr. G. Alan Solem
Department of Invertebrates
Field Museum of Natural History
Chicago, Illinois 60605

Dr. David H. Stansbery
Museum of Zoology
The Ohio State University
Columbus, Ohio 43210

Dr. Ruth D. Turner
Department of Mollusks
Museum of Comparative Zoology
Cambridge, Mass. 02138

Dr. Gilbert L. Voss
Division of Biology
School of Marine and Atmospheric Science
10 Rickenbacker Causeway
Miami, Florida 33149

EDITORS

Dr. R. Tucker Abbott
Delaware Museum of Natural History
Box 3937, Greenville, Delaware 19807

Dr. Charles B. Wurtz
3220 Penn Street
Philadelphia, Pennsylvania 19129

Mrs. Horace B. Baker
Business and Subscription Manager
11 Chelten Road
Havertown, Pennsylvania 19083

OFFICE OF PUBLICATION
Delaware Museum of Natural History
Kennett Pike, Route 52
Box 3937, Greenville, Delaware 19807

Second Class Postage paid at Wilmington, Delaware

Subscription Price: $7.00 (see inside back cover)

THE
NAUTILUS

Volume 87, number 4 -- October 1973

CONTENTS

INDEX TO THE NAUTILUS

The extensive 279-page Author Index to The Nautilus, vols. 1-75, compiled and published by Aurèle La Rocque in 1963 is still available (unbound) for the extremely low price of $2.00 postpaid. A continuation, covering vols. 76-85, was recently published in no. 49 of *Sterkiana,* 1972. Reprints of this very useful addition are also available for 25 cents. When ordering both of these indispensable indices, we suggest an additional 50 cents be added to cover postage. Write: Dr. Aurèle La Rocque, 125 South Oval Dr., Ohio State Univ., Columbus, Ohio 43210.

american malacologists

presenting an indispensable desk companion for all mollusk research workers and historians . . .

a national register of living professional and amateur conchologists

plus biographies of 500 great, as well as little-known, American malacologists of the past

Here are the facts about each biographee—*date and place of birth, occupation, educational record, professional career, present position, malacological and civic memberships, writings* (including titles of most important papers and books), *current mollusk research activities, extent of shell collection, expeditions, sources of additional biographical information, marital status, current address*—all in a clear and compact style.

Also contains **Three Major Cross-Indexings** with over 1,000 biographees arranged (1) geographically by states and cities, (2) by current research activities, and (3) by occupations.

ISBN No. 0-913792-02-0

American Malacolpgists
6314 Waterway Drive
Falls Church,
Va. 22044

normally lists for $12.50

☐ for institutional libraries (20% discount) $10.00

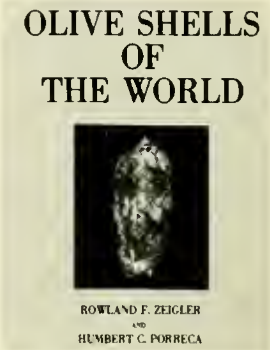
☐ special PRE-PUBLICATION cost
(for unlisted persons until Dec. 1, 1973) $10.00

The Shell Cabinet

Successor to:
Richard E. Petit
and
John Q. Burch

SPECIMEN SHELLS

NATURAL HISTORY BOOKS



OLIVE SHELLS
OF
THE WORLD

ROWLAND F. ZEIGLER
AND
HUMBERT C. PORRECA

International Directory of Conchologists - $3.50
A current worldwide list of 2,000 people interested in mollusks and in exchanging shells. Gives addresses and interests. Available only from The Shell Cabinet.

Olive Shells of the World by Zeigler and Porreca - $12.95
13 full-page color plates illustrating over 150 species and named varieties. The only current treatment of the popular family. Clothbound. Available from your book store or directly from us.

Other Recently Published Shell Books Available
Post Office Box 29, Falls Church, Virginia 22046

Limited Edition

A Rare Collector's Item . .

SWAINSON'S EXOTIC CONCHOLOGY

now available at a startlingly low price!
Now only *$13.75* (formerly $30.00)

The few remaining copies of this unusual facsimile have been purchased by the Delaware Museum of Natural History and are now made available practically at cost to all libraries, scientists and amateur conchologists. 48 beautiful, colored plates, representing a faithful reproduction of Swainson's 1834 and 1841 classic, together with the original text and a modern analysis by R. Tucker Abbott and Nora McMillan. Handsomely bound, gilt-edged on 3 sides and in full 9 x 12 inch page size. A useful and rare work belonging in the library of every lover of mollusks. Both available from your favorite book dealer or directly from the

Delaware Museum of Natural History
Box 3937, Greenville, Delaware 19807, U.S.A.

ACTEON ELOISEAE, A NEW OPISTHOBRANCH FROM ARABIA

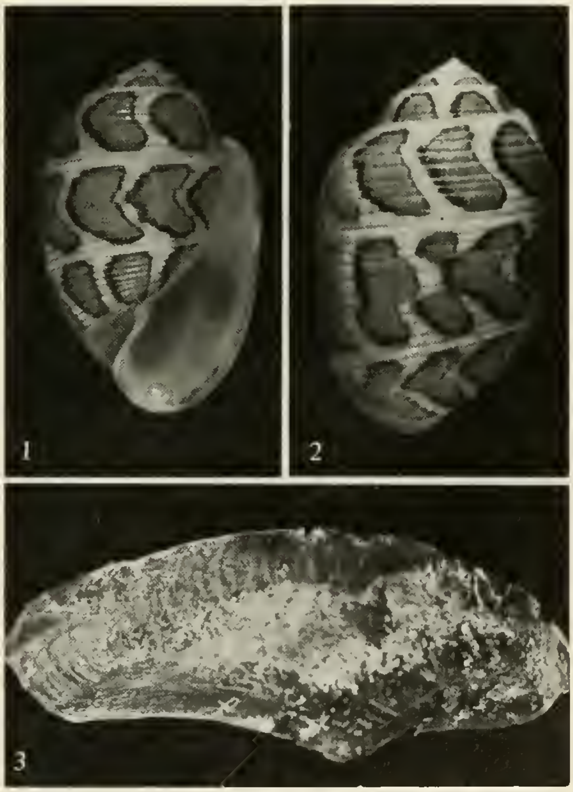
R. Tucker Abbott
Delaware Museum of Natural History
Greenville, Delaware 19807

In 1970, Dr. Donald Bosch of the American Mission Hospital in the Muscat obtained eight specimens of an undescribed species of *Acteon.* Unfortunately, soft parts were not preserved, although one shell contained a dried operculum. When the radulae are known it may be possible to place properly this species which closely resembles members of the genus or subgenus *Maxacteon* Rudman, 1971. I take great pleasure in naming this species after the discoverer's wife, Eloise Bosch.

Acteon eloiseae new species, **Abbott**
Figs. 1-4

Diagnosis—Adult shell 30 to 35 mm, stoutly ovate, solid, spirally and closely grooved, with about 7 whorls and a low spire. Color white with 3 spiral rows of large rose-colored, crescent-shaped, irregular splotches, each of which is bordered by a strong black line. Columella white, with one spiral cord. It is most similar to *Acteon flammeus* (Gmelin) but the latter is smaller, less obese, with more numerous axial flames of color which are lacking the black borders.

Description—Shell 30 to 35 mm in length (1 3/8 inches), stoutly ovate, solid, with a deep but minute umbilicus; whorls 7 to 8; nuclear whorls 2, smooth, white. Postnuclear whorls in the spire with 5 to 7 deep, narrow spiral grooves which are crossed by regular, microscopic axial threads giving a pitted appearance. Between the grooves there are raised, slightly rounded cords crossed by numerous weak growth threads. Last whorl with about 30 grooves. Suture slightly channeled. Aperture ovate, narrow above white within. Spire slightly elevated and about 1/3 to 1/4 the length of the shell. Outer lip thin and sharp. Parietal callus thick and translucent white. Columella thick, glistening white and bearing a single, smooth, large, spiral cord which runs back into the aperture. Umbilicus very narrow and deep, well-grooved. Periostracum thin, translucent tan, but thicker in the umbilical region. Color of shell white, with 3 spiral bands of irregular, crescent-shaped, rose to crimson blotches which are bordered by a narrow black line. The latter is usually wider on the adapertural side. There are 6 to 7 blotches on the top and bottom rows and about 11 in the middle row. Operculum thin, chitinous, translucent amber, elongate, 14 mm in length, 6 mm in width (from a shell 31 mm in length). Nucleus indistinct and at the broader thick end. It resembles the operculum of *Acteon tornatilis* (Linné) in shape.



FIGS. 1-3. Acteon eloiseae *Abbott, new species, Figs. 1, 2. holotype, Delaware Museum Natural History, no. 27213. 31 mm in length. Fig. 3. Exterior of chitinous operculum. 14 mm in length.*

FIG. 4. Acteon eloiseae *Abbott, new species. Paratype, details of sculpture and color pattern. X6. FIG. 5. Details of sculpture and color pattern of* Acteon flammeus *(Gmelin, 1791) from Praia de Chocas, Mozambique. X6. Photos by the author.*

Measurements (mm) –

length	*width*	*no. whorls*	
31.0	19.5	7.0	holotype
34.8	22.2	8.0	paratype
34.6	21.5	8.0	paratype
34.1	21.6	8.0	paratype
31.0	19.5	7.0	paratype

Types—The type locality: Al Masirah Island, Oman Protectorate, southeast Arabia. Collected by fishermen in shallow water near shore, 1970. Holotype in the Delaware Museum of Natural History, no. 27213. Paratypes in Delaware Museum of Natural History, no. 67746, and in the collection of Dr. Donald Bosch.

Remarks—*Acteon eloiseae* is a very colorful and attractive species of unusual large size, and is characterized by the three rows of large, black-bordered, rose-colored blotches. Its nearest relative, found in the Indian and southwest Pacific Oceans, *A. flammeus* (Gmelin), differs in having twice as many, narrower, pinkish rose, axial flames of color which lack the black borders. Other curious marine mollusks inhabiting the waters of this island include *Cypraea teuleri* Cazenavette, 1846, and *Cymatium boschi* Abbott and Lewis, 1970.

●

SYSTEMATICS AND DISTRIBUTION OF THE DEEP-SEA GASTROPOD *EPITONIUM (ECCLISEOGYRA) NITIDUM*

Michael A. Rex
Department of Biology, University of Massachusetts
Boston, Massachusetts 02116
and
Kenneth J. Boss
Museum of Comparative Zoology, Harvard University
Cambridge, Massachusetts 02138

ABSTRACT

Recent deep sea dredging in the western North Atlantic and South Atlantic Oceans has yielded new specimens of the rare, open-coiled gastropod Epitonium nitidum *(Verrill and Smith). It is the type-species of the subgenus* Eccliseogyra *Dall, 1892, which is now removed from the subfamily Liotiinae (family Turbinidae) and placed in the genus* Epitonium *(family Epitoniidae). The synonymy and Pan-Atlantic distribution of this species are discussed.*

INTRODUCTION

In 1885, Verrill described a fragment of an open-coiled gastropod shell dredged by the *Albatross* as *Delphinula nitida* and provisionally referred the unusual species to the prosobranch family Trochidae. Subsequently, Dall (1889a) assigned *nitida* to *Laxispira* Gabb, a subgenus of *Liotia* Gray in the Delphinulidae. But later, after discovering that Gabb's taxon was based on a fossil cast or mold of *Siliquaria,* Dall (1892) proposed the subgenus *Eccliseogyra* for *nitida.* A very similar, but intact, specimen was described from the *Challenger* material by Watson (1886) as *vermetiformis* and placed in the genus *Scalaria* Lamarck, now a synonym of *Epitonium* Röding (Clench and Turner, 1951). Locard (1897 a, b) named two additional specimens collected during the *Travailleur* and *Talisman* expeditions as *Scalaria dissoluta,* distinguishing them from *S. vermetiformis* Watson on the basis of minor differences in shell size, shape and sculpture. Bayer (1971) first suggested that, except for the relative height of the spire, Verrill's and Watson's species were "close . . . if not identical."

