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(*Geographical,* vols 1-90; *Scientific Names,* vols 61-90)

REGISTER OF AMERICAN MALACOLOGISTS

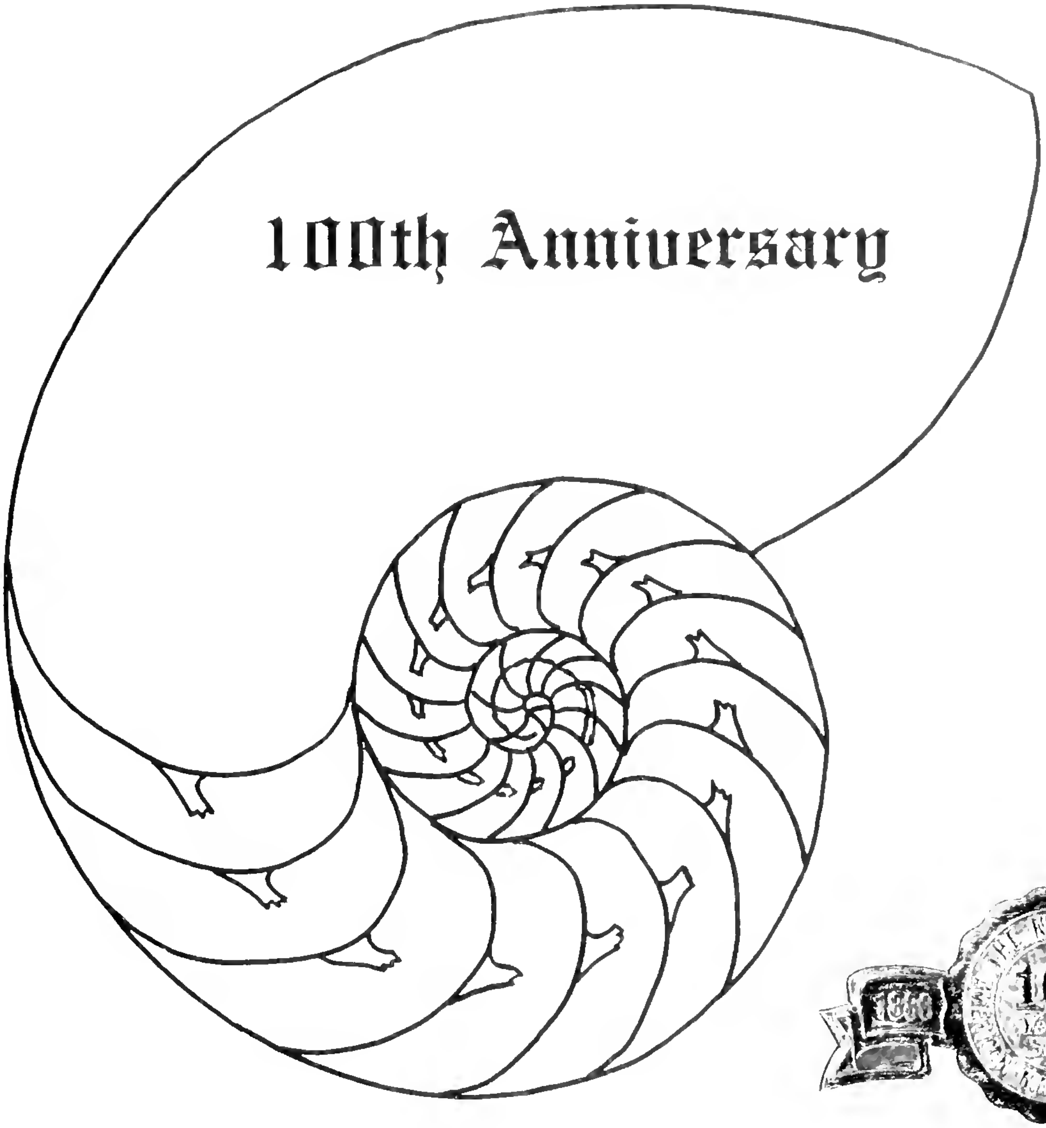
JANUARY 31, 1986

THE
NAUTILUS

ISSN 0028-1344

Vol. 100

No. 1



100th Anniversary

A quarterly
devoted to
malacology and
the interests of
conchologists

Founded 1889 by Henry A. Pilsbry. Continued by H. Burrington Baker.
Editor-in-Chief: R. Tucker Abbott

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(signed) R. Tucker Abbott, Editor

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THE NAUTILUS

ITS 100th ANNIVERSARY
and
Volume 100

Dedicated to all the mollusk enthusiasts, both private conchologists and professional malacologists, who founded and carried on for the last one hundred years America's oldest journal devoted exclusively to the study of mollusks. To its 500 contributors and 15 consulting editors are added many thanks and appreciation.

DEDICATED TO THE FORMER EDITORS[1]

William D. Averell (1853-1928)
Founder of the Conchologists' Exchange, 1886

Henry A. Pilsbry (1862-1957)
Founder, editor of The Nautilus, 1888-1957

Charles W. Johnson (1863-1932)
Business manager, 1890-1932

Horace Burrington Baker (1889-1971)
Business manager, co-editor 1932-1957
Editor, 1958-1970

Charles B. Wurtz (1916-1982)
Co-editor, 1958-1974;
consulting editor, 1974-1982

Bernadine B. Baker (1906-living)
Business manager, 1958-1979

Morris K. Jacobson (1906-1980)
Consulting editor, 1972-1980

William J. Clench (1897-1984)
Consulting editor, 1972-1984

Joseph Rosewater (1928-1985)
Consulting editor, 1972-1985

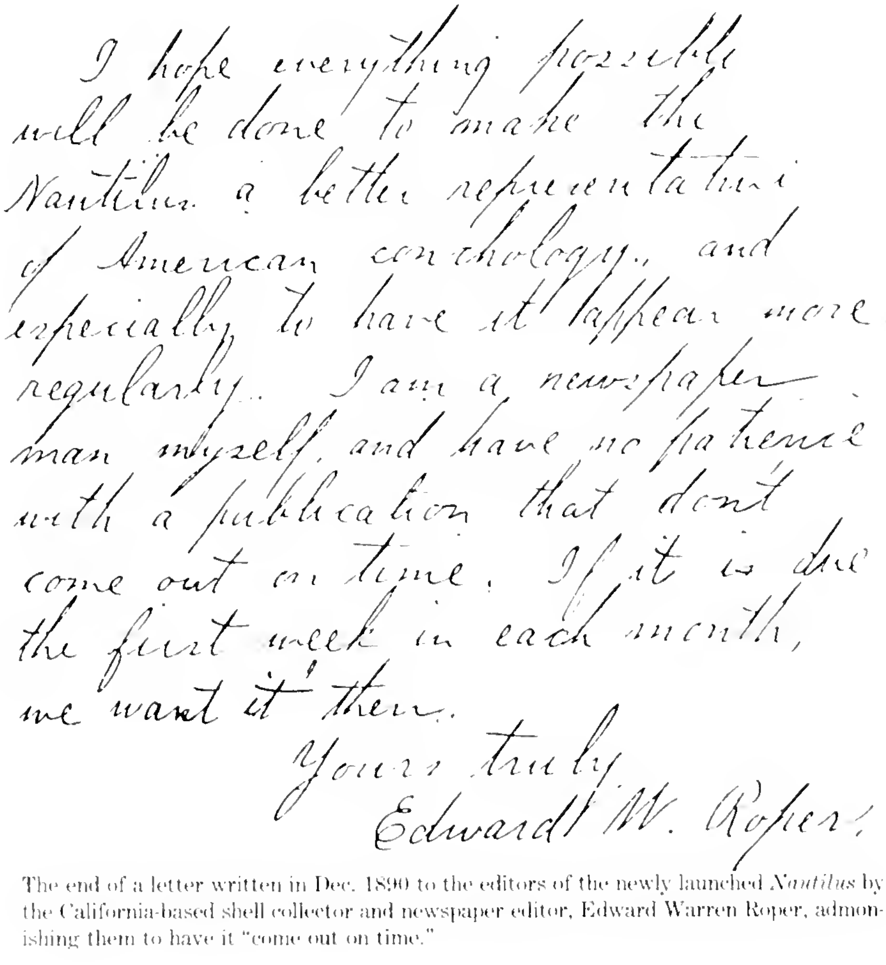
---

[1] The present staff is R. Tucker Abbott, co-editor, 1958-1969, editor since 1970; Cecelia W. Abbott, business manager, since 1979; M. G. (Jerry) Harasewych, associate editor, beginning with this volume. Mrs. H. B. Baker, former business manager, lives in Haverford, Pennsylvania.

BIRTH AND GROWTH OF THE NAUTILUS

It was the year 1886. The country was recovering from the depression of 1884. President Grover Cleveland, in his first term, was about to dedicate the newly erected Statute of Liberty in New York harbor. There were still 12 states to be added to the Union, and it took a two-cent, brown postage stamp with Washington's likeness to send a letter across the country. In Philadelphia the only means of transportation were horses, bicycles, the steam locomotive and boats on the Delaware River. The Academy of Natural Sciences of Philadelphia had not built its large new annex and still used gas lights in its halls and study rooms. In England, they were celebrating Queen Victoria's Diamond Jubilee, and the Spanish American War was still 12 years away.

In 1886, in some respects, it was the best of times for American conchology. William H. Dall of the U.S. Geological Survey in Washington, D.C. had already produced over 50 major works on mollusks, and Harvard University had just published the first part of his famous "Blake Report" on deepsea mollusks. George W. Tryon, Jr., the Philadelphia author of "Structural and Systematic Conchology," had just completed the tenth volume of his monumental "Manual of Conchology." Verrill and Bush in New England were at the height of their reports on the dredgings of the Steamers *Fish Hawk* and the *Albatross.* William G. Binney, living in New Jersey, just across the river from Philadelphia, had just revised his classic "Manual of North American Land Shells." The Conchological Section under the wing of Philadelphia's Academy was flourishing with such active members as S.

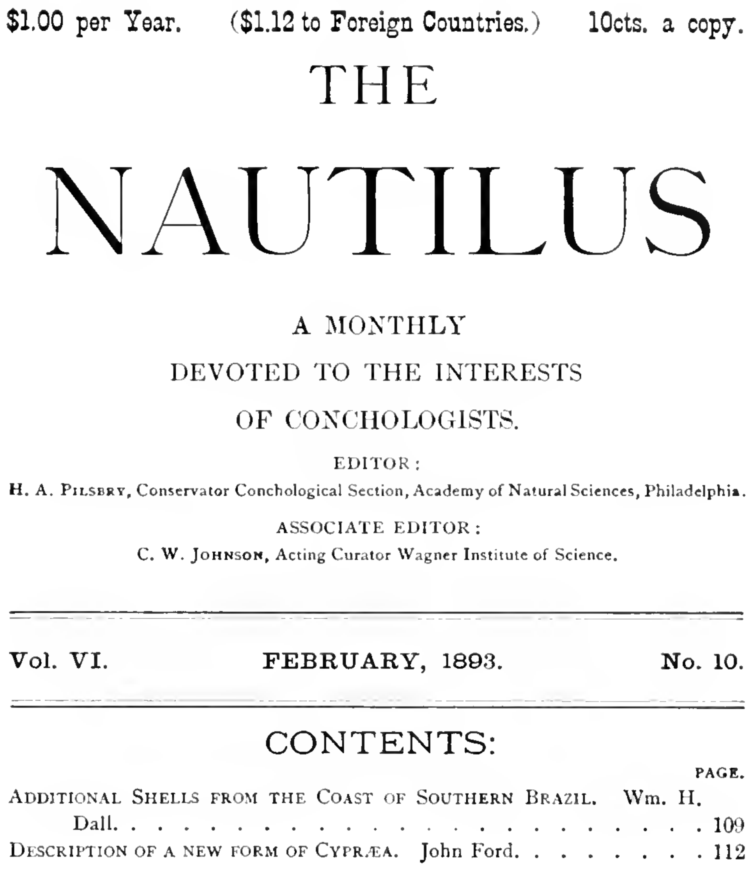


I hope everything possible will be done to make the Nautilus a better representative of American conchology, and especially to have it appear more regularly. I am a newspaper man myself, and have no patience with a publication that don't come out on time. If it is due the first week in each month, we want it then.

Yours truly

Edward W. Roper.

The end of a letter written in Dec. 1890 to the editors of the newly launched *Nautilus* by the California-based shell collector and newspaper editor, Edward Warren Roper, admonishing them to have it "come out on time."



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THE NAUTILUS

A MONTHLY
DEVOTED TO THE INTERESTS
OF CONCHOLOGISTS.

EDITOR:
H. A. Pilsbry, Conservator Conchological Section, Academy of Natural Sciences, Philadelphia.

ASSOCIATE EDITOR:
C. W. Johnson, Acting Curator Wagner Institute of Science.

Vol. VI. FEBRUARY, 1893. No. 10.

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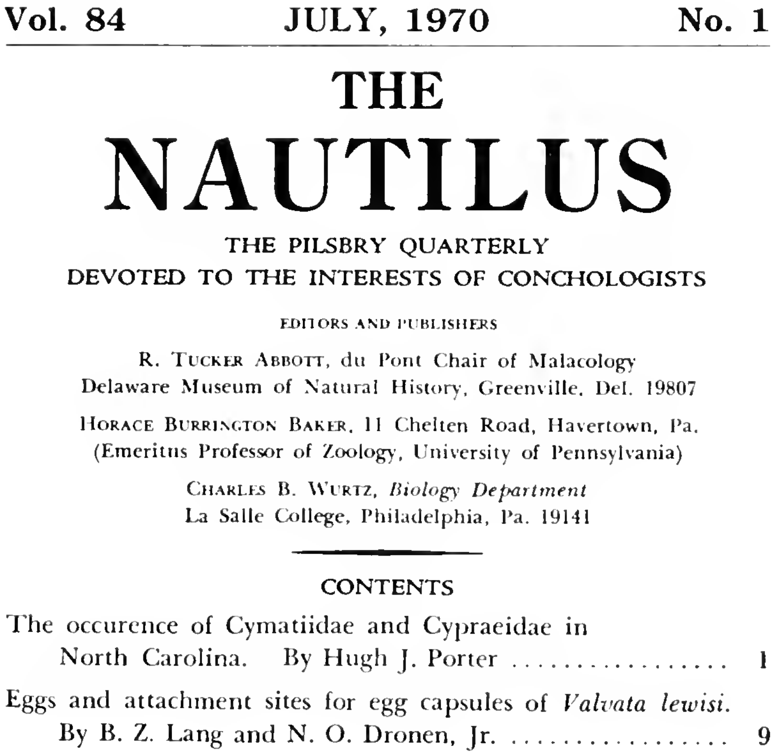

Vol. 84 JULY, 1970 No. 1

THE NAUTILUS

THE PILSBRY QUARTERLY
DEVOTED TO THE INTERESTS OF CONCHOLOGISTS

EDITORS AND PUBLISHERS

R. Tucker Abbott, du Pont Chair of Malacology
Delaware Museum of Natural History, Greenville, Del. 19807

Horace Burrington Baker, 11 Chelten Road, Havertown, Pa.
(Emeritus Professor of Zoology, University of Pennsylvania)

Charles B. Wurtz, *Biology Department*
La Salle College, Philadelphia, Pa. 19141

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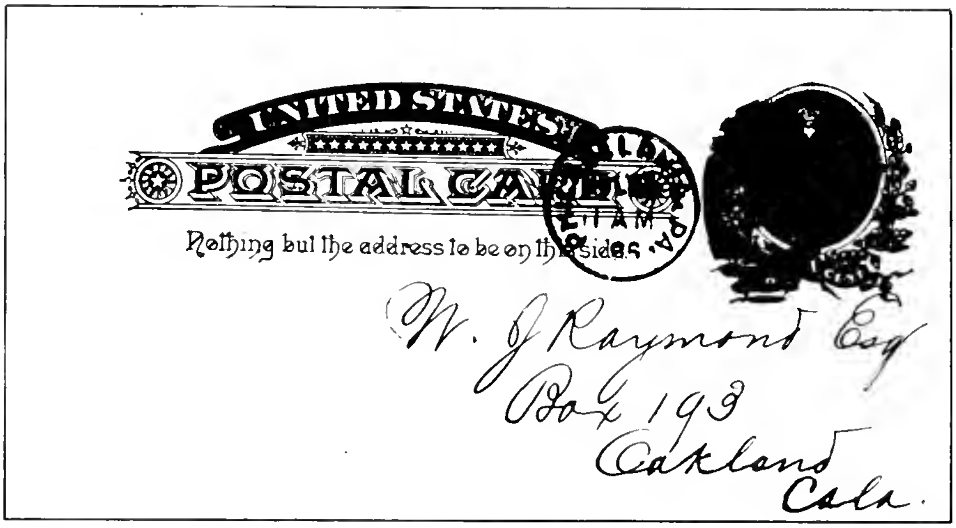

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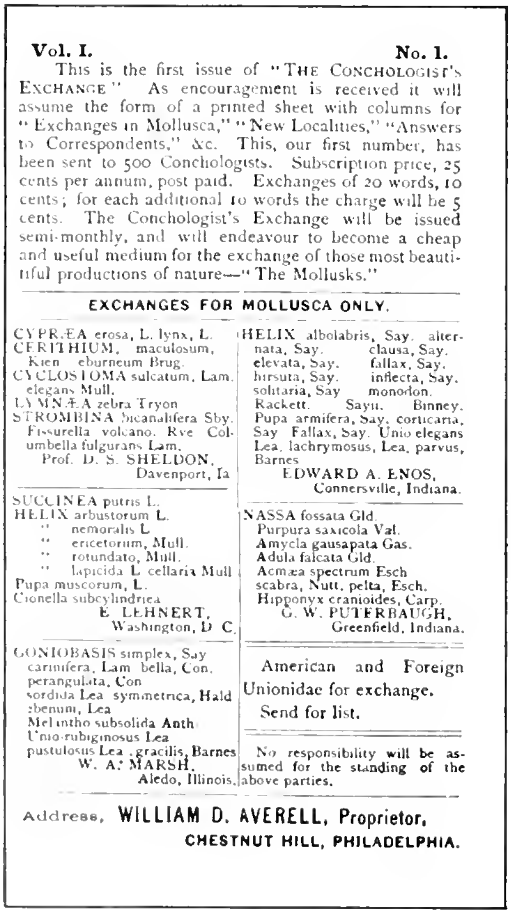

Vol. I. **No. 1.**

This is the first issue of "THE CONCHOLOGIST'S EXCHANGE." As encouragement is received it will assume the form of a printed sheet with columns for "Exchanges in Mollusca," "New Localities," "Answers to Correspondents," &c. This, our first number, has been sent to 500 Conchologists. Subscription price, 25 cents per annum, post paid. Exchanges of 20 words, 10 cents; for each additional 10 words the charge will be 5 cents. The Conchologist's Exchange will be issued semi-monthly, and will endeavour to become a cheap and useful medium for the exchange of those most beautiful productions of nature—"The Mollusks."

EXCHANGES FOR MOLLUSCA ONLY.

CYPRÆA erosa, L. lynx, L. CERITHIUM, maculosum, Kien eburneum Brug. CYCLOSTOMA sulcatum, Lam. elegans Mull. LYMNÆA zebra Tryon STROMBINA bicanalifera Sby. Fissurella volcano. Rve Columbella fulgurans Lam.
Prof. D. S. SHELDON,
Davenport, Ia

SUCCINEA putris L.
HELIX arbustorum L.
" nemoralis L
" ericetorum, Mull.
" rotundato, Mull.
" lapicida L cellaria Mull
Pupa muscorum, L.
Cionella subcylindrica
E LEHNERT,
Washington, D C.