Recent deep sea dredging operations on vessels of the Woods Hole Oceanographic Institution (Sanders, Hessler, and Hampson, 1965) have yielded numerous additional specimens of *nitida* (Table 1 and Figure 1). This new material was compared with the holotype of *vermetiformis* Watson, the

FIG. 1. *Typical specimen of* E. nitidum *(Verrill and Smith) from the western North Atlantic (Chain station 103, see Table 1). Height 6.3 mm.*

paratype of *dissoluta* Locard, additional fragments identified by Verrill as *nitida* (USNM 78566), but evidently never reported on, and Bayer's excellent photograph (1971: Figure 11, D). It is concluded that all belong to the same species and that previously noted small differences between specimens are aspects of intraspecific character variation.

Keen (1960) considered *Eccliseogyra* Dall a genus and placed it in the family Turbinidae of the superfamily Trochacea. On the basis of morphological features of its type species, *Eccliseogyra* is here considered a subgenus of *Epitonium* and is transferred to the Epitoniidae.

SYSTEMATICS

The following synonymy summarizes the nomenclatorial history of this species.

Genus *Epitonium* Röding 1798
Subgenus *Eccliseogyra* Dall 1892

Eccliseogyra Dall 1892, Trans. Wag. Free Inst. Sci. 3: 307 (type species: *Delphinula nitida* Verrill and Smith 1885, by monotypy).

Solutiscala de Boury 1909, Bull. Mus. Hist. Nat., Paris 15: 482 (type species: *Scalaria [=Epitonium] dissoluta* Locard, original designation).

Epitonium (Eccliseogyra) nitidum (Verrill and Smith 1885)

Figs. 1-4; Table 1

Delphinula nitida Verrill and Smith 1885 [*in*] Verrill, Trans. Conn. Acad. Arts Sci. 6 (2): 424-425, pl. 44, fig. 11. (*Albatross* Sta. 2229, off Chesapeake Bay, 37°38'40" N; 73°16'30"W, 1423 fathoms [= 2602 meters]; holotype in the USNM destroyed); paratype, USNM 78566, *Albatross* Sta. 2714, SW of Nantucket, 38°22'N; 70°17'30"W, 1825 fathoms [= 3338 meters].

Scalaria vermetiformis Watson 1886, *Challenger* Repts., Zool. 15: 142, pl. 9, fig. 6. (*Challenger* Sta. 122, off Pernambuco [Recife], Brazil, 09°5'S; 34°50'W, 350 fathoms [= 640 meters]; holotype in BMNH).

Liotia (Laxispira) nitida (Verrill [*sic*]). Dall 1889, Bull. Mus. Comp. Zool. 18: 386 [generic and subgeneric affinities of *nitida* discussed]; Dall 1889, Bull. U. S. Nat. Mus., 37: 166, pl. 46, fig. 11 [Verrill and Smith's figure of *nitida* reproduced].

Liotia (Eccliseogyra) nitida (Verrill [*sic*]). Dall 1892, Trans. Wag. Free Inst. Sci. 3 (2): 307 [*nitida* assigned to a new subgenus].

Scalaria dissoluta (P. Fischer MS) Locard 1897. L'Échange, Revue Linnéenne, 145, p. 3; Locard 1897. Expéd. Sci. *Travailleur* et *Talisman*, Mollusques Testaces 1: 407-408, pl. 19, figs. 1-3 (*Talisman* Sta. 113, off Cape Verde Islands, 495-618 meters [corrected to 80-110 meters by Smith, 1888]; location of figured holotype unknown; paratype, here figured, *Travailleur* Sta. 3 [1881, Atlantic Series], W of Portugal, 39°47'50"N; 9°51'45"W, 3307 meters).

Solutiscala (Solutiscala) vermetiformis (Watson). Clench and Turner 1952, Johnsonia 2: 347, pl. 170, figs. 1-2.

Epitonium (Solutiscala,) vermetiforme (Watson). Bayer 1971, Bull. Mar. Sci. 21: 133, fig. 11 d (*Gerda* Sta. G-966, Straits of Florida SW of Marquesas Keys, 24°10'N; 82°22'W, 544-549 meters).

REMARKS

A specimen from the new material dredged in the western North Atlantic (Table 1) is shown in Figure 1. For comparison, the paratype of *Scalaria dissoluta* Locard and the holotype of *Scalaria vermetiformis* Watson are illustrated in Figures 2 and 3 respectively. The protoconch was described by Watson (1886, p. 142, pl. 9, fig. 6; see also Figure 3 this paper). It is brown in color, has four connected whorls and is sculptured with closely placed axial ribs. The postlarval shell was described by Verrill (1885). It is delicate and whitish gray in color. Whorls are circular in cross-section and are completely disconnected. Sculpture consists of many closely placed spiral ribs crossed by delicate axial lamellae which completely circumscribe the whorls. As Verrill (1885) pointed out, the lamellae are more elevated on the upper, inner and lower surface of the whorls (see, *e.g.*, Figure 1). This fact, along with the broken appearance of the lamellae, suggests that they are normally more extended, but have been damaged during dredging.

Except for the relative height of the spire, there is little variation among the specimens that we have examined. The width to height ratio at the end of the fourth whorl ranges from 0.68 (specimen in Figure 1) to 0.48 (specimen in Figure 2).

From its general appearance, *nitidum* is referable to *Epitonium* and we concur with Clench and Turner (1952) who placed it in the subgenus *Solutiscala* which deBoury (1909) established for the uncoiled species. However, deBoury's taxon, is a junior subjective synonym of *Eccliseogyra* Dall 1892 and, thus, the proper nomen for the species is *Epitonium (Eccliseogyra) nitidum.*

Unfortunately, both Verrill's surviving fragment and specimens in the new material are missing the distinctive protoconch illustrated by Watson (1886, pl. 9, fig. 6). Several specimens in the new material show remains of broken eroded apices which are smooth and lack periostracum. However, the similarities both in the sculpture and in the form of postlarval whorls are sufficient to justify the synonymy of *vermetiformis* and *dissoluta* with *nitidum.*

Epitonium revolutum (Hedley, 1899), reported from shallow water in Funafuti Atoll, is reminiscent of *E. nitidum* because of its open-coiled shell, and was included in *Solutiscala* by deBoury (1909). However, it can be clearly distinguished by its less numerous and more pronounced varices. Ladd (1972) recently noted this species from the Late Miocene of Palau.

An unusual feature of *E. nitidum* is its open-coiled or *alloiostrophic* (Simroth 1896-1907)

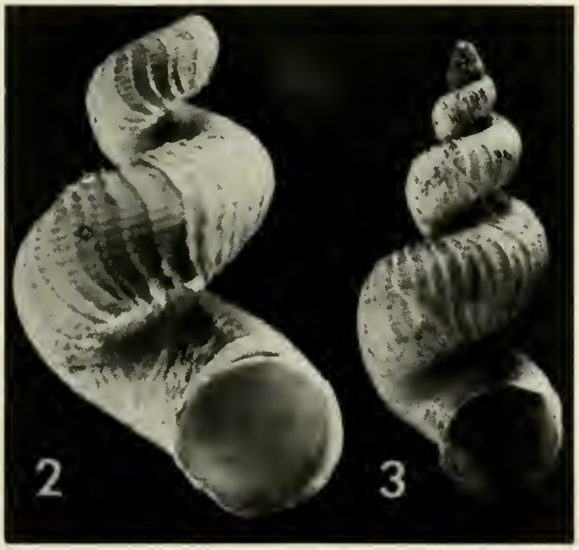


FIG. 2. *Paratype of* Scalaria dissoluta *Locard (*Travailleur *station 3, off Portugal, MNHP 642). Specimen decollated, height 5.5 mm, coated with magnesium oxide for photography.*

FIG. 3. *Holotype of* Scalaria vermetiformis *Watson (*Challenger *station 122, off Pernambuco [Recife], Brazil, BMNH 87.2.9.500. Specimen complete with protoconch, height 4.8 mm, coated with magnesium oxide for photography.*

FIG. 4. *The distribution of* Epitonium nitidum *(Verrill and Smith, 1885) in the Atlantic Ocean. Solid stars indicate individual records, and the open star in the western North Atlantic represents a composite of the first nine new records presented in Table 1 and two previous records from Verrill discussed in the text.*

condition. Coiling in snails was described by Raup (1966) in terms of four geometric parameters: whorl shape (S), rate of whorl expansion (W), distance of whorls from the coiling axis (D), and translation rate along the coiling axis (T). Yochelson (1971) pointed out that "open coiling may occur if any of these components is large enough to prevent contact of the whorls." In isostrophic (planispiral) shells it obtains when either $D > \frac{1}{W}$ or $W > \frac{1}{D}$ (Raup, 1967; Yochelson, 1971). In orthostrophic (downward spiraling) forms such as *E. nitidum* it is generally achieved by having an exceptionally high translation rate. Alloiostrophy occurred in numerous lineages of fossil gastropods (*cf* Wenz, 1938) and is widespread in Recent fresh-water and marine prosobranchs as well as in terrestrial and fresh-water pulmonates (Boss and Rex *in prep.*). In the Vermetidae, open coiling provides increased surface area for cementation (Gould, 1966), but the adaptive significance of open coiling in other cases is not clear. In sedentary deposit, or suspension feeding forms it might function to maintain position in the substratum.

DISTRIBUTION

New locality records for *E. nitidum* are presented in Table 1, and all known localities are plotted in Fig. 4.

The horizontal distribution pattern depicted in Fig. 4 is largely an artifact of where extensive dredging has taken place. It is evident, however, that the geographic range of the species includes both the eastern and western North Atlantic, and a Pan-Atlantic distribution appears likely. Unfortunately, there is some confusion about the location and depth of *Talisman* station 113. Locard (1897 b) variously cited this station as being located either in the Azores or the Cape Verde Islands at depths ranging from 495 to 1983 meters. We have followed Smith (1888) in placing *Talisman* station 113 in the Cape Verde Islands at depths of 80-110 meters (Fig. 4).

Though a comparatively rare species[1], *nitidum* exhibits nearly the same broad geographic range as dominant deep sea gastropod species such as *Cithna tenella* Jeffreys, *Adeorbis umbilicatus* Jeffreys, *Mangelia bandella* Dall, and *Lacuna cossmanni* Locard (Rex, 1972). Madsen (1961) and Knudsen (1970) have shown that macro-topographic relief of the ocean floor, such as the Mid-Atlantic Ridge, does not exert an important influence on the distribution of many deep sea benthic invertebrate groups. This appears to be true of some gastropods, including *E. nitidum*.

In the northwestern Atlantic, *E. nitidum* has been collected only between the depths of 2022 and 4693 meters (Table 1) despite extensive dredging both above and below these depths. However, in more equatorial regions the species' bathymetric range extends into much shallower waters including the upper continental slope off Brazil (*Challenger* Sta. 122, 640 meters), off Florida (*Gerda* Sta. G-966, 544-549 meters), and the continental shelf in the Cape Verde Islands (*Talisman* Sta. 113, 80-110 meters according to Smith 1888). Thus *nitidum* has a vertical distribution ranging from the continental shelf to the abyssal plain. Deep sea benthic invertebrate species with wide horizontal distribution are typically eurybathic (Vinogradova 1959), but this tendency has not previously been reported for gastropods because of inadequate material. It should be noted that this type of distribution is not universal among deep sea gastropods and that its frequency remains to be determined.