GONIOBASIS simplex, Say carinifera, Lam bella, Con. perangulata, Con sordida Lea symmetrica, Hald ebenum, Lea Melantho subsolida Anth Unio rubiginosus Lea pustulosus Lea .gracilis, Barnes
W. A. MARSH,
Aledo, Illinois.

HELIX albolabris, Say. alternata, Say. clausa, Say. elevata, Say. fallax, Say. hirsuta, Say. inflecta, Say. solitaria, Say monodon. Rackett. Sayii. Binney. Pupa armifera, Say. corticaria, Say Fallax, Say. Unio elegans Lea. lachrymosus, Lea. parvus, Barnes
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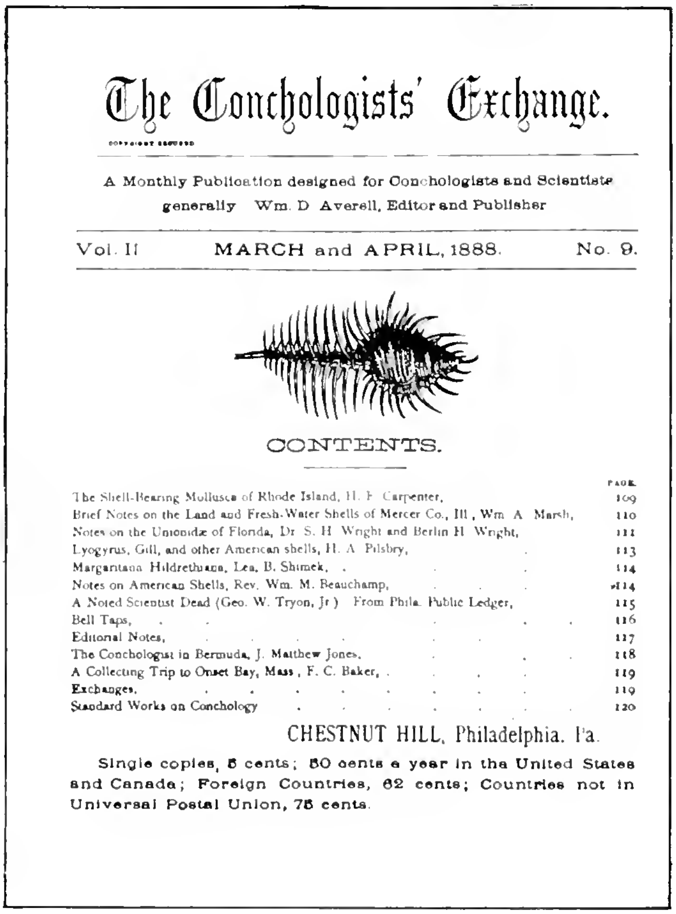

The Conchologists' Exchange.

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A Monthly Publication designed for Conchologists and Scientists generally Wm. D Averell, Editor and Publisher

Vol. II MARCH and APRIL, 1888. No. 9.

CONTENTS.

CHESTNUT HILL, Philadelphia. Pa.

Single copies, 5 cents; 50 cents a year in the United States and Canada; Foreign Countries, 62 cents; Countries not in Universal Postal Union, 75 cents.

Raymond Roberts (Cypraeidae), John Ford (Olividae), Dr. Benjamin Sharp (Scaphopoda) and Angelo Heilprin (Florida fossils).

But in the late 1880's, in other respects, it was the worst of times for American conchology. It was like the changing of the guard. Aging Isaac Lea died in 1886 at the age of 95; Lucy Say, widow of America's first conchologist, died on Nov. 15, 1887, and Andrew Garrett, the conchologist of the South Seas, died the same month. Then, like a clap of thunder, George Tryon, at the age of 49, succumbed to a heart attack on February 5, 1888, soon after a walk in a severe winter storm. It was a time when there was no journal in America devoted solely to mollusks. Tryon's *American Journal of Conchology* had succumbed in the financial panic of 1873.

In Europe, in 1886, there were eight respectable scientific journals devoted solely to mollusks – two each in England, Germany and France and one each in Belgium and Italy (Jutting and Altena, 1958). For their outlets, American malacologists depended on the general publications of the Smithsonian Institution, the California Academy of Sciences, Harvard's Museum of Comparative Zoology, and the Academy of Natural Sciences of Philadelphia.

The need for a new American serial publication was evident. There were several hundred active conchologists in United States and Canada, many of them already publishing privately or in obscure natural history magazines. Among them were Henry Hemphill, Temple Prime, R. E. C. Stearns, T. H. Aldrich, W. W. Calkins, Charles T. Simpson and Victor Sterki, to mention but a few.

The Nautilus had a very inauspicious beginning. William D. Averell, a 33-year-old shell dealer and close friend of Tryon's living in nearby Chestnut Hill, began the predecessor of *The Nautilus* as the *Conchologists' Exchange* in July 1886. Volume 1, number 1 was merely a postcard sent out to 500 people announcing that the annual subscription price for this monthly 4-page publication would be all of 25 cents. It was to contain conchological news, exchange notices and answers to correspondents. By February 1887, it had grown to 8 pages and the price rose to 35 cents. The final number, vol. 2, no. 9, issued in April 1888, two months after Tryon's death, had 16 pages. Already it had served as a publication medium for such well-known mollusk workers as F. C. Baker, Josiah Keep of California, C. F. Ancey of Algiers, W. H. Dall, T. D. A. Cockerell and a Harry A. Pilsbry (later to call himself, Henry).

But a quirk of circumstances in Philadelphia changed the history of this journal. William B. Marshall, a Jessup Student at the Academy and the assistant to Tryon, left in 1887 to be the Assistant Zoologist at the New York State Museum in Albany, and later to serve under Dall and Bartsch in Washington for 40 years. Just at this time a young newspaper reporter by the name of Pilsbry from Davenport, Iowa, and a contributor to the *Conchologists' Exchange*, visited the Academy on his way to seek new employment in New York. Tryon was favorably impressed with the 24-year-old amateur conchologist who already had considerable knowledge about mollusks, was an excellent draftsman and had a natural bent for research and publishing. Upon Marshall's sudden departure for Albany, Tryon immediately invited Pilsbry to return from New York and be his new assistant. Pilsbry arrived in November 1887, and Tryon died three months later.

Pilsbry was elected as conservator of the Conchological Section in 1888, and he immediately plunged into the task of finishing the marine series of the *Manual of Conchology*, a publication that supplied much of his salary. There was a reawakening of interest in the *Conchologists' Exchange*, and in early 1889 a "Prospectus" was sent out announcing its continuation as *The Nautilus* with Pilsbry as editor and Averell as business manager. Volume 3, no. 1 began on May 5, 1889.

According to Pilsbry's colleagues (H. B. Baker, 1958) the one year's association with Averell "was none too happy" and, at the end of volume 4, no. 1, Averell's share was bought out by another Philadelphian, at the Wagner Free Institute of Science: Charles W. Johnson. This ideal partnership lasted for the next 42 years until Johnson's death in Boston in 1932.

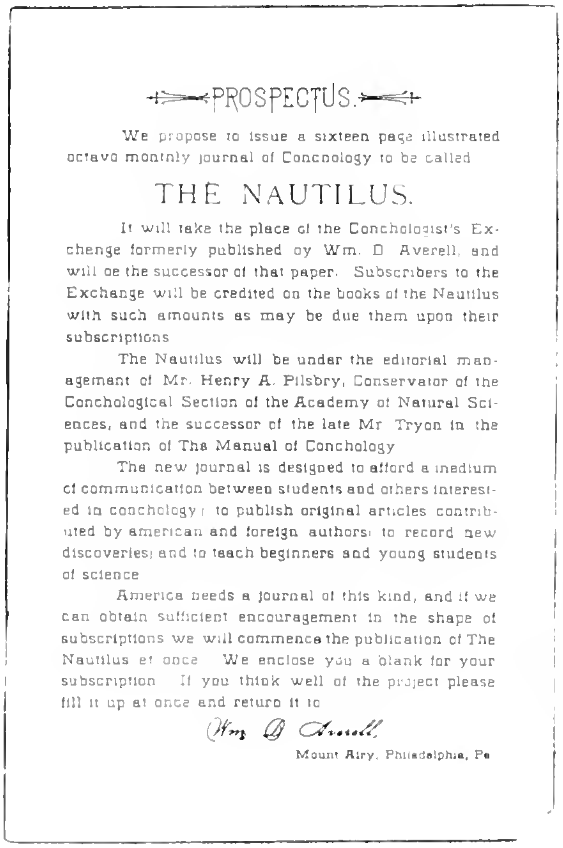
Johnson was a very affable and knowledgable gentleman whose forte was entomology and paleontology, as well as malacology. He was particularly successful in inspiring young naturalists, and when he moved to Boston in 1903 to assume the curatorship of the Boston

Society of Natural History, William J. Clench as a youngster fell under his spell. Years later, from 1926 to 1932, Clench was the Curator of Mollusks at nearby Harvard, and often assisted Johnson in the business affairs of *The Nautilus*. It was Johnson's understanding that Clench would succeed him as business manager, but upon the former's death in 1932, Pilsbry (then 69) thought that both editors of *The Nautilus* should be in the same city; so H. Burrington Baker, one of America's leading land snail experts and Professor of Zoology at the University of Pennsylvania, began his association as junior editor and business manager in October 1932 with volume 46. Meanwhile, Clench in 1941 launched the marine journal, *Johnsonia*, naming it after his old mentor.

The Nautilus continued to flourish and grow. Its history is well-told in the Pilsbry memorial number of *The Nautilus* by Dr. Baker (1958, vol. 71, no. 3, pp. 112-115). Pilsbry died on October 26, 1957 at the age of 94, and the editorship of the journal continued under Baker's capable hands until his death on March 11, 1971, at the age of 82.

In April 1958, two junior editors joined *The Nautilus*, one being the land snail expert and aquatic biologist, Charles B. Wurtz (1916-1982) who had received his Ph.D. under Dr. Baker at the University of Pennsylvania. At the age of 34 I had left the Smithsonian Institution in 1954 to become the first occupant of the newly-formed Pilsbry Chair of Malacology at the Academy. I became the other junior editor and often assisted Pilsbry in the preparation of the journal, sometimes entirely assembling and editing it during Pilsbry's winter sojourns in Lantana, Florida. Also, at this time, Dr. Baker's wife, Bernadine Barker Baker, known to her family and friends as "Bunny," took over the business and subscription management, and continued in that capacity with great success for the next twenty years.

In 1969 I helped found and organize the Delaware Museum of Natural History in Greenville, and became the curator of their Depart-



PROSPECTUS.

We propose to issue a sixteen page illustrated octavo monthly journal of Conchology to be called

THE NAUTILUS.

It will take the place of the Conchologist's Exchange formerly published by Wm. D. Averell, and will be the successor of that paper. Subscribers to the Exchange will be credited on the books of the Nautilus with such amounts as may be due them upon their subscriptions

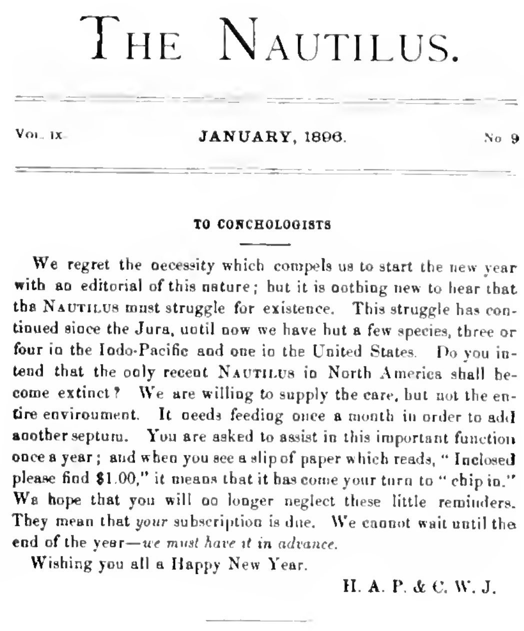
The Nautilus will be under the editorial management of Mr. Henry A. Pilsbry, Conservator of the Conchological Section of the Academy of Natural Sciences, and the successor of the late Mr Tryon in the publication of The Manual of Conchology

The new journal is designed to afford a medium of communication between students and others interested in conchology; to publish original articles contributed by american and foreign authors; to record new discoveries; and to teach beginners and young students of science

America needs a journal of this kind, and if we can obtain sufficient encouragement in the shape of subscriptions we will commence the publication of The Nautilus at once We enclose you a blank for your subscription If you think well of the project please fill it up at once and return it to

Wm D Averell

Mount Airy, Philadelphia, Pa



THE NAUTILUS.

Vol. IX. JANUARY, 1896. No 9

TO CONCHOLOGISTS

We regret the necessity which compels us to start the new year with an editorial of this nature; but it is nothing new to hear that the NAUTILUS must struggle for existence. This struggle has continued since the Jura, until now we have but a few species, three or four in the Indo-Pacific and one in the United States. Do you intend that the only recent NAUTILUS in North America shall become extinct? We are willing to supply the care, but not the entire environment. It needs feeding once a month in order to add another septum. You are asked to assist in this important function once a year; and when you see a slip of paper which reads, "Inclosed please find $1.00," it means that it has come your turn to "chip in." We hope that you will no longer neglect these little reminders. They mean that *your* subscription is due. We cannot wait until the end of the year—*we must have it in advance.*

Wishing you all a Happy New Year.

H. A. P. & C. W. J.

ment of Mollusks. I moved *The Nautilus*, now owned by Mrs. Baker, to Delaware. In 1979, upon the recommendation of Bunny, my wife, Cecelia White Abbott, took over the duties of business manager.

There was need for an improvement in the format of the journal which had remained unchanged for several decades. In May 1972 (volume 86) the page size was increased to 8 × 10½ inches, a two-column format established on a glossy paper, and a board of 13 consulting editors formed. By now, 85 years after its inception, the annual subscription rate had risen from 25 cents to $7.00 for individuals. Today it stands at $15.00.

With the demise of the Department of Mollusks at the Delaware Museum in 1979 as a functioning, scientific entity, we moved *The Nautilus*, now under the jurisdiction of my American Malacologists, Inc., to Melbourne, Florida, where it has been published for the last six years. We have now added an associate editor, Dr. M. G. (Jerry) Harasewych, a newly appointed associate curator in mollusks at the U.S. National Museum in Washington, D.C.

For over twenty years *The Nautilus* served as the official organ of the American Malacological Union at no cost to their organization. Proceedings of the meetings were published by them from 1932 to 1953 in the same format as that of *The Nautilus*. Like all growing organizations, the AMU eventually required its own periodical and now issues the extensive *American Malacological Bulletin* (vol. 1, no. 1, July 1983) under the capable editorship of Dr. Robert S. Prezant of the University of Southern Mississippi.

The life of an editor is not easy, especially in the case of scientific journals that constantly need financial help. The editors of the privately owned *Nautilus* were no exception, and they had to make repeated appeals for subscribers to "pay up." (Pilsbry and Johnson, 1893). In my 28 years of experience as an editor I had to face financial and production problems, and I sometimes found manuscripts poorly written, badly organized, without nomenclatorial knowledge and often lacking references to the very same subject. It is work getting some of them into shape, and sometimes there is little thanks. There is an old adage that "the next time you see an understanding and beloved editor, you will see him laid out horizonally and surrounded by flowers."

But there are rewards – a sense of accomplishment and the joy of creating – a sense of helping others to participate in "our glorious science of conchology" as Averell put it so often in his editorials of a hundred years ago. A few years ago I gathered together and published a collection of interesting articles and reproductions of ancient advertisements (Abbott, 1975). In *The Best of The Nautilus* one can sense the spirit of comradship among our early contributors. *The Nautilus* is for both the beginning scientist, the enthusiastic amateur with new discoveries, as well as for the accomplished malacologist on the "cutting edge of the science" and immersed in "the state of the art." It is still a joint and cooperative effort. Let's hope that *The Nautilus* goes on for another 100 years!

– *R. Tucker Abbott*, Melbourne, Florida

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__________ (editor). 1975. *The Best of The Nautilus*. 280 pp., American Malacologists, Inc., Greenville, Delaware.

__________ 1979. Bernadine Barker Baker – A Tribute upon her Retirement. *The Nautilus* **93**(2-3):ii.

__________ 1983. Charles B. Wurtz – An Obituary. *The Nautilus* **97**(1):43, portrait.

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Abbott, R. Tucker and Chas. B. Wurtz. 1971. Horace Burrington Baker, 1889-1971. (An obituary). *The Nautilus* **85**(1):1-4, 3 portraits.

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TOM PULLEY AND THE TRAIN

Thomas Edward Pulley, born October 15, 1916, Director of the Houston Museum of Natural Sciences since 1957, and a malacological student of the late William J. Clench of Harvard, passed away on November 19, 1985, at the age of 69. In preparation for the 100th anniversary volume of The Nautilus, *which in part is dedicated to Dr. Clench, I asked Tom to write a personal anecdote that typified his mentor. If my readers will recall, in my "Farewell to Bill Clench" (*The Nautilus **98***(2):55-58), Bill drew a huge arrow in the sandy beach for his students that pointed to a waiting train. Tom Pulley has now caught up with the other students, and here is Tom's personal account of The Train written in July 1984. He asked that this last picture of Bill Clench be included—(RTA).*

Everyone who knew Bill was aware of his capacity for enthusiasm over a new shell. We who worked with him at the MCZ often witnessed the thrill of anticipation with which he opened each new package of shells and spread out the contents on the wide brown table. It was almost like watching the bright-eyed wonder of a small child at his first real Christmas.

But Bill had the same happy way of appreciating most of the other simple pleasures of life. He and Julia once invited me and my wife and 5-year-old son to a Sunday afternoon picnic; Bill would grill the hamburgers.

When we arrived at his chosen site I was a bit surprised to see that we were on a nice grassy spot, but it was on the railroad-right-of-way. There were houses nearby, but they were mostly concealed by trees. I had known that Bill liked trains, and I soon learned that we were here to wave at the afternoon train when it passed by. We lighted the charcoal and opened some beer and cokes.

When the coals were ready, Bill grilled the hamburgers and they were delicious. As we were finishing I saw that Bill kept glancing at his watch. Soon we heard the faint whistle of


William J. Clench, age 86, in California.

one of the last steam trains, and Bill quickly jumped to his feet. He strained to view the big engine when it first came into sight around a distant bend, and long before it was near us he raised both hands in the air and began to wave. As the train approached he began jumping in the air and waving more excitedly. The engineer saw him and began tooting his whistle in a long series of short bursts. The excitement was catching, and by the time the engine had reached us my son was as excited as Bill, and I was amazed to find that I, too, was jumping and waving like a 5-year old. The smiles that were exchanged between Bill and the engineer as the train roared by led me to believe that this must have happened many times before.

I understood Bill's joy that afternoon as the train passed by, because I had taken part in it. I later realized that Bill experienced this same kind of happy pleasure in many of the less dramatic events of daily life. To Bill, the thrill of seeing a new shell, meeting an old friend or making a new one, finishing another number of *Johnsonia*, or even telling one of his old bad jokes was comparable to his pleasure that day by the railroad tracks. –Tom Pulley, July 1984

JOSEPH ROSEWATER (1928-1985)
A TRIBUTE AND BIBLIOGRAPHY

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On March 20, 1985, malacologists the world over lost an eminent and treasured colleague, and those close to him a dear friend. His untimely death left a void in the ranks of malacologists that will be hard to fill, and his associates at the Smithsonian still find it difficult to believe that we will not see him at any moment leaving his room or coming around the corner in the halls or in the range of the Division of Mollusks.

Joe was born on September 18, 1928 in Claremont, New Hampshire, in the Connecticut River Valley, the only child of Joseph and Alice Tipping Rosewater. His mother had come to Claremont from the Rosewater home in Queens, Long Island, New York, to be with her parents at this time.

Joe's father was an accountant with the City of New York, and his mother had been a Navy nurse in World War I. When Joe was eight years old his father died. Joe graduated in June 1946 from John Adams High School in South Ozone Park, Long Island, two months after the death of his mother. Joe's mother, before her death, had appointed her brother Charles to be Joe's legal guardian, and therefore Joe moved to his uncle's home in Claremont, New Hampshire.

In the fall of 1946 Joe entered the University of New Hampshire at Durham, graduating in 1950. As a boy he had had an interest in animals, and had kept an aquarium in his room. His special interest in mollusks began apparently in

FIG. 1. Joseph Rosewater in a recent informal pose.

Joe Rosewater

his junior year at the University when his zoology professors, Emery F. Swan and George M. Moore, persuaded him to undertake a molluscan project for a master's degree. This is evidenced by the fact that Joe states that his first field work started in 1949 with collecting mollusks in New England.

Joe began working on his Master's degree in the fall of 1950 but his plans were interrupted by the arrival of a draft notice in February 1951. That month he married Mary Carlson of Gilmanton, New Hampshire, and in May he was formally drafted and went to Fort Meade, Maryland, for basic training. In the fall he was sent to Fort Sam Houston, Texas, to receive further training as a medical technician in radiology. In early March 1952 Joe was sent overseas to Germany where until April 1953 he was a medical technician in radiology in the 97th General Hospital in Frankfurt-am-Main.

After his return from Germany and after leaving the service, Joe worked as an x-ray technician at the Sacred Heart Hospital in Manchester, New Hampshire, and as an instructor in biology at Mount St. Mary's College in nearby Hooksett until May 1955. That summer he enrolled at the University of New Hampshire, attending the summer school and then the academic year 1955-56, receiving a Master's degree in June 1956.

In the fall of 1956 he entered Harvard University as a graduate student to work under Dr. William J. Clench in malacology. Here, in the company of Richard I. Johnson, Richard W. Foster, Robert Robertson, Arthur H. Clarke and Arthur S. Merrill, he spent four happy and fruitful years under the genial and caring tutelage of Bill Clench and Ruth Turner.

In the summer of 1957 Joe came to Washington and spent three months in the Division of Mollusks of the U. S. National Museum as a Summer Intern, working on the family Pleuroceridae in connection with his doctoral studies. In the course of his studies he reorganized the North American members of the family Thiaridae in the museum collection.

The following summer Joe accompanied Bill Clench on a field trip through Kentucky, Tennessee and Georgia, collecting and studying the freshwater faunas of the area.

During his years at Harvard Joe was a Teaching Fellow in Biology, and in his last year he held a position as Curatorial Assistant in the Department of Mollusks. In the fall of 1959, Joe's final year at Harvard, Bill Clench and Joe were beginning to plan for Joe's immediate future after he received his degree in the coming June, and Bill wrote to me regarding a possible opening at the National Museum. For a year or more we had on file a job application form that Joe had filled out for a position in the Division, awaiting the time when we would get approval to hire an additional staff member. At this time the opportunity opened up to hire a malacologist under a grant that the National Museum had received from the Office of Naval Research and Atomic Energy Commission (ONR-AEC) to work on the marine faunas of the Pacific, especially that of the Marshall Islands – Bikini and Enewetak.

This position was offered to Joe and he started working on January 1, 1960. In the year and nine months that he was on this contract he helped identify and arrange many lots of Indo-Pacific mollusks, and spent several days a week reorganizing and expanding the collections of Indo-Pacific marine mollusks, bringing the classification up to date and adding thousands of lots to the collection. In August 1961 Joe made his first visit to the Pacific attending the Tenth Pacific Science Congress in Hawaii.

On October 2, 1961 Joe joined the staff as Associate Curator, and for the next twenty-three and a half years was a valued and important member of the scientific staff of the National Museum of Natural History.

With the addition of Joe, the staff of the Division of Mollusks was once more at full strength, and this fact seemed to infuse new energy into the divisional activities, stimulated in part no doubt by Joe's enthusiasm in his new position. Recorded in the annual report for that year was a notable increase in the number of specimens distributed in exchange, lent for study and identified for correspondents.

Although Joe's doctoral dissertation dealt with a freshwater mollusk, marine mollusks were his first love, as he told me in a letter he wrote when I offered him the opportunity of coming to the Smithsonian on the ONR-AEC grant. He had just finished preparing for the cataloguer the last of the marine collection of the old Boston Society of Natural History that had been turned over to the Museum of Comparative Zoology, and was in the midst of incorporating Tucker Abbott's Philippine marine shells into the collection. When he came to work in the Division under the grant, sorting and classifying the Indo-Pacific mollusks was, therefore, a familiar task. After he and Ruth Turner had finished the western Atlantic Pinnidae they had planned to monograph the Indo-Pacific species of the family. Now Ruth suggested that Joe do the paper alone, and this he did. He finished the project and it was published before the end of his contract. Following this he began studying the family Tridacnidae and the Indo-Pacific Littorinidae, both of which were eventually published in 1965 and in 1970/72. He continued his interest in these three families and published several papers. He was working on a study of the Eastern Pacific members of the Littorinidae at the time of his death, and also had underway a study of the bivalve family, Periplomatidae.

During his years in the Division of Mollusks Joe went on several expeditions and field trips. In February and March 1963 he spent six weeks at the Enewetak Marine Biological Laboratory of the Atomic Energy Commission, and that winter he spent three months in the western Indian Ocean on the research vessel *Te Vega* as part of the International Indian Ocean Expedition. In August and September 1966 Joe was in Australia spending most of the time carrying on field work in Western Australia with Barry C. Wilson, and in May and June 1970 he was a member of the Mariel King Memorial Moluccas Expedition on the R/V *Pele*, again together with Barry Wilson. In April 1974 he spent two weeks in Tunisia at the Mediterranean Marine Sorting Center, and in July 1976 he was a member of a party from the Smithsonian that spent ten days making a survey of the littoral fauna of Ascension Island. Later he made several trips to Panama, and to the Pacific coast, including Alaska, in connection with his study on the Littorinidae of that fauna. His last trips away from Washington were to the Harbor Branch Laboratory at Fort Pierce, Florida where for several years he carried on field studies on *Periploma* and the Littorinidae.

Joe was a member of the American Malacological Union from 1957 on and was its President in 1969. He was also a member and past president of the Biological Society of Washington, the Society of Systematic Zoology of which he was treasurer 1963-1966, and the Paleontological Research Institute, Ithaca, New York. He was a member of the National Capital Shell Club and its president in 1965. He served as a Consulting Editor of *The Nautilus* from 1972 to 1984, and contributed 17 articles to that journal.

In the Museum he represented the Department of Invertebrate Zoology on several committees – the Professional Advancement Evaluation Committee, the Council of the Senate of Scientists, and the Advisory Committee on the Naturalist Center. On the Departmental Collections Advisory Committee he represented the Division of Mollusks.

Joe is survived by his wife Mary Carlson Rosewater and three children, Katherine Louise Rosewater (Waitt) of Sandown, New Hampshire, Gail Ann Rosewater of Rockville, Maryland, and Carl Joseph Rosewater of Kensington, Maryland, and a granddaughter, Megan Rosewater-Waitt.

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H A Pilsbry

William J. Clench

Yours sincerely
Wm H. Dall

Yours very truly,
Josiah Keep.

Believe me to be most sincerely yours
Chas T Simpson

DESCRIPTION OF THE HABITAT OF THE ENDANGERED MUSSEL *PLETHOBASUS COOPERIANUS*

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ABSTRACT

A total of 26 species of unionids, in addition to the Asian Clam, Corbicula, *were collected at a mussel bed on the Ohio River near Olmsted, Illinois. The bed was dominated by* Corbicula *(1475/m², 128.2 g/m² of Tissue Dry Mass, TDM) and* Fusconaia ebena *(66.0/m² and 39.7/m² of TDM) although eight other unionids,* Amblema plicata, Elliptio dilatatus, Leptodea fragilis, Ligumia recta, Megalonaias gigantea, Pleurobema cordatum, Potamilus alatus, *and* Truncilla donaciformis *were also judged common. In addition, three live specimens of the Federally endangered Orange-footed Pimpleback Mussel,* Plethobasus cooperianus, *were identified. All appeared healthy and were adult-sized, ranging in total shell length from 68 to 74 mm. While there are no records of recent recruitment for* P. cooperianus, *it appears that this mussel bed, which contains a diverse community of bivalves in addition to a dense population of* Corbicula, *provides good habitat for this particular species.*

Three live specimens of the Endangered *Plethobasus cooperianus* (Lea 1834), the Orange-footed Pimpleback Mussel, were found in September 1983 during a survey of a gravel bar in the Ohio River near Olmsted, Illinois. In the summer of 1982, Williams and Schuster (1982) collected mussels at this site and found a single live *P. cooperianus*. However, other workers brailed this gravel bar and found no live endangered species (Neff & Pearson 1980, Williams 1969). The purpose of this paper is to document the existence of this species, and to provide information on habitat characteristics and community structure where it was collected.

The historical range of *P. cooperianus* included the Ohio River from western Pennsylvania to southern Indiana; the Wabash River below Mt. Carmel, Illinois; the Cumberland River from Cumberland County, Kentucky, to the vicinity of Nashville, Tennessee; the lower Clinch River in Anderson County, Tennessee; and the Tennessee River from near Knoxville, Tennessee, to Kentucky Lake, Benton County, Tennessee. It has also been recorded from the Caney Fork, Holston, and French Rivers in Tennessee and from the Green and Rough Rivers in Kentucky. At present, *P. cooperianus* is restricted to the Ohio and lower Wabash Rivers where it is uncommon and to the lower Tennessee River in Alabama and western Tennessee where it is also uncommon.

The shell of *P. cooperianus* is up to 87 mm long, 75 mm high, and 45 mm wide; it is heavy, subcircular, and tuberculate. The periostracum is chestnut colored and the nacre is either white or faintly pink and iridescent posteriorly.

Superficially this species resembles *Q. pustulosa*, but the latter species is usually smaller and has fewer and relatively larger tubercles which tend to be laterally rather than radially extended. In addition, *Q. pustulosa* exhibits white nacre and young specimens have prominent green rays, whereas in *P. cooperianus* the rays are obscure and narrow. The most definitive characteristic in *P. cooperianus* is the bright orange viscera, which can be seen in live specimens by gently prying the valves apart (Clarke and Fuller 1983).

Wilson and Clark (1914) reported collecting two gravid females in June from the Cumberland River; evidently it is a summer breeder although the host fish is unknown. Although ecological data are virtually non-existent, this is a large river species which has been collected from sand and gravel substrate in shoals and riffles.

Methods and Study Area

On 26-29 September 1983 molluscs were collected from a reach of the Ohio River below Lock and Dam 53 near Olmsted, Illinois. The study area included the upper portion of a mussel bed delimited by Williams (1969) and Williams and Schuster (1982). During the four-day study bivalves were collected by hand along the shore, with the use of a 5-ft brail bar, and by an experienced shell diver using underwater breathing apparatus. As part of this work the diver completed three 30-min qualitative searches, and collected six 0.25- m^2 quadrat samples from each of four sites on the mussel bed. This project was undertaken for the U. S. Army Engineer District, Louisville, to provide information for a Feasibility Report and Environmental Impact Statement for the Lower Ohio River Navigation Project.

The gravel bar where mussels were collected was about 3 miles long and followed the Illinois shoreline. Substrate consisted of densely packed coarse sand and gravel. Particle sizes varied from less than 1.0 cm to more than 10.0 cm with the greatest fraction of total weight in the 1- to 3- cm range. Water depths where *P. cooperianus* were taken ranged from approximately 3 to 6 m deep. The study site was Ohio River Mile 966.6 to 967.2, approximately 4 miles downriver of Lock and Dam 53; navigation and barge fleeting were taking place in the immediate area. No recent evidence of sedimentation, physical abrasion, or propeller wash from navigation activities, were noted at this portion of the gravel bar.

Results

Using qualitative and quantitative techniques, 26 species of unionids, in addition to the Asian Clam, *Corbicula*, were collected at or adjacent to the gravel bar (Table 1). Although nine species were judged common, the most abundant bivalves were *Corbicula*, *Amblema plicata*, *Fusconaia ebena*, *Lampsilis teres*, *Megalonaias gigantea*, and *Potomilus alatus*.

TABLE 1. Bivalves collected at a gravel bar near Olmsted, Illinois, 26-29 September 1983. All taxa were collected alive.

Scientific Name	Presence*
Family Unionidae	
Actinonaias carinata	UC
Amblema plicata	C
Cyclonaias tuberculata	UC
Ellipsaria lineolata	FC
Elliptio crassidens	FC
Elliptio dilatatus	UC
Fusconaia ebena	C
Lampsilis ovata	UC
Lampsilis teres	C
Lasmigona complanata	UC
Leptodea fragilis	C
Ligumia recta	C
Megalonaias gigantea	C
Obliquaria reflexa	FC
Obovaria olivaria	UC
Plethobasus cooperianus	UC
Plethobasus cyphyus	UC
Pleurobema cordatum	C
Potamilis alatus	C
Quadrula metanevra	FC
Quadrula nodulata	FC
Quadrula pustulosa	FC
Quadrula quadrula	FC
Tritogonia verrucosa	UC
Truncilla donaciformis	C
Truncilla truncata	UC
Family Corbiculidae	
Corbicula manilensis	C

* Presence, for this study:
UC = Uncommon, < 6 collected
FC = Fairly common, 6-20 collected
C = Common, > 20 collected

A total of 14 species of unionids were collected in 24 0.25-m^2 quadrat samples (Table 2). Total unionid density ranged from 28 to 124/m^2 ($\bar{X}$ = 60). Numerically, *F. ebena* ($\bar{X}$ = 46/m^2) and *Truncilla donaciformis* ($\bar{X}$ = 12/m^2) dominated the unionids. Two species, *Q. metanevra* and *Q. nodulata*, judged fairly common in the study area, were found in only 1 of the 24 quantitative samples. The gravel bar was numerically dominated by *Corbicula*, with numbers ranging from 556 to 2628/m^2 ($\bar{X}$ = 1475). Average tissue dry mass (TDM) for *Corbicula* (128.2 g/m^2) was approximately three times that for total unionids ($\bar{X}$ = 39.7). Because of their large size and high

TABLE 2. Bivalves collected in 24 0.25-m^2 quadrat samples at a gravel bar near Olmsted, Illinois, 28-29 September 1983.

Species	Occurrence*	No/m^2	TDM/m^2
Corbicula manilensis	24	1475	128.2
Total unionids	24	66.0	39.7
Fusconaia ebena	24	45.5	27.4
Truncilla donaciformis	24	11.5	0.4
Leptodea fragilis	11	2.5	1.3
Obliquaria reflexa	9	1.8	0.8
Quadrula pustulosa	8	1.5	1.4
Amblema plicata	6	1.0	3.1
Ellipsaria lineolata	7	1.3	1.5
Tritogonia verrucosa	3	0.5	0.4
Lampsilis ventricosa	6	1.2	0.03
Quadrula quadrula	5	0.8	1.3
Quadrula metanevra	1	0.2	0.1
Quadrula nodulata	1	0.2	0.1
Megalonaias gigantea	2	0.3	1.3
Actinonais carinata	1	0.2	0.3

* Occurrence - Number of quadrats with live organisms (total quadrats collected = 24).

numbers, *F. ebena* represented the majority, about 70% (27.4 g/m^2) of the total unionid biomass. Although numerically dominant, *T. donaciformis*, because of its small size, represented only about 1% ($\overline{X} = 0.4$ g/m^2) of the unionid biomass. Based upon these quantitative collections, evidence of recent recruitment (presence of clams less than 12 months old judging from their small size and unweathered appearance) was observed for 12 of the 14 unionids collected in the quadrats.

The three specimens of *P. cooperianus* were obtained near Ohio River Mile 967.2 by the diver during two of the three 30-min qualitative searches of the bar. The diver had been instructed to concentrate on pustulate organisms or species judged uncommon by our earlier work. On the second search, he obtained eight species, including one *P. cooperianus* and two *Q. pustulosa*. During the final search he retrieved eleven species, including two *P. cooperianus* and two *Q. pustulosa*. The Orange-footed Pimpleback was not found with the brail, on any of the shoreline searches, or in the quadrat samples.

Conchological data on the three live *P. cooperianus* are as follows:

Length (mm)	*Height (mm)*	*Width (mm)*
74	63	37
68	60	38
71	64	42

By gently prying the valves apart, it was observed that soft tissues were healthy looking and certainly not moribund.

Discussion

This gravel bar was dominated both in numbers and biomass by *Corbicula;* evidently this had no effect on the unionids or *P. cooperianus*. In addition, it appears that requirements for food, water quality, and substrate for adult *P. cooperianus* must differ very little from the 25 other unionids inhabiting this bed. In a study of 21 species in Michigan streams, Strayer (1983) concluded that microhabitat differences were not discernible for 21 of the unionids. In addition, two other species, the fairly uncommon

Cumberlandia monodonta and the endangered *Lampsilis higginsi*, have also been collected from very diverse and densely populated mussel beds in the Upper Mississippi River. *Cumberlandia monodonta* was usually taken in samples where 50% of the sites had at least 20 species of common or wide-ranging mussels. *Lampsilis higginsi* was in association with 17 or more common unionids at 50% of the reported sites in the upper Mississippi River (Nelson and Freitag 1979).

Wilson and Clark (1914) judged *P. cooperianus* to be "not rare" during their survey of the Cumberland River. However, Neel and Allen (1964) were unable to locate this species during a follow-up study on the same river. It is apparent that the historical range of *P. cooperianus* has diminished and the species is in danger of becoming extinct. Some of the reasons often cited for the loss of mussels in large rivers include: sedimentation, navigation activities, pollution, reservoir construction (many with deoxygenated, low pH, and cold water releases), and loss of fish hosts (Fuller 1974).

Conversion of large, free-flowing rivers such as the Ohio to navigable waterways altered the habitats of many benthic organisms. However, some extensive areas with suitable substrate, flow, water quality, and nutrients still exist which support recruiting unionid communities. For the endangered *P. cooperianus*, the studied gravel bar on the Ohio River appears to meet requirements necessary for maintenance of adults.

The range reduction for *P. cooperianus* is probably related to species-specific problems of reproduction or recruitment. Conversion of the Ohio River from a freely-flowing river to a controlled waterway probably modified the available habitats and could have had detrimental effects on host fish. However, it is also possible that this species is slightly more sensitive to altered habitats than the other thick-shelled unionids at the mussel bed. Perhaps conditions have degraded to a point that *P. cooperianus* can maintain itself but does not possess energy reserves necessary for production of adequate numbers of glochidia.

Similar problems may also be blamed for loss of species in the genus *Dysnomia*, which were once commonly collected in riffles or shoals in large rivers (Stansbery 1970). Riffle and shoal habitats are now almost non-existent in large rivers in North America; their disappearance could be blamed for loss of recruiting populations of *Dysnomia* and *Plethobasus*.

A possible solution for long-term maintenance of *P. cooperianus* is artificial propagation (Isom and Hudson 1982) and translocation of immature forms to suitable habitats. Projects such as these will be important for separating direct effects of habitat alteration from indirect effects such as reduction in the availability of the host fish.