ACKNOWLEDGMENTS

We thank W. D. Hartman (PMNH), J. Rosewater (USNM), J. Taylor (BMNH), and M. Testud (MNHP), for the loan of specimens from these institutions. This research received support from NSF Grant GB-19922 to Harvard University (R. C. Rollins, principal investigator). We especially wish to thank H. L. Sanders who kindly provided the new material presented in Table 1 which was collected by WHOI under NSF Grants GB-563 and GB-15638. The manuscript was read by R. D. Turner, R. Bullock and R. Tucker Abbott.

---

[1] Eight live specimens collected between the depths of 2022 to 3834 meters off North America (Table 1) comprised less than 0.7% of the number of live gastropods dredged between these depths during the WHOI Gay Head-Bermuda deep sea dredging project.

ABBREVIATIONS

USNM	United States National Museum, Washington, D. C.
PMNH	Peabody Museum of Natural History, Yale University
WHOI	Woods Hole Oceanographic Institution
BMNH	British Museum of Natural History
MNHP	Museum of Natural History, Paris

LITERATURE CITED

Bayer, F. M. 1971. New and unusual mollusks collected by R/V John Elliott Pillsbury and R/V Gerda in the tropical western Atlantic. Bull. Mar. Sci. 21: 111-236.

Boss, K. J. and M. A. Rex. In prep. Alloiostrophy in Tertiary and Recent Gastropods.

deBoury, E. 1909. Observations sur les Scalidae des Expéditions scientifiques du *Travailleur* et du *Talisman*. Bull. Mus. Natl. Hist. Nat., Paris 15: 478-484.

Clench, W. J. and R. D. Turner. 1951. The genus *Epitonium* in the western Atlantic. Johnsonia 2: 249-288.

Clench, W. J. and R. D. Turner. 1952. The genera *Epitonium* (Part II), *Depressiscala, Cylindriscala, Nystiella* and *Solutiscala* in the western Atlantic. Johnsonia 2: 289-356.

Dall, W. H. 1889a. Report on the Mollusca, Part II Gastropoda and Scaphopoda. Reports on the results of dredging . . . in the Gulf of Mexico (1877-78) and in the Caribbean Sea (1879-80), by the U. S. Coast Survey steamer "Blake" . . . Bull. Mus. Comp. Zool. 18: 492 p.

Dall, W. H. 1889b. A preliminary catalogue of the shell-bearing marine mollusks . . . Bull. U. S. Nat. Mus. 37: 1-221.

Dall, W. H. 1892. Contributions to the Tertiary fauna of Florida, with special reference to the Miocene Silexbeds of Tampa and the Pliocene beds of the Caloosahatchee River. Part. II. Streptodont and other gastropods, concluded. Trans. Wagner Free Inst. Sci. (Philadelphia) 3: 201-473.

Gould, S. J. 1966. Notes on shell morphology and classification of the Siliquariidae (Gastropoda). The protoconch and slit of *Siliquaria squamata* Blainville. Amer. Mus. Novitates 2263: 1-13.

Hedley, C. 1899. The Mollusca of Funafuti. Part 1 Gastropoda. Australian Mus. Mem. 3: 395-488.

Keen, M. 1960. *In* Moore, R. C. [ed.] Treatise on Invertebrate Paleontology. Part I, Mollusca 1, Univ. Kansas, Lawrence, Kansas, 351 p.

Knudsen, J. 1970. The systematics and biology of abyssal and hadal Bivalvia. Galathea Rept. 11: 1-241.

Ladd, H. S. 1972. Cenozoic fossil mollusks from western Pacific islands; Gastropods (Turritellidae through Strombidae). Geol. Surv. Prof. Pap. 532: 1-79.

Locard, A. 1897a. Notices conchyliologiques. XLII. Scalaridae nouveaux. L'Échange, Revue Linnéenne 145: 2-3.

Locard, A. 1897b. Expéditions scientifiques du *Travailleur* et du *Talisman*. Mollusques Testacés 1: 1-516.

Madsen, F. J. 1961. On the zoogeography and origin of the abyssal fauna, in view of the knowledge of the Porcellanasteridae. Galathea Rept. 4: 177-218.

Raup, D. M. 1966. Geometric analysis of shell coiling: general problems. Jour. Paleontology 40: 1178-1190.

Raup, D. M. 1967. Geometric analysis of shell coiling: coiling in ammonoids. Jour. Paleontology 41: 43-65.

Rex, M. A. 1972. Species diversity and character variation in some western North Atlantic deep sea gastropods. Unpublished Ph.D. Thesis, Harvard University, 178 pp.

Sanders, H. L., R. R. Hessler and G. R. Hampson. 1965. An introduction to the study of deep-sea benthic faunal assemblages along the Gay Head-Bermuda Transect. Deep-Sea Res. 12: 845-867.

Simroth, H. 1896-1907. Mollusca. *In* H. G. Bronn [ed.]. Klassen und Ordnungen des Tier-Reichs 3: 1506 p. C. T. Winter'sche Verlagshandlung, Leipzig.

Smith, S. 1888. Lists of the dredging stations of the U. S. Fish Commission . . . Ann. Rept. U. S. Comm. Fish and Fisheries, for 1886: 837-1017.

Verrill, A. E. 1885. Third catalogue of Mollusca recently added to the fauna of the New England Coast . . . Trans. Conn. Acad. Arts. Sci. 6: 395-452.

Vinogradova, N. G. 1959. The zoogeographical distribution of the deep-water bottom fauna in the abyssal zone of the ocean. Deep-Sea Res. 5: 205-208.

TABLE 1. *New Records of* Epitonium (Eccliseogyra) nitidum *(Verrill and Smith, 1885) in the Atlantic Ocean.*

Cruise	Station	Depth in Meters	Locality	Date	Number of Specimens
Chain 58	103	2022	39°43.6'N, 70°37.4'W	V/4/1966	1 live
Atlantis II 12	72	2864	38°16'N, 71°47'W	VIII/24/1964	1 dead + fragments
Atlantis II 12	64	2886	38°46'N, 70°06'W	VIII/21/1964	2 dead
Atlantis II 17	95	3753	38°33'N, 68°32'W	XII/17/1965	1 live, 13 dead + fragments
Atlantis II 24	126	3806	Beg. 39°37.0'N, 66°47.0'W End 39°37.5'N, 66°44.0'W	VIII/24/1966	2 live
Chain 50	78	3828	38°0.8'N, 69°18.7'W	VI/30/1965	2 live, 4 dead
Chain 50	85	3834	37°59.2'N, 69°26.2'W	VII/5/1965	2 live, 4 dead + fragments
Atlantis II 40	175	4667-4693	Beg. 36°36'N, 68°29'W End 36°36'N, 68°31'W	XI/29/1965	1 dead
Atlantis II 12	70	4680	36°23'N, 67°58'W	VIII/23/1964	1 dead + fragments
Atlantis II 31	156	3459	Beg. 00°46.0'S, 29°28.0'W End 00°46.5'S, 29°24.0'W	II/14/1967	1 dead
Atlantis II 31	149	3861	10°30.0'N, 18°18.0'W	II/7/1967	2 live

Watson, R. B. 1886. Report on the Scaphopoda and Gastropoda collected by the H.M.S. "Challenger" during the years 1873-1876. Challenger Repts., Zool. **15**: 1-756.

Wenz, W. 1938. Gastropoda, Teil 1: Allgemeiner Teil und Prosobranchia. *In* O. H. Schindewolf [ed.], Handbuch der Paläozoologie **6**: 1-948, Gebrüder Borntraeger, Berlin.

Yochelson, E. L. 1971. A new Late Devonian gastropod and its bearing on problems of open coiling and septation. *In* J. T. Dutro, Jr. [ed.]. Paleozoic perspectives: A paleontological tribute to G. Arthur Cooper: Smithsonian Contr. Paleobiology **3**: 231-241.

BOOK REVIEW

A PARTIAL BIBLIOGRAPHY OF OYSTERS, WITH ANNOTATIONS. By Edwin A. Joyce., Jr. State of Florida Department of Natural Resources, Special Scientific Report No. 34, June 1972. Paperback, 846 pp.

Among the many useful scientific works on marine mollusks emanating from the Marine Research Laboratory in St. Petersburg, Florida, this enormous compilation leads this year's contributions in popularity and usefulness. Joyce's bibliography now replaces the famous, but hard to obtain, oyster reference book that J. L. Baughman issued in 1948.

Although the emphasis is naturally on papers dealing with commercial oysters, there is excellent coverage in other research areas, such as on the venerid clams, the freshwater *Corbicula* and unionid mussels, scallops and gastropod predators. Of the 4,117 references listed 45% are annotated, a feature invaluable to those without an extensive library. The key to the literature appears in a *Subject Index* that lists all papers dealing with one of 55 various categories, such as Age and Longevity; Embryology; Mariculture; Pearls; Pollution and Taxonomy. Edwin Joyce and his Florida associates are to be congratulated and thanked for producing this much-needed compendium.

R. Tucker Abbott
Delaware Museum of Natural History

ON THE DOUBLE HECTOCOTYLIZATION OF OCTOPODS

Francisco J. Palacio[1]
University of Miami
Rosenstiel School of Marine and Atmospheric Science
Miami, Florida 33149

ABSTRACT

Two cases of double unilateral hectocotylization in Incirrate octopods are reported for the first time. The supernumerary hectocotylized arms have smaller ligulas, calami and seminal canals, and the last few rows of suckers are reduced in size. The extra modified arms are believed to be sexually functional. Double hectocotylization is not accompanied by modifications of the genitalia. The extra hectocotylization is possibly caused by a sex-linked mutation, and it is manifested in a uniform proportionality.

Most male octopods have the third right arm modified for insemination; the tip of the arm is transformed into a spoon-shaped or flat ligula which may bear small transverse ridges; and a velar membrane, converted into a seminal groove, fringes the margin of the arm terminating distally into a conical "cheeked" calamus. In shallow water Octpodinae the ligula is small, usually not exceeding 15% of the arm length. In deeper water forms the modified portion may attain 60 or 70% of the arm length.

Only three monotypic genera have the third left arm hectocotylized: *Scaeurgus unicurrhus* d'Orbigny of worldwide distribution, *Euaxoctopus panamensis,* from the Gulf of Panama (Voss, 1971), and *Pteroctopus tetracirrhus* (delle Chiaje) occurring in the Atlantic Ocean (a doubtful species, *Pteroctopus witjazi* was described from off the Kamchatka Peninsula (Akimsuhkin, 1963).

In the past only two cases of double bilateral hectocotylization phenomena have been reported. One case was in *Eledone cirrosa* from the Mediterranean and North Sea (Appelof, 1892), with the third left arm also modified. An idea of the rarity of the case was given by Morales (1958) who examined 1,538 specimens of this common species without finding a single example. The other case was in *Octopus briareus,* from Curacao and the West Indies, which had the second left arm also modified (Robson, 1929).

In the course of a study of the cephalopod fauna of Brazil, I encountered a double unilateral hectocotylization in *Octopus vulgaris* from off Rio de Janeiro, in which the fourth right arm is also hectocotylized. Another double, unilateral hectocotylization was observed by Mr. Martin Wolterding during morphometric measurements of *Octopus selene* from the Gulf of Panama, in which the second right arm is also modified.

From my observations and the previous records, it appears that when this unique phenomenon occurs, the double hectocotylization is manifested in a similar pattern. Fig. 1 illustrates the modification of the tips of the arms of *Octopus selene* and *vulgaris* the present observations indicate a regular pattern of proportional modification of the extra hectocotylized arm to the normally hectocotylized arm.