Acknowledgments

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CHARACTERIZATION OF A BIVALVE COMMUNITY IN THE TANGIPAHOA RIVER, MISSISSIPPI

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ABSTRACT

On 5 July 1983 a quantitative collection of bivalves was made at the Tangipahoa River in southern Mississippi. Although the river water was extremely soft and the substrate and water quality were good, a diverse and healthy mollusk community was found. In addition to the Asian Clam, Corbicula, *five species of unionids (*Fusconaia flava, Quadrula pustulosa, Elliptio crassidens, Tritogonia verrucosa *and* Villosa sp.*) were taken. Numerically,* Corbicula *(8.93/m²), outnumbered total unionids (1.24/m²). However the dominant feature of the benthic biomass were the unionids with a total tissue dry mass of 1704.5 mg/m² as compared with 1015.0 mg/m² for* Corbicula.

Mississippi bivalves were first investigated by Hinkley (1906), later by Grantham (1969), and then Stern (1976) who concentrated on the unionids of the Lake Maurepas-Pontchartrain-Borgene drainage system. Recent mollusk studies in Mississippi include an investigation of mussels in the Big Black River (Hartfield and Rummel 1984), distribution of *Corbicula* (Hartfield and Cooper 1983), and a discussion of diversity and abundance of mussels in the southwest portion of the state (Hartfield and Ebert 1984). The above-cited studies, while providing useful information on species composition and ecology, have been directed toward qualitative assessments of the molluscan fauna. Quantitative unionid studies, either in Mississippi or other parts of the country, are relatively uncommon. The primary reason for this is the difficulty of collecting significant numbers of live mussels from a measured area. Benthic grab samplers usually do not retrieve enough substrate to provide reliable population estimates; in addition, they do not function well in gravel habitats. The purpose of this research was to characterize, using quantitative field and laboratory techniques, a bivalve community in the Tangipahoa River in southern Mississippi.

Study Area

The Tangipahoa River originates in Lincoln County, flows south through Amite and Pike counties, then enters Lake Tangipahoa approximately 4 miles southeast of McComb in southern Mississippi. Below Lake Tangipahoa the river flows in an easterly direction into Louisiana and ultimately enters Lake Pontchartrain near New Orleans. The study site (latitude 31°07′15″N., longitude 90°29′25″W., elevation 85.3 M, McComb S, Miss., US Geological Survey Quadrangle) was located south of Lake Tangipahoa and 2 miles south of the town of Magnolia. In this area the river consisted of pools, riffles, and runs with steep, partially eroding banks. Canopy cover was usually complete and surrounding land was either undeveloped riparian forest or pasture. At the time of collection the water depth was no greater than 1.0 m, except in pools, and widths ranged from 4 to 10 m. Based upon preliminary surveys, this site was judged to be one of the richest for bivalves when compared with adjacent rivers or other portions of the Tangipahoa River.

Substrate at the study site consisted of gravelly sands. On 5 July 1983 chemical conditions of the river water were as follows: calcium hardness, 3.2 mg/1; pH, 6.8; and turbidity, 8.9 NTU. On 12 August at 1300 hr the air temperature was 27°C and water temperature was 24°C. Additional chemical data from the Tangipahoa River at Hwy 190 in Louisiana (taken from the Louisiana Stream Control Commission as cited by Stern 1976) further characterize this river as clear, well oxygenated, and with low dissolved solids and turbidity.

Methods and Materials

Mollusks were collected from two adjacent riffles by two workers during a 6-hr period on 5 July 1983. Unionids were obtained from both sites (214 m^2) and *Corbicula* were taken only from a subsection of the downriver site (44 m^2). Bivalves were the dominant feature of the community; no snails or fingernail clams and only a few immature insects were collected. Collections were made by hand or with a basket dredge, an open-ended wire basket that was pulled through the substrate and retained only objects equal to or greater than 1 cm in diameter. All mollusks were kept cool and returned to the laboratory alive. The majority of the specimens were used in a series of laboratory experiments on navigation effects that were part of the Environmental and Water Quality Operational Studies at the Waterways Experiment Station.

In the laboratory, total shell length and height were recorded. Anterior and posterior mussels were cut with a scalpel or small knife and the viscera removed. Shells and viscera were dried for 24-48 hr at 75°C before weighing to the nearest 0.1 mg on a Mettler balance. Regression equations for length, height, or tissue dry mass (TDM) were derived after transforming data to $\log_{10}$ or $\log_2$ with an IBM 4331 computer using the Statistical Analysis System.

Results and Discussion

At the study area on the Tangipahoa River, *Corbicula*, which was common in Mississippi by the late 1960's (Grantham 1969), represented 87.8% of the total bivalve fauna (Table 1). Asian Clams were common throughout the downriver site, even in shallow water on unanchored sands where unionids were never collected. Length-frequency analysis (Fig. 1) indicated that two major cohorts were present in early July. About 40% of the *Corbicula* were approximately 14-mm long; the second cohort ranged from 20 to 30 mm. Based on *Corbicula* collections made in May in the Altamaha River, Georgia, Sickle (1979) identified a cohort at 14 mm and a second at 22 mm. In that river the first year spawn had achieved 4 mm by August of the same year. In the Tangipahoa River the second year cohort was more slow growing and exhibited a wider range of lengths than did the first year group, findings which are consistent with Sickle (1979). A power curve (Fig. 2) provided the highest r^2 value for the relationship between shell length and TDM. Sickle (1979) concluded that the rela-

TABLE 1. Summary statistics for bivalves collected from two adjacent sites on the Tangipahoa River, Pike County, Mississippi, 5 July 1983.

	Total Numbers			Tissue Dry Mass		Shell Length, mm			
Species	No. Collected	No./m^2	%	TDM/m^2	%	$\bar{X}$	CV*	min	max
Corbicula	393	8.93	87.8	1015.0	37.3	21.6	23.6	10.0	33.0
Fusconaia flava	158	0.74	7.3	531.1	19.5	46.0	16.1	31.3	70.0
Quadrula pustulosa	55	0.26	2.5	296.8	10.9	47.6	11.8	36.6	64.2
Elliptio crassidens	31	0.14	1.4	605.5	22.3	105.9	10.9	84.0	126.0
Tritogonia verrucosa	18	0.08	0.8	271.1	10.0	94.0	13.1	69.0	108.0
Villosa sp.	4	0.02	0.2	-	-	52.9	15.3	43.8	61.1
Total unionids	266	1.24	12.2	1704.5	62.7				
Total bivalves	659	10.17		2719.5					

* Coefficient of variation

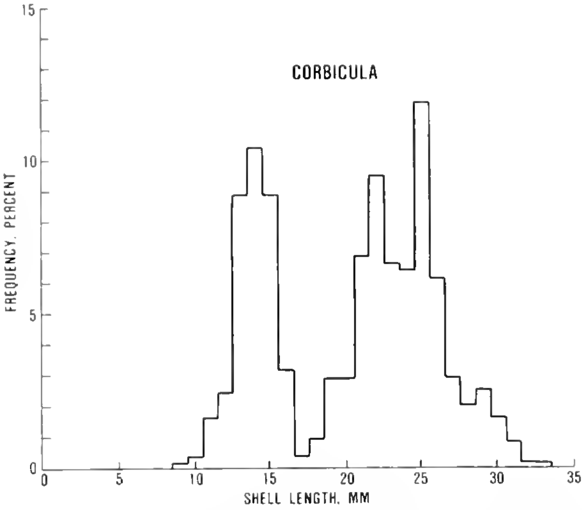

FIG. 1. Shell length-frequency distributions for *Corbicula* collected from the Tangipahoa River, Pike County, Mississippi.

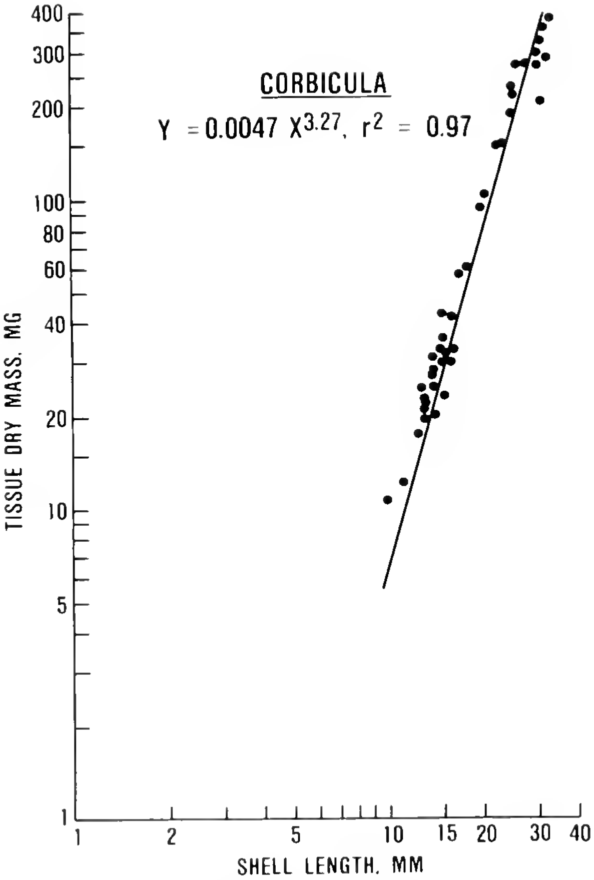

FIG. 2. Relationship between tissue dry mass and shell length for *Corbicula* collected from the Tangipahoa River, Pike County, Mississippi.

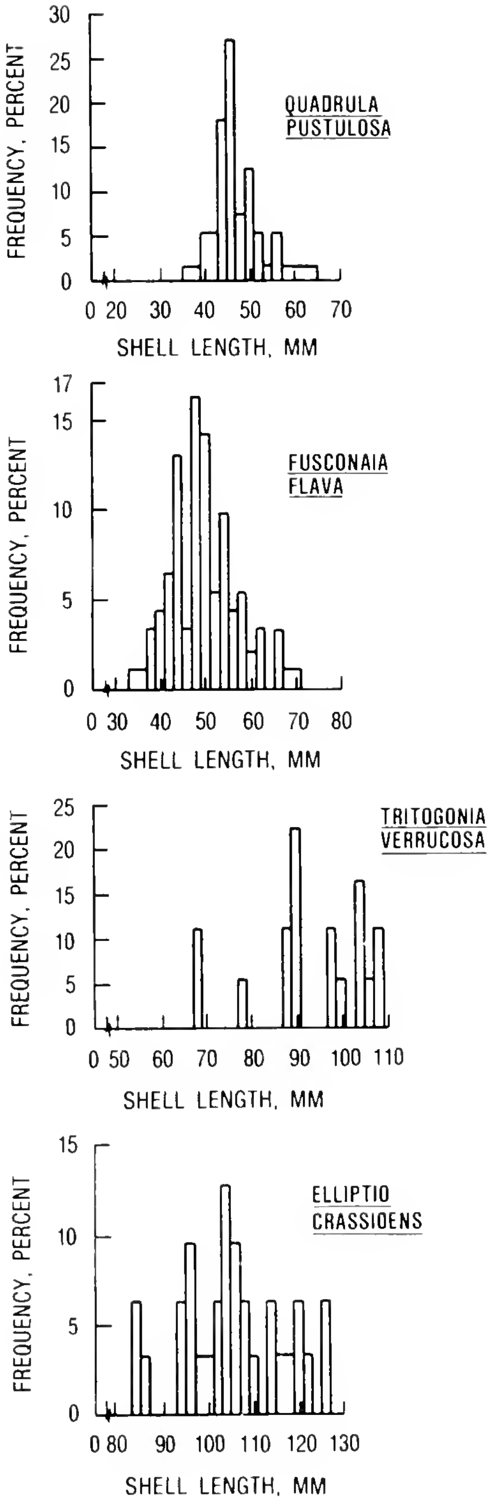

FIG. 3. Shell length-frequency distributions for four species of mussels collected from the Tangipahoa River, Pike County, Mississippi.

tionship between length and TDM was best described with a power curve for Altamaha River fauna and collections made in the Mud River, West Virginia, by Joy and McCoy (1975). Although *Corbicula* numerically dominated the Tangipahoa River bivalve community, because of their smaller size they constituted only 37.3% of the total molluscan TDM (Table 1).

Fusconaia flava[1], a widely distributed unionid in southern Mississippi and Louisiana (Stern 1976), was the most abundant unionid in the Tangipahoa River with densities equal to 0.74/m². The second most abundant species, *Quadrula pustulosa*, (this southern form called *refulgens* Lea by some) has been collected in mud, sand, and gravel substrate in flowing and slack water habitats in this region (Stern 1976). Total shell length for *F. flava* ranged from 31.3 to 70.0 mm; length-frequency distributions (Fig. 3) suggest that a major cohort existed from 36 to 44 mm. For *Q. pustulosa* a cohort was identified at approximately 45 mm with at least one below and possibly two cohorts above this range. For both of these Tangipahoa River unionids, the highest r² for length and TDM was a function of X² (Fig. 4). *Quadrula pustulosa* exhibited a slightly higher ratio of TDM to shell length, an indication of greater tissue mass compared to length of shell, than did *F. flava*. While *F. flava* and *Q. pustulosa* comprised only 7.3% and 2.5% of the bivalve community, because of their larger size they represented 19.5% and 10.9% of the total bivalve TDM, respectively.

While *Elliptio crassidens* and *Tritogonia verrucosa* exhibited densities of 0.14 and 0.08/m², respectively, the contribution of these larger bivalves to the total TDM was approximately equal to that of the previous two species (22.3% and 10.0%, respectively). Grantham (1969) reported that the former species had sporadic distribution in Mississippi, and Stern (1979) found *E. crassidens* common in headwater streams in this region. Average shell length of *E. crassidens* (105.9 mm) exceeded that for *T. verrucosa* (94.0 mm) by approximately 10%. A linear plot of total shell length to total shell height (Fig. 5) demonstrated a greater ratio of height to length for *E. crassidens* then *T. verrucosa* at sizes greater than 97 mm. For individuals larger than 97 mm, the reverse was true; height to length was greater for *T. verrucosa* than for *E. crassidens*.

In this section of the Tangipahoa River, *F.*

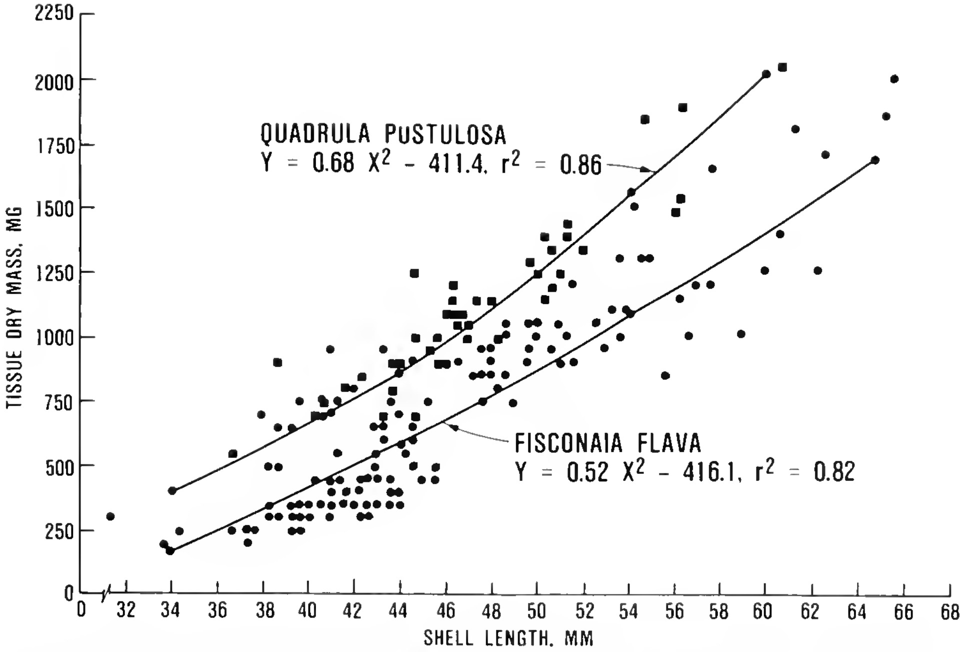

FIG. 4. Relationship between tissue dry mass and shell length for *Q. pustulosa* and *F. flava* collected from the Tangipahoa River, Pike County, Mississippi.

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[1] Alias *cerina* Conrad, 1838. See Hartfield and Rummel (1985).

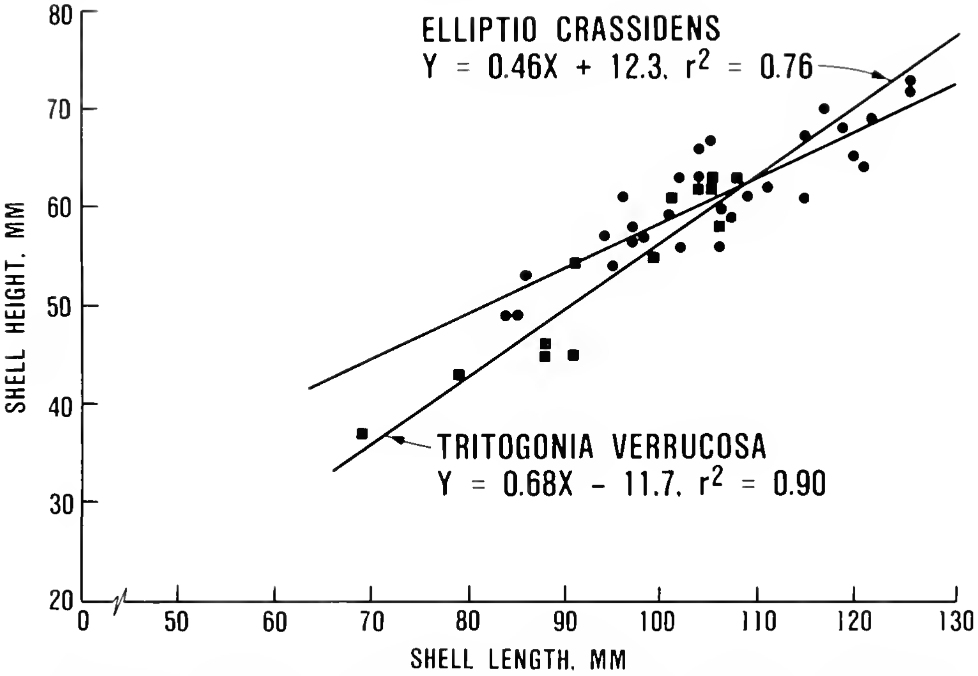

FIG. 5. Relationship between shell height and shell length for *E. crassidens* and *T. verrucosa* collected from Tangipahoa River, Pike County, Mississippi.

flava, because of its numbers, and *E. crassidens*, because of its size, dominated the unionid TDM. The other three unionids, *Q. pustulosa*, *T. verrucosa*, and *Villosa* sp., were a minor part of the unionid community. While the unionids dominated the bivalve biomass (62.7%), they were outnumbered by *Corbicula* (87.8%). In addition, the Asian clams, because of their rapid growth rates, exhibited higher productivity in terms of tissue growth per unit time than did the unionids.

Since dissolved calcium is of obvious importance for shell maintenance, it is significant that the Tangipahoa River supported a healthy community regardless of soft water (3.2mg/ℓ as $CaCO_3$). In central New York, Clarke and Berg (1959) collected no unionids in water with total alkalinity less than 47 ppm. Harman (1969) found unionids in water with total alkalinity ranging between 20 and 30 mg/ℓ and stated that sudden changes in pH were probably more detrimental than low dissolved solids. Tangipahoa River fauna live in water at the extreme lower end of the range of dissolved calcium concentrations usually reported for the freshwater Mollusca.

A site on the Tangipahoa River in southern Mississippi was identified which supported a dense, fairly diverse mollusk community. Bivalves were found in good quality substrate in water that was clear, well oxygenated but with extremely low dissolved calcium levels. While freshwater mollusks are usually found in medium to hardwater habitats, it appears that reduced dissolved calcium concentrations are not limiting the Tangipahoa River fauna.

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NOTES ON SPECIES OF *BROCCHINIA* (GASTROPODA: CANCELLARIIDAE)

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ABSTRACT

Available replacement names are discussed for Voluta mitraeformis *Brocchi, 1814, the type species of* Brocchinia *Jousseaume, 1887, and a primary junior homonym of* Voluta mitraeformis *Lamarck, 1811.* Cancellaria pusilla *Adams, 1869 is also preoccupied. This Recent species is redescribed as* Brocchinia clenchi, *n. sp.*

Voluta mitraeformis Brocchi, 1814, a well-known cancellariid of the European Tertiary, is the type species of the genus *Brocchinia* Jousseaume, 1887. Although this taxon is frequently cited, its status as a junior primary homonym of *Voluta mitraeformis* Lamarck, 1811 has been noted in the literature only by Malatesta (1974:376) and Davoli (1982:61).

Malatesta (1974:377) considered *Cancellaria pusilla* H. Adams, 1869 to be available as a replacement name for the preoccupied *Voluta mitraeformis* Brocchi, although he considered the Recent and Tertiary populations to be separable. He further stated that the "fossil subspecies" (*sottospecie fossile*) had as an available name *Cancellaria cerithiopsis* Almera & Bofill, 1887 (*sic*). Malatesta's conclusions are incorrect as *C. pusilla* H. Adams is not an available name, being a junior primary homonym of *Cancellaria pusilla* Sowerby, 1832, and *C. cerithiopsis* Almera & Bofill dates from 1898, not 1887. Earlier synonyms of *V. mitraeformis* Brocchi exist, as shown below.

Davoli (1982:61) stated that *Voluta mitraeformis* Brocchi, 1814 and *Voluta mitraeformis* Lamarck, 1811 should not be regarded as primary homonyms inasmuch as Brocchi pointed out that his species belonged to Lamarck's genus *Cancellaria*. Davoli referred to the Preamble of the International Code of Zoological Nomenclature in his plea for retention of Brocchi's *V. mitraeformis*, but the applicable portion of the Code in this instance is Article 60a which states: "A junior homonym *must* be rejected . . ." (italics added). This is unequivocal.

Brocchinia Jousseaume, 1887

Type, by subsequent designation of Sacco, 1894, *Brocchinia mitraeformis* (Brocchi) (= *Voluta mitraeformis* Brocchi, 1814 non *Voluta mitraeformis* Lamarck, 1811; = *Brocchinia parvula tauroparva* Sacco, 1894).

Brocchinia has been cited as a subgenus of *Narona* H. & A. Adams, 1854 by various authors (see synonymy in Malatesta, 1974:377).

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The type of *Narona* is *Cancellaria clavatula* Sowerby, 1832 from the tropical eastern Pacific. There is no evidence for a subgeneric relationship between the two genus-level taxa. *Narona* is characterized by a somewhat tabulate shell having a distinct anterior canal; its columella bears two strong, sharp folds, the posterior one being superior. *Brocchinia* has a small nontabulate shell with a rounded anterior; the short siphonal canal evidenced only as a slight curving of the columella; its two columellar folds are weak and rounded.

Brocchinia parvula parvula (Beyrich, 1856)

Synonymy–

Cancellaria parvula Beyrich, 1856:58, pl. 3, figs. 82a-b.

Cancellaria bicarinata Hörnes & Auinger, 1890:281, pl. 33, figs. 16a-c.

Brocchinia mitraeformis parvula (Beyrich), Janssen, 1983:9, pl. 1, figs. 5-7; pl. 5, fig. 3, text-fig. 4.

Cancellaria parvula Beyrich is apparently the earliest named taxon considered to be a synonym or subspecies of *Voluta mitraeformis* Brocchi, and therefore becomes the nominotypical subspecies of the species group (I.C.Z.N. Article 47). This German Miocene species was cited by Glibert (1952:130, pl. 9, fig. 16; 1960:4) as a form of *C. mitraeformis* (Brocchi), his figure agreeing well with Beyrich's original figures. *Brocchinia parvula* has been treated as a valid species, separable from *B. mitraeformis*, by Kautsky (1925:137), Sacco (1894:70) and Seiber (1936:93). Davoli (1982:61) mentions *C. parvula* in his discussion but does not include it in his synonymy of *B. mitraeformis*. Malatesta (1974:376), in his synonymy, lists Kautsky's citation of *B. parvula* but does not list the original description, a possible indication that he considered the two to be separable. In the most recent paper treating the subject, Janssen (1983:9, 10) considers *B. parvula* to be a subspecies of *B. mitraeformis* (Brocchi) and states that *B. parvula* occurs in the Mediterranean Pliocene as well as in the northern European Miocene. This interpretation of the relationship between *B. parvula* and *B. mitraeformis* agrees with this writer's opinion.

Brocchinia parvula tauroparva Sacco, 1894

Synonymy–

Voluta mitraeformis Brocchi, 1814:645, pl. 15, fig. 13 (non *Voluta mitraeformis* Lamarck, 1811:73).

Brocchinia mitraeformis var. *tauroparva* Sacco, 1894:68, pl. 3, fig. 82.

Narona (Brocchinia) mitraeformis (Brocchi), Davoli, 1982: 61, pl. 7, figs. 3-6.

Sacco (1894:68-70) named eight varieties of *Brocchinia mitraeformis* (Brocchi) from the Italian Pliocene. The first of these, *Brocchinia mitraeformis tauroparva*, is not distinct from the typical form, and is here considered to be a subjective synonym of *B. mitraeformis* (Brocchi). *Brocchinia tauroparva* (Sacco) thus replaces the preoccupied *V. mitraeformis* Brocchi.

Brocchinia clenchi, n. sp.

Figs. 1-4

Synonymy–

Cancellaria pusilla H. Adams, 1869:274, pl. 19, fig. 12 (non *Cancellaria pusilla* Sowerby, 1832:6, fig. 34).

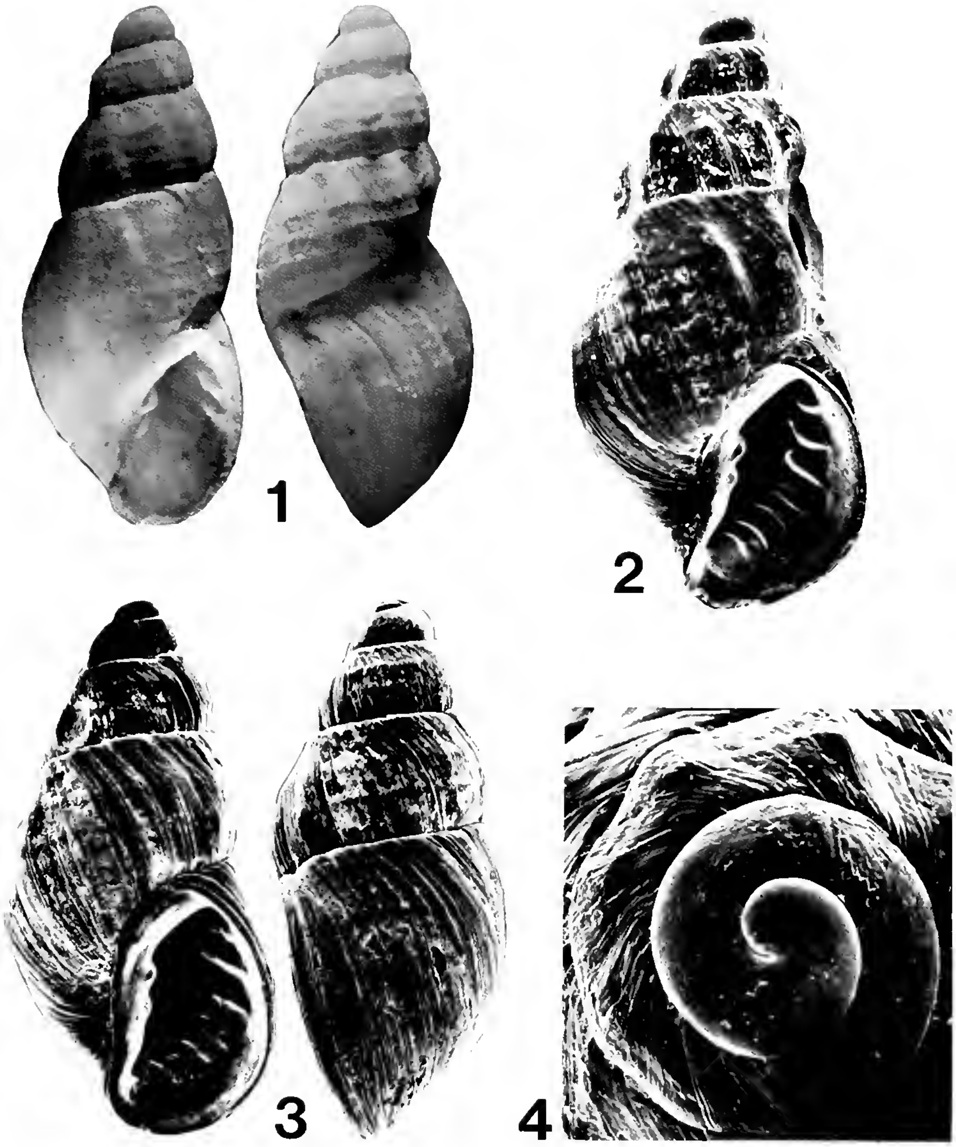
Cancellaria mitraeformis Brocchi, Jeffreys, 1885:49.

Narona (Brocchinia) pusilla (H. Adams), Nordsieck, 1968: 151, pl. 25, fig. 87.30.

Description–Paucispiral nucleus smooth, heliciform, consisting of about 1½ whorls; transition from protoconch to teleoconch almost imperceptible. Faint peripheral spiral cords arise midway on the first postnuclear whorl. The spiral sculpture consists of 3 to 5 extremely weak cords, with 3 usually visible on the spire whorls, and 5 or so on the body whorl. Axial sculpture, when present, consists only of weak nodes on the periphery that are crossed by the spiral cords. Suture distinct, slightly impressed. Teleoconch of about 4 whorls; nonumbilicate. Aperture ovate with a weak but noticeable columellar callus. Columella with two distinct, rounded folds of approximately equal size, the posterior one being slightly larger and more pronounced. Siphonal canal indicated by the angled base of the columella and a minute depression in the base of the aperture. Outer lip prosocline, usually denticulate within. The denticles, which do not extend to the edge of the lip, vary in strength and number. Shell white or horn colored. Animal unknown.

Type Material: Holotype, 4.5 mm × 2.3 mm (USNM 849002); Paratype, 5.2 mm × 2.6 mm (USNM 189694); Paratype, BM(NH) 1855.4. 4.202, 6.0 mm × 2.5 mm (possibly the type of *C. pusilla* Adams).

Type locality: Josephine Bank, 340-430 fms. Josephine Bank is situated at approximately



FIGS. 1-4. *Brocchinia clenchi* new species. **1**, Paratype, BM(NH) 1855.4.4.202, Oratova, Canary Islands, 15×. **2**, Paratype, USNM 189694, Josephine Bank, 621-786 m, 20×. **3**, Holotype, USNM 849002, Josephine Bank, 621-786 m, 20×. **4**, Apical view of protoconch of holotype, 65×.

37°N, 14°W, due West of the southern tip of Portugal. The type and paratype in the USNM are from the Jeffrey's collection.

Etymology: This species is respectfully dedicated to the memory of the late Dr. William J. Clench.

Discussion: This Recent species was previously described as *Cancellaria pusilla* Adams, 1869, but that name is preoccupied by *C. pusilla* Sowerby, 1832. Jeffreys (1885:49) placed *C. pusilla* Adams in the synonymy of *C. mitraeformis* (Brocchi), while Sykes (1911:332), Harmer (1918:396) and Dautzenberg (1927:73) considered the Recent species to be distinct.

The Recent *B. clenchi* is easily separable from the Tertiary species by its much smaller size and by its comparatively weak sculpture. The illustration accompanying Adams' description of *C. pusilla* is misleading, as the fine, almost indistinct spirals are shown to be quite strong.

The drawings of Nordsieck (1968:pl. 25, fig. 87.30; 1979:pl. 37, fig. 6) are too poor to be recognizable. Although included by Nordsieck & Talavera (1979:152) with the notation that its occurrence in the Canaries may be accidental, specimens have now been found in fish traps in Tenerife South at a depth of 43 m (Talavera, pers. comm.).

As the type of *C. pusilla* Adams cannot be positively identified, the species has been redescribed so that a holotype can be designated, rather than simply proposing a *nomen novum*. The BM(NH) specimen listed as a paratype is from the R. M. McAndrew collection.

Acknowledgments

This paper would not have been possible without considerable assistance. Dr. Franco Davoli, Universita di Modena, Italy, furnished a translation of his work, and corresponded regarding the desirability of retaining Brocchi's taxon. Mr. Piero Piani, Bologna, Italy, furnished translations, comments and literature.

Mrs. Kathie Way, British Museum (Natural History), London, located the possible type of Adams' *C. pusilla* and made it available for study.

The late Dr. Joseph Rosewater, National Museum of Natural History, Washington, D.C., made the Jeffreys specimens available and located pertinent references.

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ON THE TYPE SPECIES OF *METULA* H. & A. ADAMS, 1853: *BUCCINUM CLATHRATUM* A. ADAMS AND REEVE, 1850 (GASTROPODA: BUCCINIDAE)

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ABSTRACT

The type species of Metula *H. and A. Adams, 1853:* Buccinum clathratum *A. Adams and Reeve, 1850 (not Kiener, 1834, nor Anton, 1839) is determined to be referable to* Metula amosi *Vanatta, 1913, from the tropical eastern Pacific. The genera* Acamptochetus *Cossmann, 1901;* Antemetula *Rehder, 1943; and* Colubrarina *Kuroda and Habe, in Kuroda, Habe, and Oyama, 1971, are placed in the synonymy of* Metula.

The "*Metula* problem" has long been the concern of workers dealing with these buccinid gastropods owing to the uncertain nomenclatural and taxonomic status of the type species of this genus-group taxon (E. A. Smith, 1904; Woodring, 1928; Tomlin, 1927; Rehder, 1943; Altena, 1949; Knudsen, 1956; Cernohorsky, 1971; Olsson and Bayer, 1972, Kilburn, 1975; and Houbrick, 1984). This note undertakes to solve these questions.

The type of *Metula*, *Buccinum clathratum* A. Adams and Reeve (1850, p. 32, pl. 11, fig. 12), was stated to have been dredged off the Cape of Good Hope, in 136 fathoms [248 meters] during the 1843-1846 voyage of the H.M.S. "Samarang". Tomlin (1927, p. 160), in his review of the South American mollusks of the "St. George" Expedition, however, noted that this species was: "Originally described from deep water off the Cape, but that locality, like many others in the 'Samarang' work, is certainly erroneous." Furthermore, Tomlin (1927, *op. cit.*) concluded that this taxon was referable to specimens in his collection from Balboa, Panama, which he identified as "*Metula clathrata* (A. Ad. & Rve.)". Because later workers have largely ignored or questioned the identity of *Buccinum clathratum* A. Adams and Reeve, 1850, the type species of *Metula* H. and A. Adams, I examined the holotypic specimen of this taxon, which is in the British Museum (Natural History).

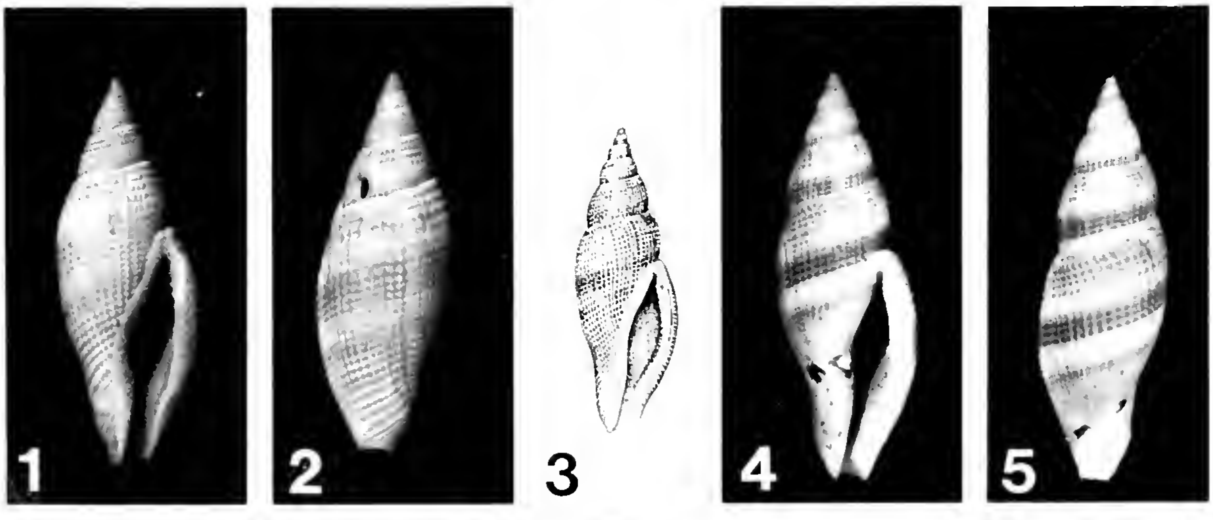
The specimen labeled as holotype of *Buccinum clathratum* (BM(NH), 1874.12.11.145; here illustrated, figures 1, 2) is 25.3 mm in height. The original polychrome illustration of the type (A. Adams and Reeve, 1850, pl. 11, fig. 12) depicts a specimen of the same size as the holotype, which is now faded and has a chip on the anterior portion of the outer lip.

As Cernohorsky (1971, p. 149) has pointed out, *Buccinum clathratum* (A. Adams & Reeve, 1850) is twice preoccupied (not Kiener, 1834, p. 101, nor Anton, 1839, p. 91). Fortunately, a replacement name is not required, as *Metula amosi* Vanatta (1913, p. 22, figs. 1, 2; Keen, 1971, p. 566, fig. 1133; Olsson and Bayer, 1972, pp. 906, 907, figs. 1, B-D) is an available junior synonym of this taxon. The most common of the Panamic *Metula*, this species ranges offshore from the Gulf of California to Panama Bay. Although large specimens attain more than 44 mm in height, mature examples of *M. amosi* in the American Museum of Natural History (AMNH) collection from Mexico and Panama are nearly as diminutive as the holotype of *M. clathrata*. Tomlin's (1927, *op. cit.*) referral of this species to Pacific Panamanian waters is thus confirmed, and the type locality of *M. amosi* is here restricted to Balboa, Bahía de Panamá.