The normal third hectocotylized arm is usually shorter and thinner than the other arms. The extra hectocotylized arm is not diminished in length, and maintains its normal relative proportionality in being 1.06-1.21 times longer and 1.05-1.25 times wider than the normal arm. The ligula of the extra hectocotylized arm is reduced by 71-83% of the normal hectocotylized arm; the extra calamus is more variable, being between 48.0-91.6% of the normal arm. The ligula/arm proportion of the extra to the normal hectocotylized arms is fairly uniform (63.0-72.0%), and the calamus/ligula proportion of the extra to the normal arm ranges

---

[1] Contribution No. 1640 from the Rosenstiel School of Marine and Atmospheric Science, University of Miami.

from 57.5-128.0%. The extra hectocotylized arm has about 1.16-1.27 times as many sucker rows than the normal arm; however, the last 19.0 - 28.0% of the suckers of the extra hectocotylized arm are conspicuously reduced in size.

As was noted in the double hectocotylized *Eledone cirrosa* and *Octopus briareus*, there are no structural differences in the genitalia of *Octopus selene* and *O. vulgaris*. Nevertheless, the seminal canal in the extra modified arm is smaller than that of the normal hectocotylized arm, although the length and width of the extra hectocotylized arm are larger.

The comparative development of the hectocotylus and the associated organogenesis has not been studied, but the structural modification of the arm takes place prior to the onset of spermatogenesis. Because of the general morphology, I believe the additional hectocotylized arm is sexually functional.

The genetic control of hectocotylization has not been studied, but I assume that it is governed by sex-linked genes, and that mutations at these loci are possibly responsible for the double hectocotylizations reported here.

ACKNOWLEDGMENTS

I am grateful to Dr. Gilbert L. Voss, Chairman,

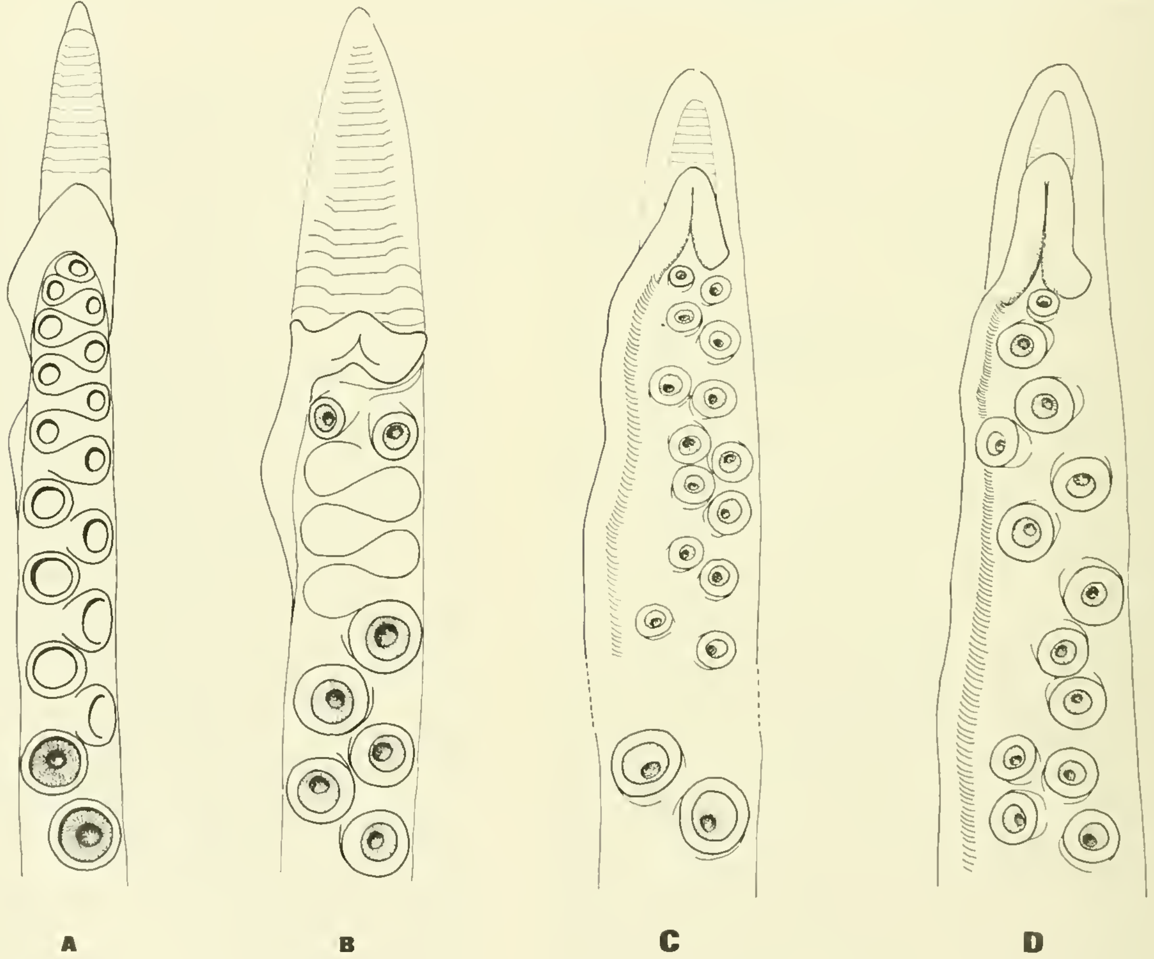


FIG. 1. A-B, Octopus selene, ♂. *A, tip of second right extra hectocotylized arm;* B, *tip of third normal hectocotylized arm.* C-D, Octopus vulgaris, ♂ . C, *tip of third right normal hectocotylized arm;* D, *tip of fourth right extra hectocotylized arm. Notice the reduction in size of the distal suckers of the extra modified arm.*

Division of Biology, Rosenstiel School of Marine and Atmospheric Science, University of Miami, for making the specimen of *Octopus selene* available to me and for the use of his laboratory and library. Special gratitude is due to Dr. P. E. Vanzolini, Museu de Zoologia, Universidade de São Paulo, Brazil, for making the Brazilian cephalopod collections available for study. I am indebted to Drs. G. L. Voss and Frederick M. Bayer for reviewing the manuscript and to Miss Susan Stevens for the illustrations.

TABLE 1. Measurements and proportions of the normal and supernumerary hectocotylized arms (in mm.).

Species	*Eledone cirrosa*			*Octopus briareus*			*Octopus selene*			*Octopus vulgaris*		
	3L*	3R	%	2L*	3R	%	2R*	3R	%	4R*	3R	%
Ligula	-	-	-	5.25	6.9	76.0	3.0	4.2	71.0	3.5	4.2	83.0
Calamus	-	-	-	1.7	2.3	77.0	1.1	1.2	91.6	1.2	2.5	48.0
Ligula/arm	-	-	-	2.0	3.2	63.0	5.1	7.6	67.0	1.4	1.9	72.0
Calamus/ligula	-	-	-	32.0	43.0	95.0	36.6	28.5	128.0	34.0	59.5	56.5
Arm length	-	-	-	260.0	215.0	121.0	59.0	55.5	106.0	256.0	219.5	116.0
Arm width	-	-	-	-	-	-	5.0	4.0	125.0	20.0	19.0	105.0
No. suckers	66	57	-	-	-	-	29	23	126.0	79	62	127.0
Last reduced suckers	-	-	-	5?	-	-	8	-	28.6	15	-	19.0

*Supernumerary hectocotylized arm

TABLE 2. Sizes and percentages of extra to normal hectocotylized arms (in mm.).

Species	*Eledone cirrosa*		*Octopus briareus*		*Octopus selene*		*Octopus vulgaris*	
	3L*	3R	2L*	3R	2R*	3R	4R*	3R
Arm length	-	-	260	215	59	55.5	256	219.5
Ligula	-	-	5.25	6.9	3.0	4.2	3.5	4.2
Calamus	-	-	1.7	2.3	1.1	1.2	1.2	2.5
Ligula/arm %	-	-	2.00	3.2	5.1	7.6	1.4	199
Calamus/ligula %	-	-	32.0	34.0	36.6	28.5	34.0	59.5
Arm width	-	-	-	-	5.0	4.0	20.0	19.0
No. Suckers	66	57	-	-	29	23	79	62
Reduced sucker pairs	-	-	5?	-	8	-	15	-
Genitalia	Normal	Normal	Normal		Normal		Normal	
Seminal canal in extra arm	-		Weak, imperfect and incomplete		Small, imperfect, damaged		Well developed, smaller	
General condition of hectolylization	-		Well defined, shorter and less elegant		Long calamus, well developed and small		Well defined, smaller	

*Supernumerary hectocotylized arm

LITERATURE CITED

Akimishki, I. I. 1963. Cephalopods of the U.S.S.R. Acad. Sci. U.S.S.R., Institute of Oceanology. U.S. Dept. Commerce (translation), 233 pp., 60 text-figs.

Appellof, A. 1892. Teuthologische Beitrage IV. Uber einem Fall von doppelseitiger Hectokotylisation bei *Eledone cirrosa* (Lam.) d'Orb. Bergens Mus. Aarbog, :14-15.

Morales, E. 1958. Notas sobre la morfologia del aparato genital en *Eledone aldrovandi* (Raf.) = *E. cirrosa* (Lamarck). Rap. Proces-Verbaux Reunios, 14: 389-394.

Robson, G. C. 1929. On a case of bilateral hectocotylization in *Octopus rugosus.* Proc. Zool. Soc. for 1929: 95-97, 1 text-fig.

Voss, G. L. 1971. Biological results of the University of Miami Deep-Sea Expeditions. 76. Cephalopods collected by the R/V JOHN ELLIOTT PILLSBURY in the Gulf of Panama in 1967. Bull. Mar. Sci. 21(1): 1-34, 6 figs., 12 tbls.

BOOK REVIEW

A FIELD GUIDE TO SHELLS OF THE ATLANTIC AND GULF COASTS AND THE WEST INDIES. By Percy A. Morris. Third Edition, edited by William J. Clench. 330 pp., 8 color pls., 68 black-and-white pls. Houghton Mifflin Co., 2 Park St., Boston, Mass. 02107. Hardback, $7.95. Paperback, $4.95.

For almost three decades, Percy Morris's field guides to shells have been a constant companion for legions of beginning conchologists. For clarity, compactness and inexpensiveness, his books have led the field and have been responsible for encouraging and serving two generations of American shelling enthusiasts. And now a much-improved and enlarged edition, with eight exquisite colored plates and 68 black-and-white plates, has been issued under the technical direction of Dr. William J. Clench. The entire format of the book is refreshingly different and affords much easier consulting. The nomenclature, and especially the use of technical and popular names, has been put on a sounder basis.

In the expanded introduction, the new class, Monoplacophora, is included, and many valuable classificatory explanations for the beginner are introduced. A list of shell clubs and an informative glossary are added. With the inclusion of several dozens of West Indian shells, this field guide now covers just over a thousand kinds of Western Atlantic shells.

It is a happy note that a close friend of the late Percy Morris and a competent malacologist, Dr. William J. Clench, should shepherd this book through the rigors of publication. Dr. Clench spent many tedious hours in bringing the finer points of nomenclature up to date. Curiously, he did the very same forty years ago for his deceased mentor, Charles W. Johnson, in 1933, when he revised and corrected the manuscript of the now historical "List of Marine Mollusca of the Atlantic Coast from Labrador to Texas." Were it not for Dr. Clench, this last monument to Mr. Morris's many literary contributions would not have attained the perfection and credit that it rightfully deserves.