It should be noted that Knudsen (1956, pp. 39, 40, pl. 1, fig. 1) referred a specimen dredged off "Spanish Guinea", West Africa to *Metula clathrata* (A. Adams & Reeve, 1850) (not Kiener, 1834, nor Anton, 1839). The specimen figured by Knudsen is 47 mm in height (here reproduced, fig. 3) and is referable to an unidentified specimen of *Metula* in the AMNH collection (#198755; here illustrated, figs. 4, 5) from "West Africa", *ex*-Marcel Pin collection. Another record of this west African species, taken in 250 meters off Dakar, Senegal (Natal Museum J. 4152) was referred to me by Dr. R. N. Kilburn. These specimens, however, are not conspecific with *Metula clathrata* (=*M. amosi* Vanatta) on the basis of the type specimen of A. Adams and Reeve's *M. clathrata* (cf. figures 1, 2 with figures 3-5), and they appear to represent a new species. Nor is Knudsen's west African specimen referable to *Metula boswellae* Kilburn (1975, pp. 594, 595, fig. 10b, 10c), from off "Moçambique", East Africa. Kilburn (1975, p. 592) accepted Knudsen's (1956, *op. cit.*) referral of the "Spanish Guinea" specimen to *M. clathrata* (A. Adams & Reeve, 1850) and he noted that this taxon was preoccupied. Kilburn (1975, *op. cit.*), therefore, renamed this taxon, *Metula knudseni* (Kilburn, 1975, p. 592). This unnecessary replacement name thus becomes a junior subjective synonym of *Metula amosi* Vanatta, 1913.

A number of authors have discussed the taxonomic status of *Metula* H. and A. Adams (1853, p. 84). Rehder (1943, p. 199) appears to be the first to attribute *Metula clathrata* (A. Adams and Reeve, 1850) as the type species (subsequent selection of Kobelt, 1876, p. 29, pl. 6, fig. 11 [="12"]). Woodring (1928, p. 286; 1964, p. 259; Keen, 1971, p. 566; Olsson and Bayer, 1972, p. 902) considered *Buccinum metula* Hinds, 1844, to be the type species by "hidden tautonymy," for which there is no provision in the ICZN Code. Thus, this designation must be rejected (Cernohorsky, 1971, p. 149). Kobelt's (1876, *op. cit.*) selection of *Metula clathrata*, as the type species, therefore, appears to be the first available designation for *Metula*.

Cernohorsky (1971, pp. 151, 152) and Houbrick (1984, p. 420) considered *Acamptochetus* Cossmann (1901, p. 123) and *Antemetula* Rehder (1943, p. 199) to be congeneric taxa. The type species of *Acamptochetus*, by original designation, is *Murex mitraeformis* Brocchi, 1814, from the Neogene of Italy and is a typical *Metula* (Cernohorsky, 1971, fig. 46). Other Neogene fossils are known from Europe, Java, Sumatra, India and the Americas (Altena, 1949;



FIGS. 1-5. 1 and 2, *Metula amosi* Vanatta, holotype of *Buccinum clathrata* A. Adams and Reeve, BM(NH) 1874.12.11.145, ×2. 3, "*Metula clathrata*" after Knudsen (1956, pl. 1, fig. 1) from "Spanish Guinea", not *Metula clathrata* (A. Adams and Reeve), ×1½. 4 and 5, *Metula* sp., AMNH 198755, ex-Marcel Pin coll., from "West Africa", ×1½.

Olsson and Bayer, 1972; Malatesta, 1974; and Grecchi, 1978). The type species of *Antemetula* by original designation is *Buccinum metula* Hinds, 1844. This species was originally reported from the "West coast of Veragua [República de Panamá] . . . from a depth of a few fathoms, among mud." This locality, however, is apparently an error, as no additional specimens have been recognized in tropical American waters. The type specimen (Hinds, 1844, pl. 16, figs. 13, 14; refigured by Keen, 1971, p. 567, fig. 1134 and by Olsson and Bayer, 1972, fig. 1A) is not in the British Museum (Natural History) *teste* Kathie Way, 1985). Furthermore, this specimen could not be located there some 35 years ago (Altena, 1949, p. 385). Many years ago Smith (1904, p. 465) noted a close resemblance of young specimens of *Metula mitrella* (A. Adams and Reeve, 1850, p. 32, pl. 11, fig. 13, from the "China Sea; . . . ten fathoms"), to the illustration of the type specimen of *M. metula*. Smith (1904, *op. cit.*) concluded that *Buccinum metula* was conspecific with *B. mitrella*, a well-known Indo-West Pacific species, and that the original west American locality was probably erroneous. I agree with his conclusions (*cf.* the illustration of Cernohorsky (1971, p. 150, fig. 47) with that of Olsson and Bayer (1972, p. 905, fig. 1A). If this interpretation is correct, *M. mitrella* (A. Adams and Reeve, 1850) is a junior subjective synonym of *M. metula* (Hinds, 1844) and this taxon should be removed from the eastern Pacific faunal list.

Kilburn (1975, p. 592) assigned the genus-group name, *Colubrarina* Kuroda & Habe, in Kuroda, Habe & Oyama (1971, p. 173) to the synonymy of *Metula*. The type species of this taxon by original designation is *Antemetula (Colubrarina) metulina* Kuroda & Habe, in Kuroda, Habe & Oyama, 1971 (*op. cit.*, p. 173, pl. 46, fig. 9), from Honshu and Shikoku, Japan, in 90-200 m. Described as a subgenus of *Antemetula* Rehder, the type species of *Colubrarina* was said to differ from the nominate subgenus by having a larger and more coarsely sculptured shell.

In summary, the buccinid genus *Metula* H. and A. Adams, 1853, with the type species: *M. clathrata* (A. Adams and Reeve, 1850) [=*M. amosi* Vanatta, 1913 (synonym: *M. knudseni* Kilburn, 1975)], is available for an assemblage of Neogene species from the Old and New World tropical belt and for several Recent species surviving in the tropics. *Acamptochetus* Cossmann, 1901 (type species: *M. mitraeformis* (Brocchi, 1814), *Antemetula* Rehder, 1943 (type species: *M. metula* Hinds, 1844) and *Colubrarina* Kuroda and Habe, 1971 (type species: *M. metulina* Kuroda and Habe, 1971) are junior synonyms.

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I also wish to join others in congratulating *The Nautilus* on its 100th anniversary of its founding and to express my particular appreciation of having known and benefited from the friendship of three past Consulting Editors – Karl Jacobson, Joe Rosewater and Bill Clench.

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SOME ADDITIONAL TAXONOMIC UNITS THAT FIRST APPEAR IN PUBLICATIONS BY J. G. COOPER

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ABSTRACT

Seventeen taxonomic units that first appeared in publications by James Graham Cooper and that were not given in my earlier table of his taxa are listed here. All but three are nomina nuda.

It is said that the more complete a list is, the more glaring are its omissions. So it is, perhaps, with my listing of the taxonomic units that first appeared in the publications of James Graham Cooper (Coan, 1982:148-185). Seventeen names that should have been in that list have come to my attention since my book was published. Most of them were well hidden, being credited to other workers. Fourteen of these names are *nomina nuda*, only three actually being validated by Cooper. Two replace previous homonyms. The third is a synonymous generic unit. It is not impossible that other similarly hidden taxa will come to light in the future.

In the listing of mollusks below, I follow the format used in my previous table. The Cooper papers cited refer to the Literature Cited of this article, but I also provide, in brackets, references keyed to the complete bibliography of Cooper's papers given in my book (Coan, 1982:223-231).

Class **Bivalvia**

beringi, Thracia – Cooper, 1894 [1894b]: Suppl., 12th sheet, *ex* Dall MS [*nomen nudum*]. Later validated by Dall, 1915: 442.

compacta, Sanguinolaria – Cooper, 1894 [1894b]: 126th sheet [*nomen nudum*]. Not subsequently validated.

complectens, Tellina – Cooper, 1894 [1894b]: Add. & Corr., 4th sheet, *ex* Carpenter MS [*nomen nudum*]. Not subsequently validated.

Philobrya – Cooper, 1867 [1867b]: 12, *ex* Carpenter MS. Type Species – *Bryophila setosa* Carpenter, 1864a: 314, by monotypy.

Remarks – *Bryophila* Carpenter, 1864a:314, proved to be a homonym (*non* Treitschke, 1825:57), and Carpenter himself later renamed it as *Philobrya* (Carpenter, 1872: index, p. 21). By then, however, it was too late; Cooper had already validated the name. Cooper did not expressly propose *Philobrya* as a replacement name and it must therefore be taken as a new genus.

Class **Gastropoda**

bimaculata Clypidella – Cooper, 1867 [1867b]: 24, *ex* Dall MS [*nomen nudum*]. Later validated by Dall, 1871:132; 160; plt. 15, fig. 7), as *Fissurellidaea bimaculata*.

callomarginata, Clypidella – Cooper, 1867 [1867b]: 24, *ex* Carpenter MS [*nomen nudum*]. Later validated by Dall, 1871:133; 160; plt. 15, fig. 8.

clathrata, Ocinebra interfossa "var." – Cooper, 1870 [1870f]:69, *ex* Carpenter MS [*nomen nudum*]. Later validated by Dall, 1919:334, as *Tritonalia interfossa clathrata*.

compactum, Buccinum – Cooper, 1894 [1894b]: 15th sheet, *ex* Dall MS [*nomen nudum*]. Not subsequently validated.

gabbiana, Chemnitzia – Cooper, 1867 [1867b]: 34. New name for *Turbonilla gracillima* Gabb, 1865:186, *non Chemnitzia gracillima* Carpenter, 1857:431.

harpa, Tornatina – Cooper, 1870 [1870f]: 56, *ex* Dall MS [*nomen nudum*]. Later validated by Dall, 1871:136-137; 160; plt. 15, fig. 11.

Leptothyra Cooper, 1867 [1867b]: 25. Type Species – "*L. sanguinea* Cpr.," = *Turbo sanguineus* Linnaeus, 1758: 763 (**subsequent designation herein**).

Remarks – A synonym of *Homalopoma* Carpenter, 1864b:537, 588, 627, 652, which has the same type species. Previous workers have evidently missed Cooper's validation of *Leptothyra*, dating it instead from Dall, 1871:130. It thus becomes a senior homonym of *Leptothyra* Pease, 1869:70, and if workers wish to save this name, a petiton would have to be filed with the International Commission on Zoological Nomenclature.

muricata, Ocinebra interfossa "var." – Cooper, 1870 [1870f]: 69, *ex* Carpenter MS [*nomen nudum*]. Not subsequently validated.

paucicostata, Leptothyra – Cooper, 1867 [1867b]: 25, *ex* Dall MS [*nomen nudum*]. Later validated by Dall, 1871: 131; 160; plt. 15, fig. 10.

sitkensis, Odostomia – Cooper, 1894 [1894b]: 100th sheet, *ex* Dall MS [*nomen nudum*]. Not subsequently validated.

stearnsiana, Lamellaria – Cooper, 1870 [1870f]: 67, *ex* Dall MS [*nomen nudum*]. Later validated by Dall, 1871: 122; 160; plt. 15, fig. 6, but as *L. stearnsii*.

Class **Polyplacophora**

fimbriatus, Callochiton – Cooper, 1867 [1867b]: 23, *ex*. Carpenter MS [*nomen nudum*]. Later validated by Keep, 1887:112, as *Callistochiton fimbriatus*.

latior, Placiphorella – Cooper, 1894 [1894b]: 113th sheet, *ex* Carpenter MS [*nomen nudum*]. Not subsequently validated.

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__________ 1870 [1870f in Coan, 1982]. Notes on the Mollusca of Monterey, California. Amer. Journ. Conch. **6**(1): 42–70 (7 July 1870).

__________ 1894 [1894b in Coan, 1982]. Catalogue of west North American and many foreign shells, with their geographical ranges. For labels, exchange, and check lists. With a supplement. Sacramento, Calif. (Calif. State Mining Bureau) 181 unnumbered pages grouped in stapled sections [see Coan, 1982, for details]. main body: Title page + Preface + 160 pp.; Suppl.: Title page + 13 pp.; Add. & Corr.: 5 pp. (April 1894).

Dall, William Healey. 1871. Descriptions of sixty new forms of mollusks from the west coast of North America and the North Pacific Ocean, with notes on others already described. Amer. Journ. Conch. 7(2):93–160; plts. 13-16 (2 Nov. 1871).

________ 1915. A review of some bivalve shells of the group Anatinacea from the west coast of America. United States Nation. Mus., Proc. **49**(2116):441–456 (27 Nov. 1915).

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Gabb, William More. 1865. Descriptions of new species of marine shells from the coast of California. Calif. Acad. Sci., Proc. (1) **3**(3):182–190 (Jan. 1865).

Keep, Josiah. 1887. West coast shells. A familiar description of the marine, fresh water, and land mollusks of the United States, found west of the Rocky Mountains. San Francisco (Bancroft Bros) 230 pp.; 182 figs.; frontis. (post-July 1887).

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NOTES ON THE HABITS AND ANATOMY OF THE INTRODUCED LAND SNAILS, *RUMINA* AND *LAMELLAXIS* (SUBULINIDAE)

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ABSTRACT

Marking experiments showed that Rumina decollata *moved no more than 25 inches from points of release in a six-month period, demonstrating, as with most introduced forms, that passive distribution prevails. Egg-to-egg span was slightly over a year in the lab. While normally considered carnivorous,* R. decollata *will feed on a variety of vegetation, and were routinely fed lettuce. Average growth is 1.46 mm in width/week and average whorl addition is 1.18 whorls/week. At 10 mm high, the snails lose the upper 3.0–3.5 whorls and fill in the top with a septum. An individual snail may deposit 30–50 ova over a period of several days on more than one occasion from February to June in this area. They are deposited in shallow depressions, and soil particles adhere to them, thus rendering them inconspicuous.*

Notes on the anatomy and a brief histological statement of the digestive, nervous, and reproductive systems of Lamellaxis gracilis *are given.*

Since the publication (Dundee, 1970) of a study of four introduced mollusks, further information has been gathered about the two species: *Rumina decollata* (Linnaeus, 1758) and *Lamellaxis gracilis* (Hutton, 1834). The information is presented here as follows: (a) observations on *Rumina decollata:* movement, reproduction, growth and decollation, longevity (b) notes on the anatomy-histology of *Lamellaxis gracilis.*

Observations on *Rumina decollata* (Linnaeus, 1758)

Movements. Six marking experiments, identical to those described for *Bradybaena similaris* and *Lamellaxis gracilis* (see Dundee, 1970), were done in Greenwood Cemetery in New Orleans. The maximum movement demonstrated in any of the experiments was 25 inches from the point of release over a six month period. This seems to verify the idea that introduced mollusks do not disperse through their own power but, rather, are distributed through

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[1] Published posthumously. Dr. Dundee died May 7, 1985. Article proofed by the editor.

passive means.

Reproduction. Despite Sealander's (1974) statement concerning self-fertilization being "... the major mode of reproduction . . ." in *Rumina decollata*, Batts (1957) reported, and I have observed, regular matings between individual snails thus suggesting that cross-fertilization is the prevailing method in the species. Sealander (1974), later in the paper, states that ". . . we cannot unquivocally conclude that reproduction in the singles involved self-fertilization rather than parthenogenesis."

Ova were seen in both in the field and in the lab. Rascop (1960) reported one snail producing 55+ ova over a period of 3-5 days. In my lab colony, the members of which began reproducing after reaching about ten months of age, the average number of eggs/snail/deposition period was 32. In the field, clusters of 15-41 eggs were observed at various times. Sealander (1974), on the other hand, reported 105 snails laying 6822 eggs or, when calculated, 64/eggs/snail average which is considerably higher than these averages. It appears that, when one considers Rascop (1960), Batts (1957), Sealander (1974), and this present work, that *Rumina decollata* may produce anywhere from 7-64 eggs at one deposition period and then repeat the process several times over a period of a few weeks.

The ova are deposited singly, but close enough together so that they form clusters. They are placed in shallow depressions in the soil. Deposition occurs from February to June in this Gulf Coast area. A non-productive period then occurs, followed by more egg deposition from September to November.

Average incubation time was ten days at an ambient temperature range of 21-27°C in the lab. Batts (1957) reported an average time of 28.5 days but recorded no temperatures. She also reported one incubation time of 9 days. Sealander (1974) reported the incubation period under laboratory conditions to be about 30 days. He did not describe lab conditions.

Growth and decollation. Nineteen lab juveniles were observed for slightly over a year. The snails, being herbivores as well as predatory carnivores, were given lettuce and other local snails as food. The graph (Fig. 1) in showing constant growth, demonstrates indirectly that this is an adequate diet to support them since they grow to maximum size on it.

Average growth in height in the lab at 21-27°C is 1.46 mm/week and average whorl addition is 1.18 whorls/week. Those figures remain valid until the snails reach 10 mm in length. At that 10-mm point the upper 3.0-3.5 whorls are lost and the snail is said to be "decollate". If one

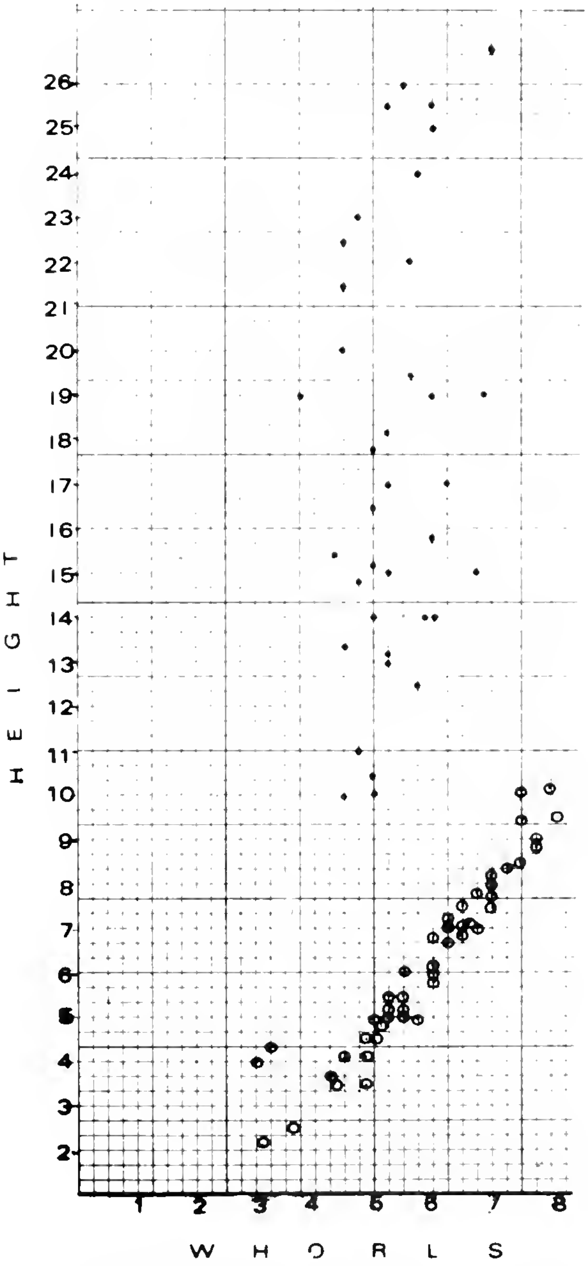


FIG. 1. *Rumina decollata*. This graph shows in terms of height and number of whorls. At the 10 mm high point, the snails become decollated thus having fewer whorls but continuing growth in height. Open circles represent non-decollate individuals; solid dots represent decollate ones.