For a handy $7.95 field guide to eastern American shells, members of the shell public will not go wrong in adding this book to their conchological libraries.

R. Tucker Abbott
Delaware Museum of Natural History

THE INFLUENCE OF LIGHT ON *BIOMPHALARIA GLABRATA*[1]

William A. Sodeman, Jr.
University of Arkansas, School of Medicine
Department of Internal Medicine
4301 West Markham
Little Rock, Arkansas 72201

ABSTRACT

The effect of changes in incident light intensity on the activity of albino Biomphalaria glabrata *was studied utilizing a treadmill apparatus to measure crawling rate of the snail. The study showed that* B. glabrata *have a threshold for light perception which is at least as low as 8 foot candles. When this low intensity light is turned off the snails respond with a transient pause in crawling activity. This response was reproducible from trial to trial and was observed with all snails tested. With sustained activity in the absence of food snails tire. The maximum crawling rate observed for* B. glabrata *was 90 cm per hour.*

Successful maintenance of the cycle of schistosomiasis in a natural environment depends upon vector snails being sited to both receive infection from and discharge it to suitable definitive hosts. It is not clear whether the evolution of the host-vector-parasite relationship depends in part upon the presence of a critical density of snails, thus permitting fortuitous snail parasite contact, or whether other environmental factors cue the snail's activity resulting in favorable positioning for both receipt and discharge of the parasite. Isolation of environmental factors that may cue behavior is difficult under field conditions. There have been substantial observations on the effect of environmental variables on physiologic responses of snails, such as growth, metabolic rates, reproductive capacity and longevity, both in the field and in the laboratory. Behavioral responses to environmental variables, particularly in a controlled laboratory setting, have received only minimal attention. This paper reports changes in the activity of *Biomphalaria glabrata* in relation to fluctuations in the intensity of incident light.

MATERIALS AND METHODS

The snails employed were *Biomphalaria glabrata* of the albino mutant M-line. Stocks were obtained in October, 1970 from the University of Michigan Museum of Zoology, and have been maintained by random breeding in 40-liter glass aquaria. Four, 10 mm-diameter snails were selected and individually isolated in 6-liter glass tanks. Snails were fed 3 times weekly with boiled dried lettuce and commercial tropical fish food (Bio-rell, Sternco, Harrison, New Jersey). The four test snails were

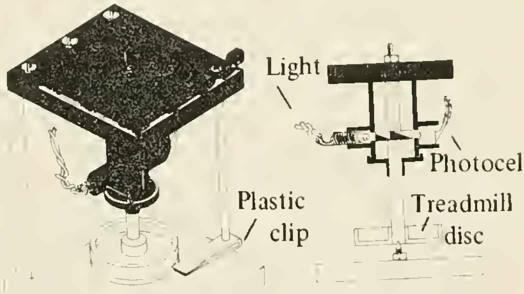


FIG. 1. *Cross section of treadmill appartus (right) and the treadmill in ¾ view (left). The lower disc and lower ¼ of the vertical axle were submerged. The remainder of the unit was above the water level. The upper disc and the light and photocell were encased in an opaque shield to prevent artifact caused by extraneous light.*

---

[1] This work was supported by a grant from the National Institutes of Allergy & Infectious Disease. AI 10292-02.

maintained under cool, white fluorescent light for a 12-hour light, 12-hour dark cycle. Light intensity at the tank surface measured 1,400 lux (130 foot candles). Tanks were continuously aerated through a charcoal and glass-wool filter.

Snail activity was monitored by a treadmill illustrated in figure 1. A horizontally oriented plastic disc, 1 cm thick and 16 cm in circumference, was balanced on a needle bearing and connected by an axle extending above the water surface to a second disc. The circumference of the upper disc was marked with two wedge-shaped masks. A beam of light was directed through the edge of the upper disc to a sensitive photo cell on the opposite side of the disc. Rotation of the disc in either direction resulted in a change in the light passing through the wedge-shaped mask and falling on the photo cell. The photo cell output was measured on a strip chart recorder (Beckman, Fullerton, Calif.). Calibration permitted monitoring of both direction and rate of rotation of the unit.

Snails were held in a plastic clip with the shell aperture 3 mm away from and facing the circumference of the submerged lower disc. On emerging from its shell the snail's foot fell on to the disc rim. All snails were able to crawl easily in either direction with the shell rigidly held and such crawling resulted in rotation of the treadmill unit. All observations were carried out in a photographic darkroom. The snails were clamped in the unit and then followed for a 3-hour observation interval. With the room lights turned off there was no incident light in the test area. With a single incandescent bulb turned on the light intensity at the treadmill level was 88 lux (8 foot candles). Four lighting patterns were tested as follows: 3 hours of continuous light (L), 3 hours of continuous dark (D), light on for ninety minutes, dark for ninety minutes (L-D) and light off for ninety minutes then turned on for ninety minutes (D-L). The initial 30 minutes were considered as a stabilization period and were discarded for the purpose of observation. Crawling rates in cm per hour were calculated for the 30 to 90 minutes (interval 1), 90 to 120 minutes (interval 2), and 120 to 180 minutes (interval 3). Each snail was observed through 7 trials of each light pattern. Light intensities were measured with a Gossen Luna-Pro Cadmium sulfide type light meter (Woodside, N. Y.).

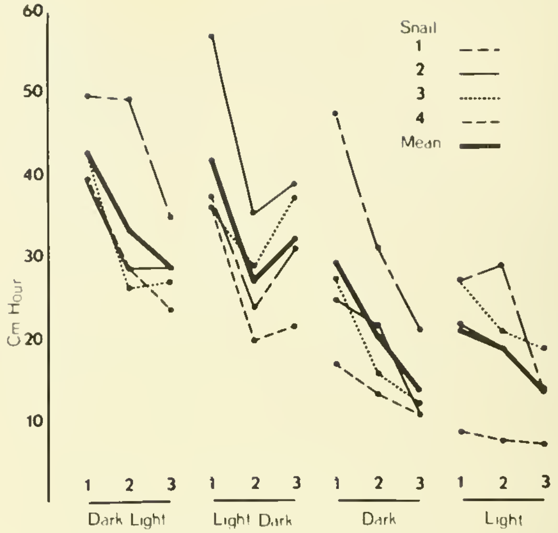


FIG. 2. *Crawling rates observed during the three periods of each lighting pattern. Dotted lines represent the means of 7 trials for each snail. The heavy lines represent the overall means for the four snails.*

RESULTS

Results are summarized in figure 2. Mean crawling rates are plotted for periods 1, 2 and 3 of each lighting pattern for each of the four snails and an overall mean is indicated by the heavy line. Analysis of the pattern yields the following results. Mean rates during period 1 were higher than the following periods. Mean rates during period 2 were usually equal to or higher than those of period 3 except for the L-D lighting. When the light was turned off there was a pause in activity expressed as a lower mean rate for period 2 of the L-D trial. The maximum crawling rate for *Biomphalaria glabrata*, 1 cm in diameter, measured over a 10 minute interval was 90 cm an hour and the maximum distance traveled during a 1 hour period of observation was 89 cm.

DISCUSSION

Three characteristics of light may be of significance in affecting snail behavior. These are intensity, duration and wave length, or color. A number of investigators have commented on the effects of the light intensity on snail behavior. Deschiens (1957) described withdrawal of *B. glabrata* into its shell on exposure to intense light. A withdrawal response on exposure to intense light has been documented for the marine mollusk, *Pleurobranchaea californica* (Davis and Mpitsos, 1971). Harry and Aldridge (1958) could not confirm a difference in distribution of *B. glabrata* between light and shade sections of the environment. Deschiens and Bijan (1956) described normal behavior and normal fertility, fecundity and development in *B. glabrata* maintained in darkness of periods of up to 90 days. Joy (1971, a, b) studied growth and oviposition of *B. glabrata* in changing patterns of light and dark. A prevalence of nighttime oviposition was demonstrated though the differences between oviposition rates in the dark and in the light narrowed as the dark interval was shortened. When a greater portion of the light energy was delivered in the infrared spectrum, oviposition in the dark interval was favored. Changes in the day length of plus or minus 2 hours did not affect the growth. Nocturnal oviposition has been documented for other species of gastropods, including *Planorbarius corneus* and *Helisoma trivolvis* (Cole, 1925), *Gyraulus parvus* (Krull, 1931) and *Oncomelania quadrasi* (Pesigan, et al., 1958) and for the limpet *Ancylus fuscus* (Clapp, 1921).

Four points are clear from the current study. First, the threshold for light perception in *B. glabrata* is at least as low as 88 lux (8 foot candles). Second, *B. glabrata* may respond to changes in light intensity as small as 88 lux (8 foot candles) with a change in activity. Third, with sustained activity *B. glabrata* will tire. Finally, the maximum rate of travel for *B. glabrata* based on a 10 minute measurement is 90 cm per hour and the maximum observed distance traveled on a one hour period was 89 cm.

The low levels of light intensity were selected for this study to represent a better simulation of changes in intensity in natural environments. A number of investigators (Abbott, 1948; Kawanoto, 1952; Komiya, et al, 1959; Deschiens, 1957; Moose and Williams, 1961-62) have documented withdrawal reactions, or correlated behavior, of a variety of snails when exposed to intense light. While abrupt transition from deep shade to brightly sunlit water could approach the levels used by most of these investigators, it is more frequent to find environmental changes of a smaller magnitude. The fact that this snail does respond to such low light intensities as 88 lux (8 foot candles) sets the physiologic limit of its perception at an even lower level. Several investigators (Joy, 1971, a, b; van der Schalie and Davis, 1968; Yasuraoka, 1955; Pesigan, et al, 1958; Clapp, 1921; Cole, 1925; Krull, 1931) reported an effect of light on oviposition by a variety of molluscan species.

This study would add locomotive activity to the list of behavioral alterations affected by changes in ambient light. Several questions are suggested by these observations, particularly the effect of changes in light intensity when they occur against a background level of ambient light rather than the light to dark changes utilized here. Also, the response to changes in light wave-length would also be of interest. Such studies were beyond the scope of the present investigation and would entail such prolonged periods of observation that another protocol permitting simultaneous observation of multiple snails would probably be necessary. In any event, changes of ambient illumination of 88 lux (8 foot candles) to darkness do result in measurable transient decrease in activity of *Biomphalaria glabrata*. Oviposition on the treadmill was never noted.

Snails were not fed during the trial. In the absence of substrate, continued activity is marked by a decrease in the rate of activity. Whether this is a result of fatigue or whether the falling activity is a result of a substrate deficiency is not clear. The cliché that our research proceeded at a snail's pace rapidly lost favor in the laboratory; however, it is the limiting factor in any behavioral study. When the snail must choose among several environments, the speed with which the snail can sample the environments controls the observation time. Mixing times in tanks 1 meter long must be well in excess of 1 hour to permit valid observations of *B. glabrata* the size with which we experimented. Critical observation of snail activity should be an integral part of the planning of any behavioral study that depends upon snail migration.

LITERATURE CITED

Abbott, R. T. 1948. Handbook of medically important mollusks of the Orient and the Western Pacific. Bull. Mus. Comp. Zool. Harvard. **100**: 245-328.

Clapp, W. F. 1921. Eggs and young of the river limpet, *Ancylus fuscus* C. B. Adams. Boston Soc. Nat. Hist. Occ. Papers. 5: 5-10.

Cole, W. H. 1925. Egg-laying in two species of *Planorbis*. Am. Nat. 59: 284-286.

Davis, W. J. and G. J. Mpitsos. 1971. Behavioral Choice and Habituation in the Marine Mollusk *Pleurobranchaea californica* MacFarland (Gastropoda, Opisthobranchia). z. vergl. Physio. **75**: 207-232.

Deschiens, R. 1957. Sur la perpetuation des elevages des mollusques vecteurs des bilharzioses a l'obscurite. Bull. Soc. Path. Exot. **50**: 229-233.

Deschiens, R. and H. Bijan. 1956. Comportement d'elevages de mollusques vecteurs des bilharzioses a l'obscurite. Bull. Soc. Path. Exot. 49: 658-661.

Harry, H. W. and D. V. Aldrich. 1958. The ecology of *Australorbis glabratus* in Puerto Rico. Bull. WHO. 18: 819-832.

Joy, J. E. 1971. The Influence of Light Conditions upon the Egg-Laying of the Planorbid Snail, *Biomphalaria glabrata*. The Nautilus 85: 43-49.

Joy, J. E. 1971. The influence of day length upon the egg-laying of *Biomphalaria glabrata*. Ann. Trop. Med. and Parasit. 65: 573-578.

Kawanoto, S. 1952. On the photophobotaxis of *Oncomelania nosophora*. Med. Biol. 23: 76-79.

Komiya, Y., K. Kuniko, and C. koyama. 1959. A simple breeding method for *Oncomelania* using a Petri dish. Jap. Jour. Parasitol. 8: 721-724.

Krull, W. H. 1931. Importance of laboratory-raised snails in helminthology with life history notes on Gyraulus parvus. Mich. Univ. Mus. Zool. Occ. Papers. 10(226): 1-10.

Moose, J. W. and J. E. Williams. 1961-62. Medical General Laboratory (406), U. S. Army Medical Command, Japan, Professional Reports.

Pesigan, T. P., N. G. Hariston, J. J. Jauregui, E. G. Garcia, A. T. Santos, B. C. Santos, and A. A. Gesa. 1958. Studies on *Schistosoma japonicum* infections in the Phillippines. 2. The molluscan host. Bull. WHO. 18: 481-578.

van der Schalie, H. and G. M. Davis. 1968. Culturing *Oncomelania* snails (Prosobranchia: Hydrobiidae) for studies of Oriental schistosomiasis. Malacologia 6: 321-367.

Yasuraoka, K. 1955. The behavior of *Oncomelania nosophora*, the intermediate host of *Schistosoma japonicum*, to light in water. Jap. Jour. Med. Sci. Biol. 8: 323.

ON THE IDENTITY OF *HELICINA GRANULUM* PFEIFFER (PROSOBRANCHIA)

Morris K. Jacobson
American Museum of Natural History
Central Park West at 79th Street
New York, N. Y. 10024

ABSTRACT

Helicina granulum *Pfeiffer, 1864 is shown to be a valid species, differing in important morphological respects from* H. tantilla *Pilsbry, 1902. The former taxon has been taken in several localities in the south central part of Oriente Province, Cuba. The use of subgenus* Poenia *Adams & Adams, 1856 for* H. granulum *is shown to be erroneous.*

The taxon *Helicina granulum* Pfeiffer (ex MS, Gundlach), 1864, has not been clearly understood in the literature. Pfeiffer described the species on the basis of a single specimen sent him from Monte Toro, Guantánamo, Oriente Province, Cuba, by Gundlach. He was moved to do this by the unusually small size of the shell, smaller than any known helicinid at that time. The original Latin description and my English translation follow:

Helicina granulum Pfeiffer (1864, Malak. Blatt. 11: 161): "T. minuta, depressa, tenuiscula, laevigata, translucida, succinea; spira parum conoideo-elevata; anfr. fere 4 convexiusculi, ultimus depresso-rotundatus, subtus medio subexcavatus, levissime callosus; columella brevissima, verticalis; apertura obliqua, late semiovalis; perist, breviter expansum, margine basali arcuatin in columellam transuente -- Operc? -- Diam maj. 2 2/3, alt. vix 1 mill. Habitat Monte Toro in districto Guantanamensi insulae Cubae."

"Shell minute, depressed, quite thin, smooth, translucent, amber-colored; spire little conic-elevated; whorls almost 4, rather convex, the last one depressed rounded, subexcavated centrally below, lightly callused; columella exceedingly short, vertical; aperture oblique, widely semi-oval; peristome briefly expanded, basal margin inserting arc-like into the columella. Operculum? Major diameter 2 2/3 mm, altitude barely 1 mm."

It might be noted that Pfeiffer did not mention the presence of axial sculpture, but this ornamentation could have been overlooked in a single dead, minute specimen. However, as will be seen later, the references to an expanded peristome and an arched basal insertion clearly point to *granulum*.

Pfeiffer's holotypic specimen was never figured and was destroyed during World War II (Clench & Jacobson, 1971a:101). There are few subsequent references to the species in the literature: Pfeiffer (1865: 233) reprinted his original description verbatim and later (1876: 271) merely listed the name. Sowerby (1866: 296) listed it as an unidentified species, and Reeve (1874) and Wagner (1910) omitted it entirely; nor did Fulton (1915)

FIG. 1. Lucidella granulum *(Pfeiffer) between Nimfitas and La Victoria, Monte Toro, Guantánomo, Oriente Province, Cuba; Ramsden, leg. 1914, ANSP 110769, 10 X.*

mention it among the names omitted by Wagner in his extensive monograph of the Helicinidae. Arango (1879), Crosse (1890), and Aguayo & Jaume (1948) repeated only the locality cited originally by Pfeiffer, thus leading to the supposition that Pfeiffer's record is the only one known, and that the species had not been collected again. Clench & Jacobson (1971b) tentatively included it in the genus *Troschelviana,* although Pfeiffer had made no reference to a mucronate protoconch, a diagnostic feature of the helicinine tribe Vianini in which the genus *Troschelviana* belongs. There is no reason to doubt that *granulum* belongs to the genus *Lucidella* Swainson, 1840, as was noted by Aguayo & Jaume (1948). However, their subgeneric placement in *Poenia* H. & A. Adams, 1856, is erroneous. As the type-species of *Poenia* they cited the subsequent designation by Fischer, 1885 of *H. unidentata* Pfeiffer. But since Fischer did not use the word "type" in his citation, this must be regarded as an example and is not a valid designation. Pilsbry (1911, p. 585) validly designated *Helicina depressa* Gray, 1825, as the type. Furthermore, *Poenia* has been regarded as a synonym of *Lucidella* by both Thiele (1929: 88) and Wenz (1938: 445). Because of the axial sculpture, *granulum* belongs in the subgenus *Poeniella* H. B. Baker, 1923, type species *Helicina plicatula christophori* Pilsbry, 1897, by original designation.

The vagueness regarding the identity of *granulum* increased when it was confused with another species, *Helicina tantilla* Pilsbry, 1902. This species was described on the basis of a single specimen taken near Palm Beach, Florida in 1899 together with other small land shells in a forest about one-quarter mile from the beach. Pilsbry wrote that the new species was distinct from any other Antillean helicinid. He did not compare it with the description of *granulum,* which it closely resembles, nor, as we have seen, were any typological specimens of that species available for study. Thus when Ramsden in 1914 sent him some small shells from Monte Toro, Pilsbry identified them as *H. tantilla,* overlooking the fact that Monte Toro is the type locality of *H. granulum.* I have been able to examine these specimens in the ANSP and they clearly differ from *tantilla* and are undoubtedly topotypes of *H. granulum.* The specimen here illustrated is, therefore, a potential neotype.

The differences between *tantilla* and *granulum* are the following: the peristome of *tantilla* is rounded and faintly thickened, but barely expanded and not reflected, and the basal angle of insertion in the body whorl is barely perceptible. In *granulum* the lip is well expanded and slightly reflected and the angle at the point of insertion is quite distinct. In addition, the spire of *granulum* is somewhat higher and the suture deeper.

Ramsden reported that he found the shell "in dirt at the root of trees." Ramsden's description of the supposed *"tantilla"* (1914: 50) clearly refers to *granulum* since reference is made to an expanded and reflected lip and a shallow notch at the basal insertion.

There are several lots of *granulum* in the Ramsden Collection labelled as *Lucidella rugosa* Pfeiffer and coming from the following localities: Florida Blanca, Alto Songo; Km. 54, Sierra Canasta, Santiago de Cuba; La Cueva, Diego Cobas, Majaguabo, all from Oriente Province. In addition the USNM has one lot from Guaso River, Monte Líbano, Guantánamo, and both the USNM and ANSP have one lot each from the type-locality, Monte Toro, Guantánamo.

Lucidella tantilla has also been reported from Cuba in Cayo Guillermo, northern Camagüey Province (Aguayo & Jaume, 1948) and from Cayo Las Brujas, Caibarién, Las Villas Province (Clench 1959: 35). In addition, Clench records it from Mores, Great Abaco, Bimini, and Great and Little Inagua Islands in the Bahamas, and Pilsbry (1948: 1085) reports it from several localities in the Florida Keys, as well as erroneously from Monte Toro.

It is thus clear that *Lucidella granulum* is confined to south central Oriente Province, while *L. tantilla* occurs in the more western provinces of Camagüey and Las Villas. From here *tantilla* appears to have dispersed to the Bahamas and the Florida Keys, since Pilsbry was most likely correct when he wrote that the Florida specimen was "probably a hurricane-borne waif from Cuba" (1948).

I wish to express my gratitude to Dr. William K. Emerson of the American Museum of Natural History who discussed the problem with me and critically read the manuscript. Dr. Robert Robertson of the Academy of Natural Sciences and Dr.

Joseph Rosewater of the National Museum of Natural History, Smithsonian Institution, most generously permitted me to examine material in their respective collections. I am indebted to the kindness of Dr. Kenneth J. Boss for the photographs. The abbreviations ANSP and USNM stand for the Academy of Natural Sciences of Philadelphia and the National Museum of Natural History, Smithsonian Institution (formerly the United States National Museum) respectively.

LITERATURE CITED

Aguayo, C. G. and M. L. Jaume, 1948. Católogo molluscos de Cuba, Helicinidae, no. 495, 1 p. mimeo.

Arango, R., 1879. Contribución a la fauna malacológica cubana, Helicinidae, Havana, pp. 41-57.

Baker, H. B., 1923. The Mollusca collected by the University of Michigan - Williamson Expedition in Venezuela. Occ. Papers Mus. Zool. Univ. of Michigan, no. 137, 58 pp., 5 pls., 21 figs.

Clench, W. J., 1959. Land and freshwater mollusks of Great and Little Inagua, Bahama Islands. Bull. Mus. Comp. Zool., Cambridge, Mass., **121**(2): 29-54, 1 pl.

Clench, W. J. and M. K. Jacobson, 1971a. Monograph of the Cuban genera *Emoda* and *Glyptemoda*. Bull. Mus. Comp. Zool. **141**(3): 99-130, 7 pls.

Clench, W. J. and M. K. Jacobson, 1971b. A monograph of the genera *Calidviana, Ustronia, Troschelviana,* and *Semitrochatella* in Cuba. *ibid.,* **141**(7): 402-463, 8 pls., 1 text fig.

Crosse, H., 1890. Faune malacologique terrestre et fluviatile de l'île de Cuba. Jour. Conchyl. 38: 173-335, pls. 4-6.

Fischer, P., 1885. Manuel de Conchyliologie, Paris, pp. 794-797, figs. 554-556 (Helicinidae).

Fulton, H. C., 1915. On Dr. Anton Wagner's monograph of Helicinidae in the Conchylien-Cabinet. Proc. Mal. Soc. London, **11**: 237-241; 324-326.

Pfeiffer, L., 1864. Zur Molluskenfauna von Cuba. Malak. Blätt. **11**: 157-161.