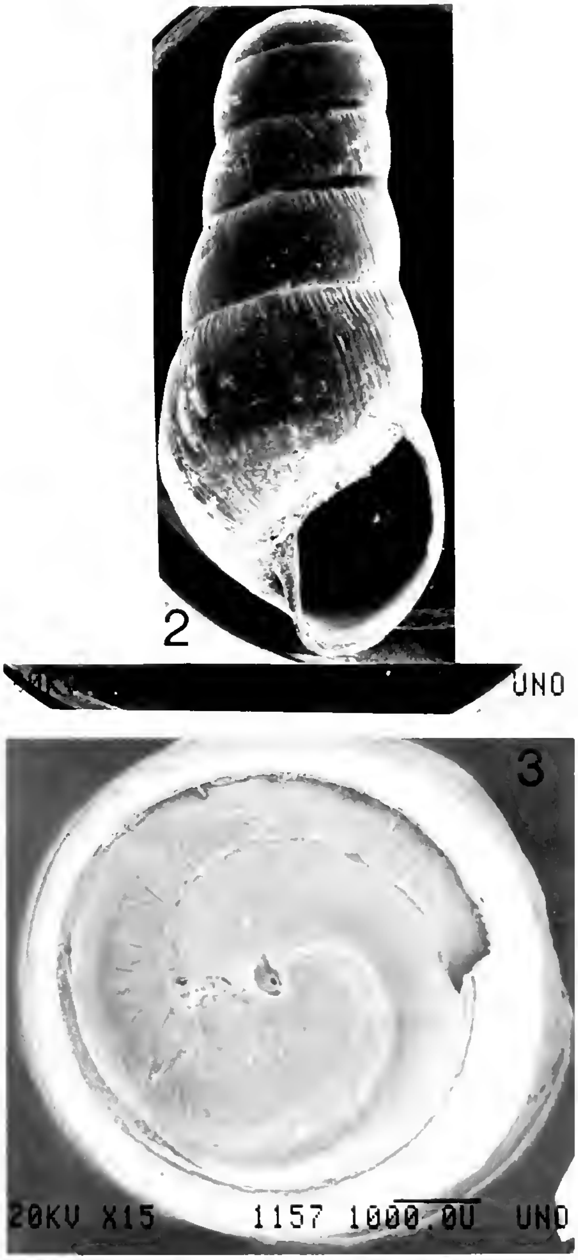
examines a 9-mm-long, non-decollate specimen (Fig. 2), one notices a peculiar-appearing apex area. The first 3.0-3.5 whorls have a smooth, glassy appearance, whereas the remaining whorls have some striations. The second major whorl below the protoconch is inflated thus giving the top of the shell a puffy appearance. The shell decollates just beneath the whorl below the inflated one. I have been unable to observe how the breakage occurs although it has been reported that the snail bangs its upper whorls violently against a hard object to get rid of them (Cooke, 1895). Batts (1957) reported observing them striking the shell against rocks or the aquarium wall to aid in decollation. A calcareous septum, resembling the protoconch, is formed as a cover for the top of the broken shell (Fig. 3). It is easily seen in the decollate forms. If one breaks off the top whorls of a 9.5-mm-long specimen, one discovers that the top 3.0-3.5 whorls break much easier than those below and that there is no septum present; it is apparently secreted after decollation occurs. Figure 3 is a view of a septum as one looks down on the top of a decollate shell. Notice that the umbilicus is retained.

Decollation occurs in widely separated taxa from pulmonates to prosobranchs. It occurs in terrestrial as well as aquatic forms (brackish water). It seems to have evolved independently several times. Examination of a serial section of a 9-mm-long *R. decollata* reveals nothing unusual about the internal anatomy in the area which is destined to break off. One can only speculate at this point on the selective advantage of casting off part of the shell. Perhaps the upper whorls serve as a storage for toxins during early growth; perhaps decollation is a behavorial matter related to habitat (e.g., ability to get under shelter); perhaps it is only a nonselective mutant. The entire matter needs further study.

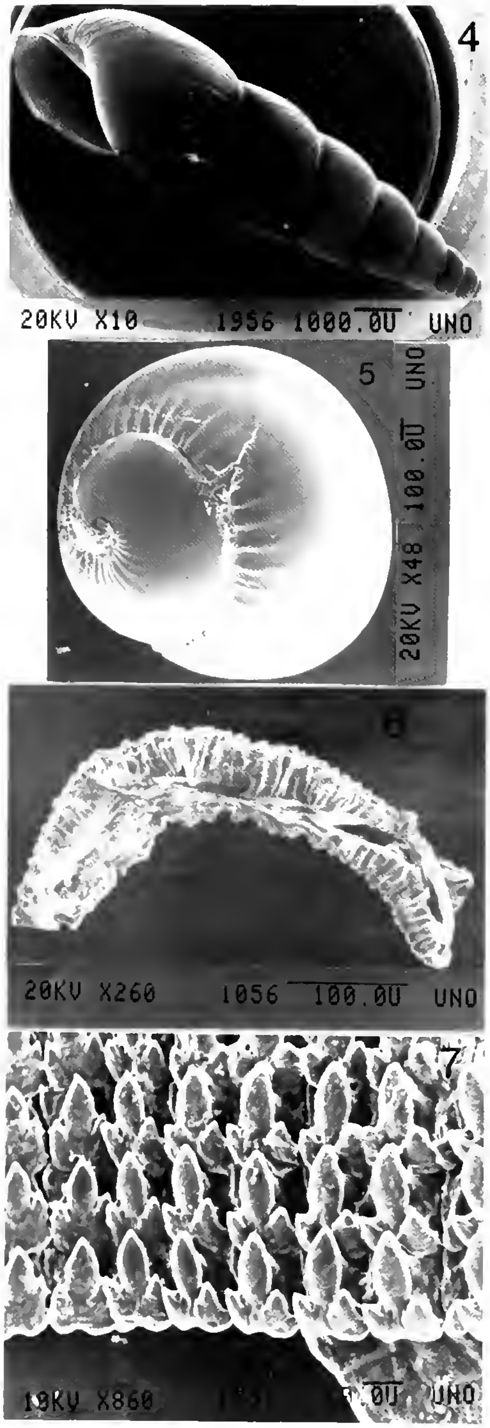
Longevity. The longest I have been able to keep this species alive in the lab is just over a year. Rascop (1960) reports a longevity record of 12 years but does not cite a reference. That seems a very long time considering longevities of various other snails (Hyman, 1967). Years of observations by the author have shown that mollusks tend to reproduce just prior to the extinction of the colony. This colony, which was followed from egg-to-egg, began reproducing at ten months which was approximately two months prior to the death of the last colony member.

Observations on *Lamellaxis gracilis*

Shell. Figure 4 shows a typical adult shell. The maximum size seen in the New Orleans area



FIGS. 2 and 3. *Rumina decollata*. 2. A specimen of approximately 9 mm showing the smooth quality of the top three whorls as opposed to the striations on the remaining ones. 3. A view into the top of a large decollate specimen.



FIGS. 4-7. *Lamellaxis gracilis*. **4**, Adult shell. **5**, An about-to-hatch snail dissected from its egg case. **6**, The jaw. **7**, Central and lateral teeth.

was 13 mm in length, 3.5 mm in width at the broadest point, and with 9.25 whorls. The maximum size of *Lamellaxis micra* (Orbigny, 1835) which also has been introduced to this area was, by contrast, 7.2 mm × 2.2 mm, and had 6.75 whorls. The color of *L. gracilis* is light tan and all whorls except the protoconch are finely striated. A small umbilicus is partially hidden by a minor reflection of the lip (Fig. 4). Unhatched ova (Fig. 5) removed from the female system show clearly the beginnings of striation except on the protoconch.

Jaw. This structure is found at the entrance to the pharynx in a mid-dorsal position. As can be seen in Figure 6, it is a single, curved device which has coarse transverse ribbing.

Radula. The radula (Fig. 7) is relatively narrow with little variation among central, lateral, and marginal teeth. The teeth are reminiscent of marginals of *Helix aspersa* except the lateral cusps are more pronounced.

Digestive system. The esophagus, lined by tall, ciliated columnar epithelium and underlain by a thin circular muscle layer surrounding an equally thin longitudinal layer. The esophagus leaves the pharyngeal area, passes through the nerve ring and posteriorly into the stomach; (Fig. 9 ST). In keeping with other Stylommatophora, no crop was found. The stomach is lined by tall, columnar, ciliated epithelium underlain by a double muscle layer (longitudinal and circular) and surrounded by connective tissue. The lining is folded in several areas. The digestive gland (Fig. 8, D) empties into the stomach via two ducts – one from each section of gland. A dissection showing the two parts is very difficult and can only be done with fresh (non-preserved) material. Histological observations reveal two cell types making up the digestive gland (also called liver and hepatopancreas). A tall columnar cell type which contains numerous vacuoles is often seen with the lumen in a state of disintegration implying secretion. The second type is a low, non-ciliated triangular form. Carriker and Bilstad (1946) reported similar cells and called them “digestive” and “calciferous” and determined that the latter contain calcium phosphate granules. Digestion is apparently both intra- and extra-cellular. Sections reveal partially digested material in the stomach lumen (Fig. 8, ST) and also in some the cells of the digestive gland. An intestine leaves the stomach, loops around in the same whorl as the stomach, descends to the right dorso-lateral of the head-

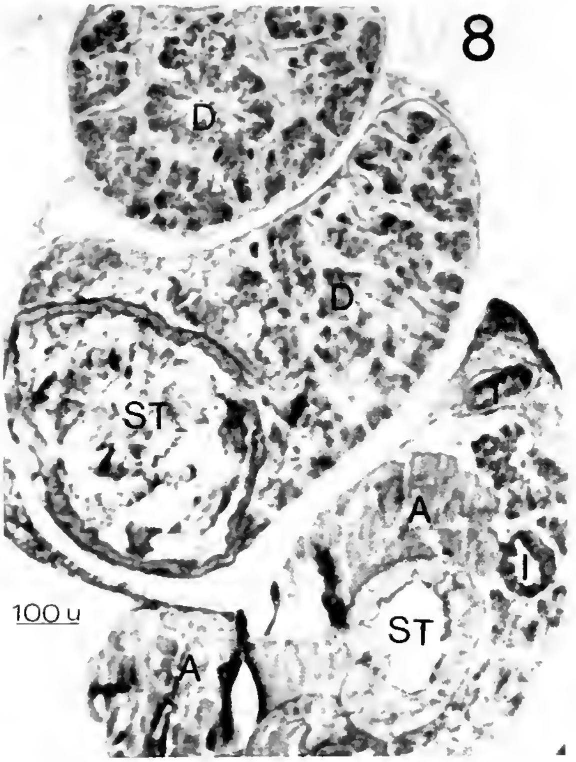


FIG. 8. *Lamellaxis gracilis.* Parasagittal section of a young snail. D = digestive gland; ST = stomach; I = intestine; A = albumen gland.

foot where the anus is located. The intestine (Fig. 8, I) is lined by tall, ciliated columnar epithelium containing mucous cells and underlain by an inner longitudinal and an outer circular muscle layer.

Nervous system. The ganglia form a ring around the anterior portion of the digestive tract just posterior to the pharynx. This is the result of detorsion wherein the parietal (intestinal) and visceral ganglia migrate forward near the pleural ganglia. In *Lamellaxis* the end result is two cerebral ganglia on the dorsal of the ring and two pleurals, two parietals, and a visceral (two fused ganglia) forming the ventral portion of the ring and innervating the entire visceral mass. The total nervous system was not traced.

A pair of eyes, located on the dorsal tips of the posterior tentacles, are typical pulmonate vesicular types (Hyman, 1967, p. 584). The statocysts, located adjacent to the pedal ganglia in the foot, are small spherical vesicles each containing calcareous granules. Each is covered by a layer of connective tissue and lined internally by a squamous-type epithelium with a layer of cilia equally spaced around the inner periphery.

Excretory system. A single nephridium is located near the dorso-posterior of the pulmonary cavity. If one holds the snail so that the aperture is facing him, the reno-pericardial mass is on the extreme lower right of the whorl above the aperture. The pericardial cavity has a duct from it into the sac-like nephridium. That nephridium, in most Pulmonates, opens into the pulmonary cavity directly via a slit or a short ureter. I could not determine which is present in this snail either by dissection or sections.

Reproductive System. *Lamellaxis* is hermaphroditic. The ovotestis, a grapelike cluster embedded in the digestive gland proximal to the columella, contains both oocytes near the periphery of each follicle and spermatocytes and sperm more centrally located near the duct of each. A coiled hermaphroditic duct, lined by low ciliated cuboidal epithelium, drains both the ovary and testis. At the lower end of that duct a small saclike structure, the seminal vesicle, appears to branch off and serves as a sperm storage area. It is seen full of sperm during the breeding season. Near that point, the male and female systems part company with each system continuing downward, closely applied to and paralleling each other (spermoviduct of some authors) through the whorls towards the anterior end.

The male system consists of a sperm duct (vas deferens) with a ciliated cuboidal lining. It receives a prostatic secretion via a small connection between the prostate and vas deferens. The prostate consists of cuboidal cells around an irregular lumen. The cells closest to the lumen disintegrate as a result of secretion. Nuclei are basal. The vas deferens continues downward and enters the verge. Just prior to that entry the duct becomes lined by tall, ciliated glandular epithelium. The system empties on the right side of the head near the base of the right tentacle. The verge is simply a long attenuated tubule with no secondary structures on it. At the point where the systems become separate the oviduct appears to enter a large albumen gland but, actually, the gland is large enough that it has the oviduct "embedded in" it (Fig. 9, A). The albumen gland has a varied histological structure ranging from cuboidal to low, ciliated, epithelial cells. This gland, in section, always appears striated and somewhat "crumbled". The lumen ends of the cells appear to disintegrate as secretions are formed.

Just ventral to this albumen gland, at the separation of the male-female systems is an area where fertilization occurs (fertilization pouch or carrefour in other pulmonates: e.g., (Petrellis and Dundee, 1969). A distinct pouch could not be located in *L. gracilis*. Only a slightly swollen area in the hermaphroditic duct exists. It is different histologically from the initial part of the duct in that the epithelium is ciliated columnar in contrast to low, non-ciliated cuboidal in initial portion of the duct. The change in histological structure indicates that the area is the equivalent of the fertilization pouch and is doubtlessly the site of fertilization.

Fertilized eggs receive their albumen coat as they pass by the albumen gland. As they continue anteriorly downward, the shell is added by the mucus gland (also called capsule gland) which is a continuation of the large glandular mass. The albumen and mucus glands can be distinguished microscopically by change from whitish, coarse appearance (albumen) to a smooth yellowish one with the entire mass convoluted (mucus). Microscopically the mucus gland differs from the albumen gland described above by being a highly glandular mass lined by cuboidal cells which, in many cases, are secreting as evidenced by the disintegrated inner cell mass. Non-secretory cells are ciliated, and cell boundaries are indistinct.

Often as many as 6-8 large ova can be seen lined up in the oviduct in the body whorl and the one immediately above it. Just at the point where ova emerge from near the mucus gland, the vagina receives a duct from the spermatheca (also called seminal receptacle or bursa), a sac which stores sperm from copulation. Histologically the spermatheca is composed of non-ciliated, tall columnar epithelium encapsulated in a muscle-connective tissue layer. The vagina is a muscular tubule lined by ciliated epithelium. It ends at the gonopore which is found in the right dorso-lateral area of the head.

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New Awards

The Division of Mollusks, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution announces the availability of two fellowships to be awarded to graduate students of systematic malacology.

1. Rosewater Fellow Award (up to $500)
2. Smithsonian - Conchologists of America Fellow Award (up to $1,000)

These awards are to help support students for short term research visits to the collections and libraries of the Division of Mollusks, National Museum of Natural History and are to be used for systematic studies of Mollusca. Funds can help cover travel, subsistence, and research costs [xerox, postage, etc.]. Interested students should submit a 1-page proposal, a budget with indication of matching funding, if available, and a supporting letter from their faculty advisors. Deadline for applications is March 1, 1986. Awards will be announced on April 1, 1986.

NOTES

NOTE ON *CRYPTONATICA* DALL, 1892 (GASTROPODA: NATICIDAE)

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The naticid subgenus *Cryptonatica* was proposed by Dall (1892:362) with no type designation. Dall's first mention of *Cryptonatica* (p. 362) lists the species *Natica clausa* Broderip & Sowerby, *N. russa* Gould and *N. pusilla* Say as being included. A few pages later (p. 366) the new species *Natica (Cryptonatica) floridana* is described. As pages 362-366 were published at the same time, all four of these taxa are originally included species and are available for designation as type-species of *Cryptonatica*.

Cossmann (1896:238) in a review of Dall's 1892 publication designated *N. (C.) floridana* Dall as the type of *Cryptonatica*, an action overlooked by all subsequent authors, including Cossmann himself. Dall (1909:85) designated *N. clausa* Broderip & Sowerby as type, and this species has been accepted as type (although with differing citations for the designation) by all subsequent authors. Among those citing *N. clausa* as type of *Cryptonatica* are Cossmann (1925:120), Woodring (1928:384), Boss, Rosewater & Ruhoff (1968:95), and Marincovich (1977:409).

Natica clausa is a cold-water Recent species and *N. floridana* is from the Florida Oligocene. It is not the purpose of this paper to investigate or discuss the probable relationship of these species or the ramifications possible as a result of Cossmann's type-designation, but to call to the attention of naticid systematists it's existence so that appropriate action may be taken.

Cossman often made type designations in his reviews which appeared in various publications from 1888 to 1924. A listing of these designations is now in preparation and will be published in the future.

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NATICA (GLYPHEPITHEMA) BAYERI, NEW NAME

Harald A. Rehder
National Museum of Natural History
Smithsonian Institution
Washington, D.C. 20560

Richard E. Petit has called my attention to the fact that the species in the Naticidae that I described as *Glyphepithema floridana* in 1943 (Proc. U.S. National Museum: 93(3161):196-197, pl. 19, figs. 19-21) is preoccupied by *Natica (Cryptonatica) floridana* Dall, 1892, described from the Oligocene of the Tampa formation (Trans. Wagner Free Inst. Sci. Philadelphia 3(2):366, pl. 17, fig. 5). The taxon *Glyphepithema*, Rehder, 1943 (op. cit., p. 196), originally proposed by me as a genus, is now quite generally cited as a subgenus of *Natica*, and therefore the species name *floridana* Rehder needs to be replaced.

I propose to name this species *Natica (Glyphepithema) bayeri* Rehder dedicating it to my longtime associate and friend, F. M. "Ted" Bayer, who collected the holotype in Lake Worth, Florida. The species is found from southeastern Florida to Panama and northeastern Brasil (Abbott, American Seashells, ed. 2, p. 159, 1974).

DEATHS

A. Myra Keen – 1905 - 1986

One of the great giants of American malacology, Angeline Myra Keen, died on January 4, 1986, at the age of 80 in California. Dr. Keen was one of the leading forces in the development of students in malacology at Stanford University, and well-known not only for her excellent taxonomic work but also for her major contribution of popular books that aided legions of appreciative private shell collectors. She assisted and gave advice to many amateurs who wished to publish on mollusks.