Pfeiffer, L., 1865. Monographia Pneumonopomorum Viventium, suppl. 2, 284 pp.

Pfeiffer, L., 1876. *ibid.,* suppl. 3, 10 + 479 pp.

Pilsbry, H. A., 1902. A new Floridian Helcina, Nautilus **19**: 53.

Pilsbry, H. A., 1948. Land Mollusca of North America. Monograph 3, Acad. Nat. Sci. Philadelphia 2(2): 1078-1090, figs. 576-581 (Helicinidae).

Pilsbry, H. A. and A. P. Brown, 1911. The Land Mollusca of Montego Bay, Jamaica; with Notes of the Land Mollusca of the Kingston Region. Proc. Acad. Nat. Sci. Phila. for 1911, p. 585.

Ramsden, C. T., 1914. Notes on some land shells of eastern Cuba. The Nautilus 28: 49-51, pl. 2.

Reeve, L., 1874. Conchologia Iconica, **19**: 34 pls. + text (Helicinidae).

Sowerby, G. B. II, 1866. Thesaurus Conchyliorum, 3: 277-302, pls. 266-278 (Helicinidae).

Thiele, J., 1929. Handbuch der systematischen Weichtierkunde, Jena, **1**: 80-91, figs. 57-67 (Helicinidae).

Wenz, W., 1938. Gastropoda *[in]* Handbuch der Paläozoologie, Berlin, pp. 435-448, figs. 1061-1118 (Helicinidae).

Wagner, A. J., 1910. *[in]* Martini and Chemnitz, Conchylien-Cabinet (2) **1**: sect. 18, pt. 2, pp. 337-351, pls. 67-69. (*Lucidella*)

THE VALVULAR MEMBRANE IN YOUNG MACTRID CLAMS, *SPISULA SOLIDISSIMA*

Wayne D. Cable
National Marine Fisheries Service
Middle Atlantic Coastal Fisheries Center
Milford Laboratory
Milford, Connecticut 06460

ABSTRACT

Juvenile surf clams, Spisula solidissima, *were reared from fertilized eggs in the laboratory. Observations were made of the appearance and activity of the valvular membrane (primary exhalant siphon), which has not previously been reported in recently-metamorphosed animals.*

The siphonal system of the bivalve mollusks has been considerably studied. Aspects of mantle fusion in the Lamellibranchia and the subsequent formation of siphons from the mantle folds were described in detail by Yonge (1957). Development of siphons in the evolution of the lamellibranchs enabled this group of animals to live in the shelter of a substrate while obtaining food and oxygen from the water above the substrate (Yonge, 1957).

In discussing the types of siphon systems,

FIG. 1. *Juvenile* Spisula solidissima *with the valvular membrane, or exhalant siphon, (on the left) fully extended to a length of 1.5 mm.*

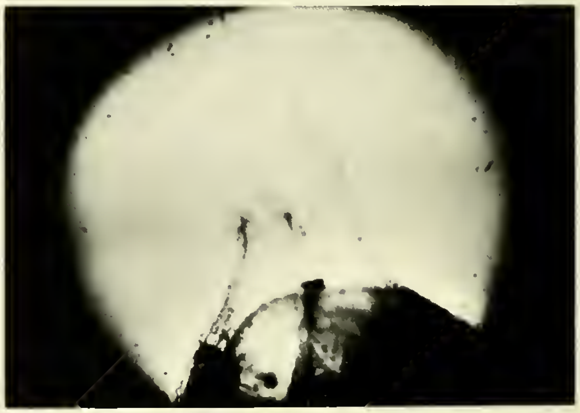


FIG. 2. *Juvenile* Spisula solidissima, *valvular membrane (on the right) collapsed but not inverted within shell.*

Yonge ascribes to the Mactridae what he terms a "type C" siphon system. In this type the opening of the definitive exhalant siphon is usually bounded by a valvular membrane (a narrow flange just inside the ring of tentacles) which, when open, controls and directs the flow of water from the exhalant siphon. However, he does not illustrate this structure in any of the Mactridae, nor does he show how this structure is formed in the young of the Mactridae. Prior to development of the definitive siphonal system in many recently metamorphosed Lamellibranchia a precursor of the definitive exhalant siphon, a valvular membrane or primary exhalant siphon is formed (Quayle, 1952; Carriker, 1961).

The presence of the valvular membrane in newly metamorphosed *Spisula solidissima* has been recently observed by the author. There was no question as to the identity of these young surf clams since they were reared from fertilized eggs spawned in the laboratory. The presence of this structure and its appearance may serve as an aid to identification of young juvenile surf clams gathered in the field.

Photographs were made approximately one month after metamorphosis; the size range of the young clams then ranged from 0.5 mm to 3.0 mm. Photograph #1 shows the siphons of a young clam 1.5 mm long. Here the valvular membrane is fully extended. Photograph #2 shows the valvular membrane in a state of collapse and dangling externally; this clam is also 1.5 mm long.

One should notice that the state illustrated in these photographs is an advanced one, in that juvenile *Spisula solidissima* of this size have already developed the inhalant siphon with its ring of tentacles, and the tentacles of the exhalant siphon have also begun to form. These structures are formed subsequent to the development of the valvular membrane.

The valvular membrane was observed to be an extremely flexible and active structure. It was rapidly extended when the young clam was pumping water through the mantle cavity, and rapidly withdrawn or inverted within the mantle cavity when the clam was disturbed.

The presence of such a "filmy membrane" on the excurrent siphon on young clams, which moved in and out with a folding motion and was held out as a hose to direct flow of water from the exhalant opening, was described in *Mercenaria mercenaria* by Belding (1912). Carriker (1961) has subsequently described in some detail the development of this membrane in young *Mercenaria mercenaria* ranging from 210 to 300 μ.

The valvular membrane of recently metamorphosed bivalve mollusks appears to function to deflect the excurrent and incurrent streams during the period of definitive siphon formation. The same function would be served in later life by the slight offset of the tips of the siphons and the smaller exhalant siphon orifice (Carriker, 1961). In describing a similar membrane in young *Mya arenaria* and *Venerupis pullastra,* Quayle (1952) reported the function of this structure to be one of keeping the mantle and gills free of feces by directing them away from the vicinity of the young animal.

Since siphon formation takes place considerably after metamorphosis and the loss of the velum, there is a sedentary phase prior to the time when the siphons are formed and the animal is able to enter the substrate (Carriker calls this the byssal plantigrade). He believes it probable that young byssal plantigrade *Mercenaria mercenaria* cannot burrow until the ring of tentacles is available on the inhalant siphon to exclude sedimentary grains. This is most likely true for other lamellibranchs that also live in soft substrates, including the *Spisula solidissima* described here.

LITERATURE CITED

Belding, D. L. 1912. Report on the Quahaug and Oyster Fisheries of Massachusetts, Commonwealth of Massachusetts, Boston.

Carriker, M. R. 1961. Interrelation of Functional Morphology, Behavior, and Autecology in Early States of the Bivalve *Mercenaria mercenaria.* Journal of the Elisha Mitchell Scientific Society 77 (2): 168-241.

Quayle, D. B. 1952. Structure and Biology of the Larva and Spat of *Venerupis pullastra* (Montagu). Trans. Roy. Soc. Edinburgh 62 (8): 255-297.

Yonge, C. M. 1957. Mantle Fusion in the Lamellibranchia. Pubbl. Staz. Zool. Napoli 26: 151-171.

SIZE AND SEX RATIO DIFFERENCES IN *UROSALPINX CINEREA* (SAY) (MURICIDAE) FROM GREAT BAY, NEW HAMPSHIRE[1]

Kenneth W. Turgeon
and
Richard A. Fralick
Jackson Estuarine Laboratory, University of New Hampshire
Adams Point, Durham, New Hampshire 03824

ABSTRACT

Three hundred and ninety-seven Urosalpinx cinerea *from Great Bay, New Hampshire, were sexed and measured for total shell length. Statistical comparison of the mean shell lengths and chi-square analysis of sex ratios for several size classes show that females are significantly larger than males. Hypotheses to account for this sexual dirmorphism are presented.*

INTRODUCTION

Previous investigators have noted in several populations of the common oyster drill, *Urosalpinx cinerea* (Say), that females attain a greater maximum shell length than males (Federighi, 1931a, 1931b; Cole, 1942; Hargis and MacKenzie, 1961). However, none of these workers demonstrated statistically significant differences in mean shell lengths between the sexes. Griffith and Castagna (1962), working with *Urosalpinx cinerea follyensis* (Baker, 1951) from Chincoteague Bay, Maryland, showed that females, in addition to having a greater maximum shell length, had a mean shell length significantly greater than males. Our paper reports the results of a similar study conducted on *U. cinerea* from Great Bay, New Hampshire.

Great Bay is a shallow, highly turbid estuary with a mud-silt bottom. Yearly salinities range from approximately seven ppt during the spring freshet to 30 ppt in late summer in the mid and lower reaches of the Bay. The drills are limited in their distribution to the few, remaining oyster reefs and are present in very low abundance. Drill density is approximately one to two individuals per square meter of oyster reef. However, they are often distributed in widely separated clusters of four to seven individuals.

METHODS

Approximately 500 oyster drills were hand-collected during the summer of 1972 by scuba divers. The collection site was an oyster reef located in the mid-portion of Great Bay encompassing an area of about 30,000 square meters. The divers collected all drills sighted. Trapping techniques were not employed since bias for a particular size or sex might have resulted. Griffith and Castagna (1962) found that male:female ratios differed between trap-collected and hand-collected drills. The low population density of the Great Bay drills and the high turbidity of the water necessitated numerous dives in order to collect sufficient numbers for statistical analyses. Only individuals greater than 10 mm in length and exhibiting a complete lack of a penis (females) or presence of a well-defined, C-shaped penis (males) were used. Smaller individuals were not used since they are extremely difficult to sex and quite often have not reached sexual maturity. Sexing was done by the live method of Hargis (1957) using 5 X and 10 X hand magnifiers. Shell length was measured to the nearest 0.1 mm with vernier calipers. Drills, after being sexed and measured, were assigned to one of four, pre-determined size classes: ⩾10 & < 15 mm (class 1), ⩾ 15 & < 20 mm (class 2), ⩾ 20 & < 25 mm (class 3) and ⩾ 25 mm (class 4). These size classes were arbitrarily chosen and do not represent natural breaks in size distribution. Statistical comparison of female and male mean shell lengths was by Cochran's approximation of the Behrans-Fisher test (Snedecor, 1956). Chi-square analysis was used to determine significant deviations from 50-50 sex ratios for the individual size classes and the total sample. All statistical analyses were evaluated at the 99 percent confidence level.

---

[1] Jackson Estuarine Laboratory Scientific Contribution No. 1.

RESULTS

The results of this study are presented in figures 1 and 2. Females had a maximum shell length of 38.3 mm and a mean shell length of 20.2 mm. The respective values for males were 30.0 mm and 17.8 mm. Statistical analysis showed that the mean shell lengths were significantly different. Two hundred and thirty-three drills (58.69%) were females and 164 (41.31%) were males. This is a female: male ratio of 1.42:1 and represents a significant deviation from a 50-50 sex ratio. Significant deviations in sex ratios occurred in size classes 3 and 4, the female: male ratios being 1.73:1 and 18:1 respectively. The sex ratios for size classes 1 and 2 showed no significant deviation from a 50-50 sex ratio (0.95:1 and 1.09:1). One hundred females (42.9%) and 39 males (23.7%) were 20 mm or more in length, while 36 females (15.4%) and only 2 males (1.2%) were 25 mm or more in length. Eleven females (4.7%) were greater than 30 mm in length.

DISCUSSION

The results of our study clearly indicate that sexual dimorphism exists in oyster drills from Great Bay, New Hampshire. In addition, our work suggests that this dimorphism is due to the significantly greater number of females than males in the larger size classes. This preponderance of large females was sufficient to yield a significant deviation from a 50-50 sex ratio.

The sexual dimorphism in Great Bay drills may be attributable to the following reasons: females have a faster rate of growth than males, females live longer than males and thus have a longer period of growth, or both. Another possibility is that sexually mature males undergo a sex transformation into females. The occurrence of female *U. cinerea* with structures resembling vestigal penises suggests that this deserves investigation.

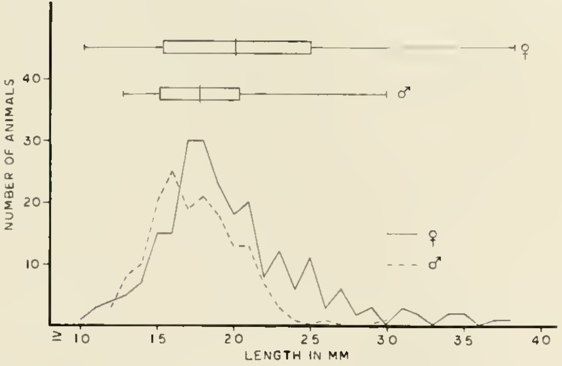


FIG. 1. *Length-frequency and size distribution of* Urosalpinx cinerea *from Great Bay, New Hampshire. Upper figure represents range, mean and ± one standard deviation.*

LITERATURE CITED

Baker, Bernadine B. 1951. Interesting shells from the Delmarva Peninsula. Nautilus 64 (3): 73-77.

Cole, H. A. 1942. The American whelk tingle, *Urosalpinx cinerea* (Say), on British oyster beds. J. Mar. Biol. Assoc. U. K. **25**: 477-508.

Federighi, H. '1931a. Further observations on the size of *Urosalpinx cinerea* Say. J. Conchol. **19**: 171-176.

Federighi, H. 1931b. Studies on the oyster drill (*Urosalpinx cinerea* Say). Bull. U. S. Bur. Fish. 47 (4): 83-115.

Griffith, G. W. and M. Castagna. 1962. Sexual dimorphism in oyster drills of Chincoteague Bay, Maryland-Virginia. Chesapeake Sci. **3**(3): 215-217.

Hargis, W. J., Jr. 1957. A rapid live-sexing technique for *Urosalpinx cinerea* and *Eupleura caudata* with notes on previous methods. Limnol. Oceanogr. 2: 41-42.

Hargis, W. J., Jr. and C. MacKenzie. 1961. Sexual behavior of the oyster drills: *Eupleura caudata* and *Urosalpinx cinerea.* Nautilus **75** (1): 7-16.

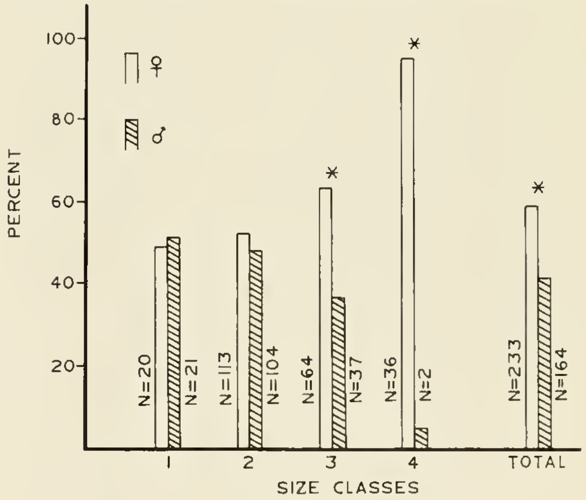


FIG. 2. *Percent distribution of female and male* Urosalpinx cinerea *from Great Bay, New Hampshire in each size class. * = Significant deviation from a 50-50 sex ratio.*

THE MOLLUSCA OF CANADARAGO LAKE AND A NEW RECORD FOR *LASMIGONA COMPRESSA* (LEA)

Willard N. Harman
New York State University College at Oneonta
Oneonta, N. Y. 13820

Canadarago Lake is located in Otsego County, New York (42°50'N, 75°00'W). The lake is 3 miles long, averages 1 mile in width and has a surface area of 761 hectares. It is shallow and turbid with the greatest depth being only a little over 12 meters and secchi transparencies averaging less than 2 meters. Summer epilimnion temperatures attain 25°C. Oxygen is absent from the hypolimnion during these periods and varies near saturation at the surface. Hydrogen ion concentration is extremely erratic, varying from about 4.5 to 10 in both surface and profundal waters (Fuhs, 1972). Canadarago would be expected to be a moderately eutrophic lake in its natural state but is now highly eutrophic as a result of sewage input from the village of Richfield Springs and from summer camps. Blue-green algal blooms are common and the undersides of cobbles are covered with fungi and bacteria. Turbid waters prevent the extensive growth of rooted macrophytes, although *Myriophyllum* is abundant in the shallows. Common emergent plants are *Scirpus, Nuphar, Nymphaea, Pontederia, Typha,* and *Sparganium.* A eutrophication study of the lake was begun in 1968 by the New York State Department of Health and the New York State Department of Environmental Conservation. As a result, a tertiary sewage treatment plant was installed at Richfield Springs and was activated in February 1973.

This survey of the molluscan fauna was undertaken for the acquisition of base line data that can be used for comparison with studies in future years to indicate possible improvements in water quality. Samples were made at 9 stations in both deep waters and littoral areas. It appears that Canadarago once supported dense populations of mollusks that are now severely depleted. We found an abundance of empty shells of *Lymnaea humilis, L. palustris, Gyraulus parvus, Helisoma anceps, Ferrissia parallela, Physa* spp., *Viviparus georgianus, Amnicola limosa, A. integra, Valvata tricarinata, Lampsilis radiata,* and *Pisidium* spp. Only a few living specimens of *L. humilis, G. parvus, F. parallela, Physa* sp. and *Pisidium* spp. were collected. All *Physa,* empty shells and living specimens, were so small as to prevent confident determination to the species level. One living specimen of *Lasmigona compressa* (Lea) (Unionidae) was found at the entrance of Herkimer Creek into the lake. This is the first record of this species in the Susquehanna River watershed.

After noting the condition of the molluscan fauna in the Lake we made collections along 5 miles of Oaks Creek, the outlet of Canadarago, to ascertain if water quality improved downstream from the lake. The only snail found was an immature *Physa* sp. A few living specimens of the bivalves *Lampsilis radiata, Elliptio complanatus* and *Strophitus undulatus* were found. Empty shells of all the mollusks found in Canadarago Lake were collected.

LITERATURE CITED

Fuhs, W. 1972. Canadarago Lake eutrophication study. Lake and tributary surveys 1963-1970. Methodology and Data. N.Y.S. Dept. of Environ. Cons., Research and Development Unit. 292 pp.

OBITUARY

Elmer P. Cheatum
(1901-1973)

On May 1, 1973, science and education lost one of their most notable contributors with the death of Dr. Elmer P. Cheatum. Throughout his 48 years of service at Southern Methodist University he remained a leader of Southwestern scientific investigation and educational inspiration.

Elmer Phillip Cheatum was born in Langdon, Kansas, July 19, 1901. He grew up in rural surroundings assisting in his father's general store. As a young man, he washed dishes in a hotel near Southwestern College where he earned his B.A. in biology (1921-1924). He was also a good athlete, setting the Kansas record for the sprint race that stood for some time. Later, he earned his M.S. in zoology at Kansas State College (1924-1925). At this time, he married Edith Deck and left alone two days later to assume a job as instructor at Southern Methodist University. Five weeks later he had earned enough money to bring his bride to Dallas. During summers and for two winters he and Edith traveled to the University of Michigan where he gained his Ph.D. in aquatic biology under such people as Dr. Paul Welch (1931-1933).

As a scientist and educator, Dr. Cheatum worked in several fields, parasitology, entomology, malacology and limnology. Although he continued to teach in these fields and in comparative anatomy, his main research interest gravitated to the Mollusca. He published over 30 scientific articles, some in The Nautilus (1934-1972). Most were concerned with the area he loved most, Texas.

His academic affiliations were numerous. He was a member of Sigma XI, a fellow in the A.A.A.S., a member of the American Microscopical Society, a fellow and past President (1941-1942) of the Texas Journal of Science, a member of the Texas Ornithological Society and the Limnological Society of America. In Dallas, he belonged to the S.M.U. Men's Faculty Club, Town & Gown Club, and he was a director of the Junior Leader Training, Circle Ten Council, Boy Scouts of America. For his leadership in Boy Scout work, he was given the Silver Beaver Award.

Although Dr. Cheatum was a moving force in the scientific world, I think his true greatness lay in his teaching. He had the unique ability to inspire student thought and activity far beyond the classroom. He led students to almost every type of environment that Texas had to offer. These field trips with Dr. Cheatum were truly experiences that few students ever forget. Dr. Cheatum's life work and collections have been transferred to the Dallas Museum of Natural History.

by Richard W. Fullington
Dallas Museum of Natural History
P. O. Box 26193, Fair Park Sta., Texas 75226


NEW IN THE PETERSON FIELD GUIDE SERIES
MORRIS
A FIELD GUIDE to SHELLS of the ATLANTIC and GULF COASTS and the WEST INDIES
3
H.M.Co.
A FIELD GUIDE TO SHELLS
of the ATLANTIC and GULF COASTS and the WEST INDIES
BY PERCY A. MORRIS
3rd edition, completely rewritten and enlarged
West Indies shells now included
1035 shells, 1033 illustrations
NATIONAL AUDUBON SOCIETY
NATIONAL WILDLIFE FEDERATION

INFORMATION FOR SUBSCRIBERS

The *annual subscription* rate for *The Nautilus* is $7.00 for individuals and $12.00 for institutions (domestic or foreign). Subscriptions may begin in January. Send check or money order to "The Nautilus" to Mrs. Horace B. Baker, Business Manager, 11 Chelten Road, Havertown, Pa. 19083.

Back issues from volume 72 to date are obtainable from the Business Manager. Volumes 1 through 71 (if available) may be obtained in reprint or original form from Kraus Reprint Co., Route 100, Millwood, New York 10546.

Advertising rates may be obtained from the Business Manager or Editor.

CONTRIBUTORS

Manuscripts: Authors are requested to follow the recommendations of the *Style Manual for Biological Journals.* which may be purchased from the American Institute of Biological Sciences, 2000 "P" Street, N.W. Washington, D.C. 20036. Manuscripts should be typewritten and doublespaced; original and one copy are required, to facilitate reviews. Tables, numbered in arabic, should be on separate pages, with the title at the top. Legends to photographs should be typed on separate sheets. Explanatory terms and symbols within a drawing should be neatly printed, or they may be pencilled in on a translucent overlay, so that the printer may set them in 8 pt. type. There is a charge of 50 cents per word for this extra service. All authors or their institutions will be charged 50 cents per line of tabular material and taxonomic keys. The publishers reserve the right, seldom exercised, to charge $32 per printed page.

An *abstract* should accompany each paper.

Reprints and covers are available at cost to authors. When proof is returned to authors, information about ordering reprints will be given. They are obtained from the Economy Printing Co., Inc., R. D. 3, Box 169, Easton, Maryland 21601.

MOLLUSK VOUCHER SPECIMENS

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

The Delaware Museum of Natural History has extensive, modern facilities and equipment for the housing and curating of voucher specimens. Material should be accompanied by the identification, locality data and its bibliographic reference. There is no charge for this permanent curating service, and catalog numbers, if desired, will be sent to authors prior to publication.