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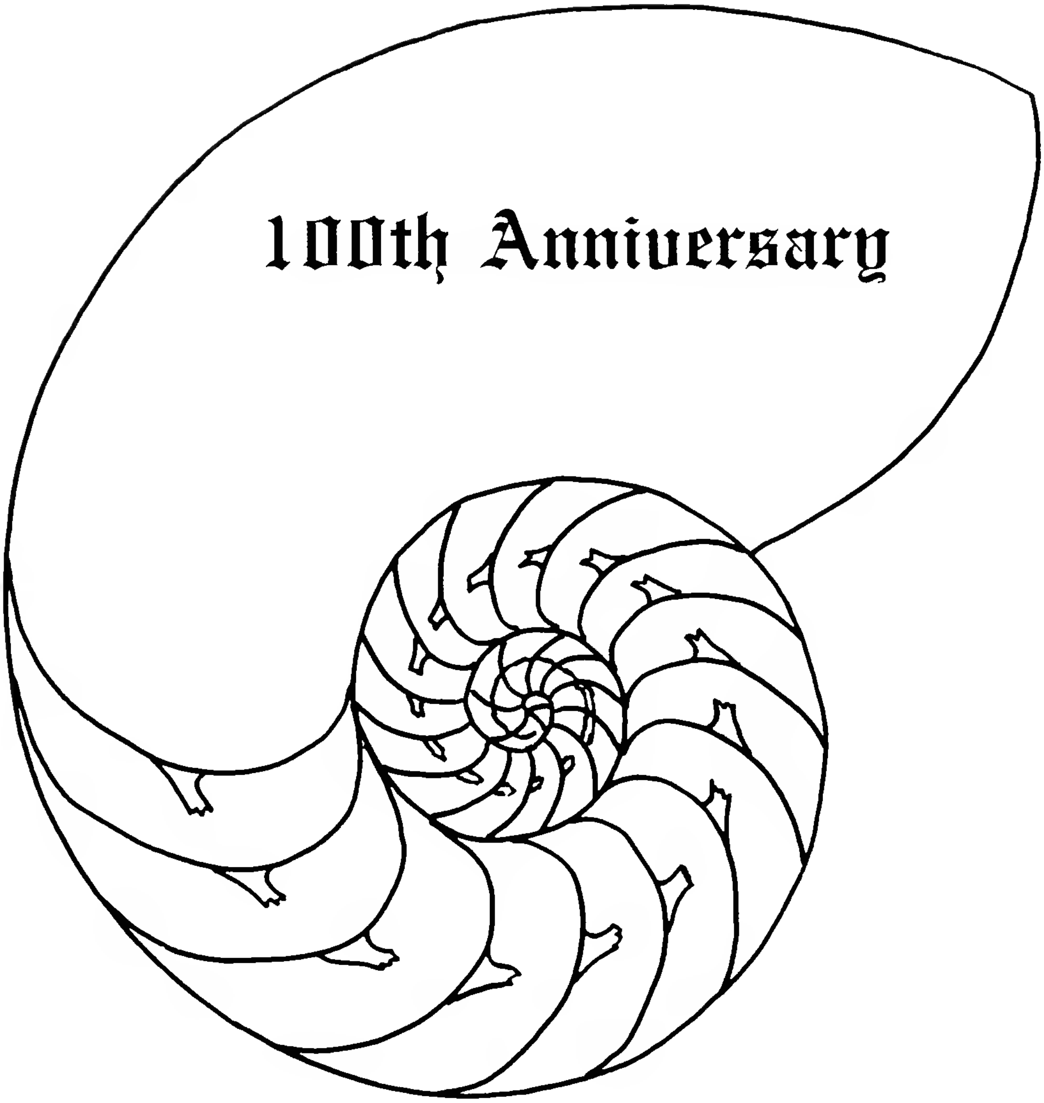

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A NEW GENUS AND SPECIES OF SCALLOP (BIVALVIA: PECTINIDAE) FROM OFF SOMALIA, AND THE DEFINITION OF A NEW TRIBE DECATOPECTININI

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ABSTRACT

Somalipecten *Waller, new genus, is one of ten extant pectinid genera that are placed in the new tribe Decatopectinini, which is characterized by low early beak inflation, very closely spaced commarginal lamellae, and very weak or absent resilial hinge teeth. The type species,* Somalipecten cranmerorum, *new species, from off Somalia in 150-300 m, is the sole survivor of a group of congeneric species that lived in the Neogene and Quaternary of the Red Sea and western Indian Ocean regions.*

Introduction

Many new species of shelled mollusks are still being discovered in the world's oceans, but it is remarkable when a new species turns out to be large in size, exquisitely beautiful in color and form, and also abundant at its type locality in a region thought to have a well-known molluscan fauna. In this report I describe a new scallop, *Somalipecten cranmerorum*, new genus and species, taken by Taiwanese trawlers working new fishing grounds off Somalia. This new pectinid genus, which has an extensive fossil record in Neogene and Quaternary strata adjacent to the Red Sea and western Indian Ocean, is one of ten extant genera that comprise a *new tribe*, Decatopectinini.

The system of measurement used here follows that in Waller (1969, 1972), in which shell height is measured as the perpendicular distance between the active outer ligament or hingeline and a parallel line drawn through the most ventral point on the ventral margin. References to numbers of teeth in the ctenolium refer only to the active ctenolium (Waller, 1984), not the inactive ctenolium partially obscured by the growth of the anterior auricle. The umbonal angle is the angle between lines diverging from the origin of growth and passing through the estimated points of union between the free margins of the auricles and the disk flanks. Observation of microsculpture was by means of a Wild M-5 binocular microscope at magnifications not exceeding ×50. Measurement employed an ocular micrometer as well as a goniometer eyepiece.

The term *antimarginal* is introduced with reference to microsculpture that maintains a nearly perpendicular relationship to the shell margin, exemplified by the *Camptonectes* microsculptural pattern (illustrated in Waller, 1972). In contrast, sculptural features such as plicae, which are described as radial, are perpendicular to the shell margins only in the midventral region and may be nearly parallel to margins in the region of the disk flanks. These terms complement the term commarginal, which has come into broad usage for features that are parallel to shell margins. I also propose new terms found to be useful for the description of hinge teeth in the Pectinacea. In the right valve, *resilial teeth* originate near the origin of growth of the shell and approximately parallel the anterior and posterior sides of the resilium, at least in early ontogeny. One such tooth borders each side of the resilium, as in *Chlamys islandica* (Müller, 1776). *Dorsal teeth* lie immediately ventral to the outer ligament, one such tooth bordering the outer ligament on each side of the hinge, and may originate at some distance from the origin of growth (arrows in Fig. 13). *Intermediate teeth* lie between resilial and dorsal teeth, are commonly differentially developed on the anterior and posterior sides of the hinge, and may be multiple, as in *Decatopecten* and *Pecten*.

The anatomy of *Somalipecten cranmerorum* cannot be described at present, because no soft parts were available to me.

Systematics

Class **Bivalvia** Linnaeus, 1758
Subclass **Pteriomorphia** Beurlen, 1944
[*emend.*, Boss, 1982]
Superorder **Eupteriomorphia** Boss, 1982
Order **Ostreoida** Waller, 1978
Suborder **Pectinina** Waller, 1978
Superfamily **Pectinacea** Rafinesque, 1815
[*emend.*, Waller, 1978]
Family **Pectinidae** Rafinesque, 1815
[*emend.*, Waller, 1978]
Subfamily **Pectininae** Rafinesque, 1815

Tribe Decatopectinini, *new tribe*

Diagnosis: Pectinidae having very closely spaced commarginal lamellae at least in early ontogeny and commonly throughout life, the spacing commonly ranging from about 30 to 70 lamellae per two-millimeter distance along a radius in center of disk at height of 10 mm; inflation of left beak very low, only very slightly exceeding that of right beak, the left beak extending only very slightly dorsal to hingeline; antimarginal microsculpture very fine and restricted to early ontogeny of disk to a distal limit slightly beyond origins of radial plicae, absent from disk flanks and auricles; dentition dominated by dorsal and/or intermediate teeth, the latter sometimes multiple or sometimes absent; resilial teeth low or absent.

Type Genus: Decatopecten Rüppel in Sowerby, 1839.

Taxonomic Composition – The new tribe contains the following extant genera, listed with their type species, geographic region, and some common synonyms:

Anguipecten Dall, Bartsch, and Rehder, 1938, type species *Anguipecten gregoryi* Dall, Bartsch, and Rehder, 1938 [junior synonym of *Pecten lamberti* Souverbie *in* Sourverbie and Montrouzier, 1874], tropical Indo-Pacific.

Annachlamys Iredale, 1939, type species *Pecten leopardus* Reeve, 1853 [junior synonym of *Pecten flabellatus* Lamarck, 1819], tropical western Pacific and eastern Indian Oceans.

Bractechlamys Iredale, 1939, type species *Bractechlamys erecta* Iredale, 1939 [junior synonym of *Pecten vexillum* Reeve, 1853], tropical Indo-Pacific and Western Atlantic.

Decatopecten Rüppel in Sowerby, 1839 [senior synonym of *Comptopallium* Iredale, 1939], type species *Ostrea plica* Linnaeus, 1758, tropical Indo-Pacific.

Excellichlamys Iredale, 1939, type species *Pecten spectabilis* Reeve, 1853, tropical Indo-Pacific.

Flexopecten Sacco, 1897 [senior synonym of *Glabropecten* Sacco, 1897, *Lissopecten* Verrill, 1897, and *Proteopecten* Monterosato, 1899], type species *Ostrea flexuosa* Poli, 1795, Mediterranean and adjacent eastern Atlantic.

Gloripallium Iredale, 1939, type species *Ostrea pallium* Linnaeus, 1758, tropical Indo-Pacific.

Juxtamusium Iredale, 1939, type species *Juxtamusium oblectatum* Iredale, 1939 [junior synonym of *Pecten (Chlamys) coudeini* Bavay, 1902], tropical western Pacific and Indian Oceans.

Mirapecten Dall, Bartsch, and Rehder, 1938, type species *Mirapecten thaanumi* Dall, Bartsch, and Rehder, 1938 [junior synonym of *Pecten mirificus* Reeve, 1853], tropical Indo-Pacific.

Somalipecten Waller, *new genus*, type species *Somalipecten cranmerorum* Waller, *new species* described herein, tropical western Indian Ocean.

Stratigraphic Range: Paleocene to present.

Discussion: In view of the common assumption that commarginal increments in many bivalves are periodic, indicative of growth rate, and hence subject to environmental modification, it would seem inappropriate to use commarginal spacing as one of the prime morphological differentia for a tribe. However, evidence is accumulating showing that growth increments are not always periodic and may occur in ways that are taxonomically specific and hence genetically determined (Jones, 1981; Ohno, 1985). Recently, Helm and Malouf (1983) suggested that there may be a minimal required distance between successive commarginal ridges in the Atlantic Bay Scallop, *Argopecten irradians* (Lamarck, 1819), and that this requirement may override any periodicity when the rate of shell growth is low. Gruffydd (1981) showed that in *Pecten maximus* (Linnaeus, 1758) faster growth is achieved by increasing both the width of growth increments and the number of ridges formed per unit of time. Whatever the cause of projecting commarginal lamellae in the Pectinidae, it is clear that these features are more closely spaced in members of the tribe Decatopectinini than in other scallops at a comparable shell size at least during early ontogeny. With few exceptions, genera outside the Decatopectinini have fewer than 25 commarginal lamellae per two-millimeter space at a height of 10 mm, and many of these have as few as 5 to 15.

As can be seen from the above list of geographic ranges of genera, the Decatopectinini are largely Indo-Pacific at present, and my own unpublished data on fossil distributions indicates that the tribe has been primarily Indo-Pacific throughout its geologic history. The two exceptional genera which also occur in the Atlantic, *Bractechlamys* and *Flexopecten*, both appear to have dispersed into the Atlantic from the Indo-Pacific, but from opposite directions.

The relationship of *Nodipecten* Dall, 1898, and *Lyropecten* Conrad, 1862, to the Decatopectinini is close, but both of these genera have more-widely-spaced commarginal lamellae, stronger intermediate teeth, and coarser umbonal microsculpture. A full account of the morphological differences that distinguish genera in the Decatopectinini, as well as a discussion of fossil history, zoogeography, and relationships to other suprageneric units within the Pectinidae, is in preparation.

Somalipecten Waller, *new genus*

Type Species: Somalipecten cranmerorum Waller, new species, from off Somalia, depth 150 to 300 m.

Diagnosis: Plicate Decatopectinini having both valves convex, byssal notch only moderately deep, left umbo only slightly convex or flattened, and disk with uneven curvature, incipient ledging, or widely spaced nodes at least in early ontogeny; secondary radial costae present distally; auricular costae on right posterior auricle weakly developed and few in number or absent; enlarged scales, if present, limited to left valve; dentition dominated by dorsal teeth, intermediate teeth weak, resilial teeth commonly absent.

Taxonomic Content: The new genus includes a number of fossil species from the western Indian Ocean region described in publications by Cox (1929) and Eames and Cox (1956): *Chlamys (Aequipecten) farsanensis* Cox, 1929, *C. (A.) isthmica* (Fuchs, 1878), *C. (A.) leesi* Cox, 1929, *C. (A.) lessepsi* (Fuchs, 1878), *C. (A.) pseudola* Eames and Cox, 1956, *C. (A.) werthi* (Philippi, 1901), and *C. (A.) wyllei* Cox, 1929.

Stratigraphic Range: Upper Miocene to present. All of the fossil species listed above, with the exception of *S. pseudola*, are from deposits adjacent to the Red Sea (Egypt, Sudan, Saudi Arabia), the western Indian Ocean (Somalia, Kenya, Tanzania, Zanzibar), and the Arabian Sea (southeastern Saudi Arabia, Iran). Their age was called "post-Miocene" by Cox (1929), and some are probably as young as late Pleistocene or Holocene. *S. pseudola* from Iran was said by Eames and Cox (1956) to range from Upper Miocene to Pliocene. *Somalipecten cranmerorum*, new species, is the only known living species.

Comparison: A somewhat flattened left umbo is also present in *Annachlamys*, which differs from *Somalipecten* in having a wider umbonal angle, in having commarginal lamellae which revert to a far-set condition late in ontogeny, and in lacking nodes, enlarged scales, or extensive secondary radial costae. Some members of *Bractechlamys*, specifically *B. langfordi* (Dall, Bartsch, and Rehder, 1938) and *B. noduliferum* (Sowerby, 1842), have nodes and ledges but differ from *Somalipecten* in having persistent deep byssal notches, strong intermediate teeth, and strong costae on all auricles. Extant *Nodipecten* Dall, 1898, and fossil *Lyropecten* Conrad, 1862, and *Macrochlamis* Sacco, 1897, differ in having far-set commarginal lamellae and much stronger intermediate hinge teeth. *Flexopecten* of the Mediterranean and eastern Atlantic differs in hinge details, the right dorsal teeth being much weaker or absent, and lacks nodes or enlarged scales. *Mirapecten* maintains a deep byssal notch throughout ontogeny and has enlarged scales on at least the posterior plica of both valves. *Notochlamys* Cotton, 1930, differs from *Somalipecten* in having persistent shagreen microsculpture, and *Mesopeplum* differs in having far-set commarginal lamellae and prominent resilial teeth.

Somalipecten crannerorum

Waller, *new species*

Figs. 1-13

Diagnosis: Somalipecten having four major plicae on right valve and three on left, the left valve also having a single plica of smaller amplitude adjacent to each disk flank; enlarged distally concave or enclosed scales few in number and widely spaced, limited to tops of plicae of left valve.

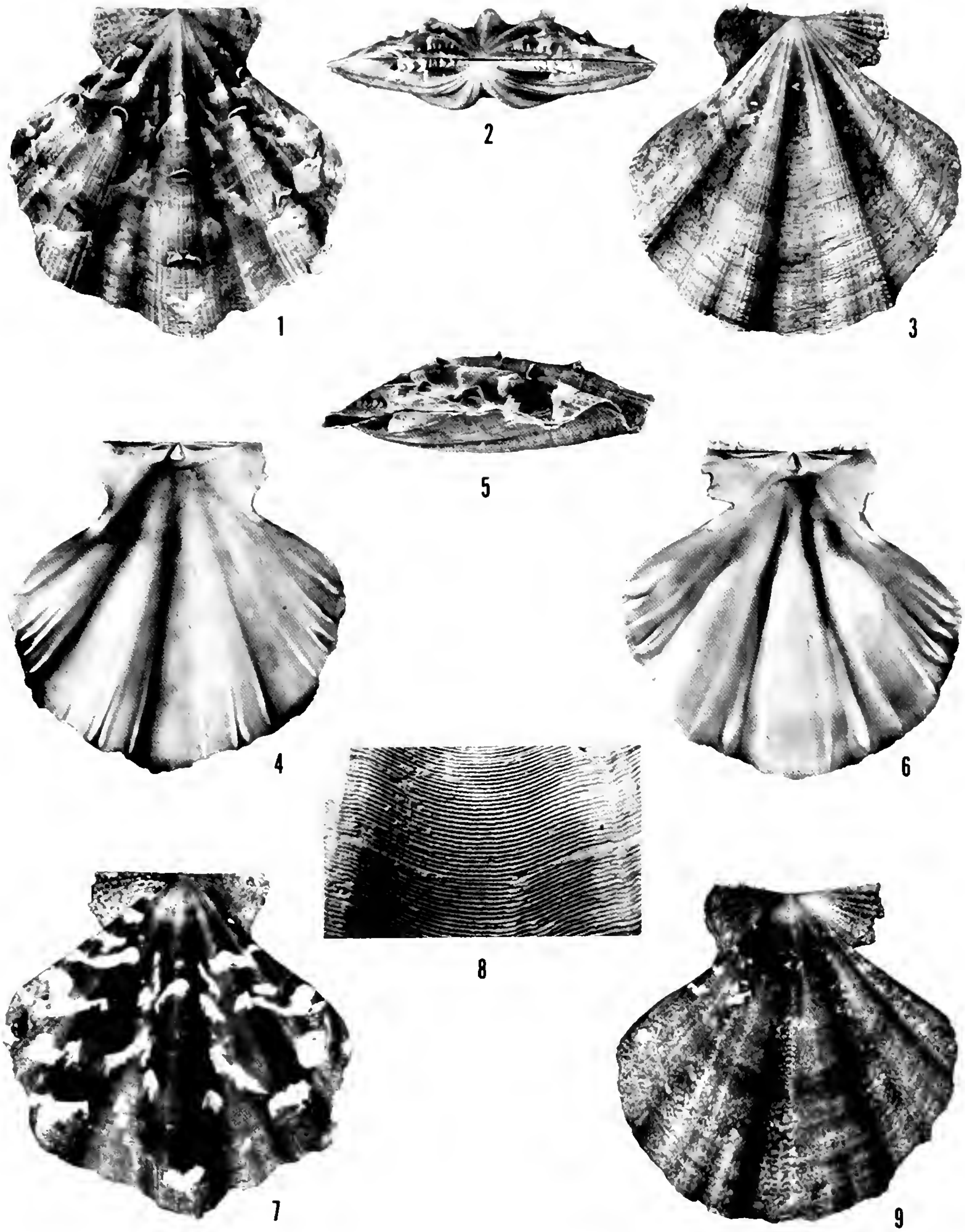
Description: Disk Outline – Moderately large, with height commonly 40 to 70 mm and seldom exceeding length, the ratio of height to length commonly 0.88 to 1.01; outline acline or slightly prosocline, rarely slightly opisthocline, and equilateral; anterior and posterior extremities of disk narrowly rounded, ventral margin broadly rounded; umbonal angle ranging from 93 to 104°; both valves convex, the right more so than the left, the umbone of left valve flattened; ratio of convexity of closed valves to height 0.22 to 0.37, averaging 0.31.

Auricle Outlines – Right anterior auricle with byssal notch only moderately deep, bordered on its ventral side by an active ctenolium of from 3 to 5 delicate, closely spaced teeth, which may be obsolescent in largest specimens; other auricles pointed, their free margins forming acute angles with hinge line; anterior auricles exceeding posterior in length, the ratio of length of anterior outer ligament to length of posterior outer ligament commonly 1.04 to 1.24; ventral migration of ligament system absent even in largest individuals.

Exterior Shell Surface – Right disk with 4 major plicae, at least the central ones beginning at a shell height of between 2 and 3 mm as pairs of low rounded costae with narrow raised crests, each pair then merging into a single broad rounded plica at shell height of 10 to 15 mm, the broad plica becoming flattened and bifid with the introduction of a median groove at a shell height of about 35 to 40 mm; anteriormost major plica bordered anteriorly in early ontogeny by a single costa along edge of disk flank; posteriormost major plica bordered posteriorly by a pair of costae in early ontogeny. Left disk with three major plicae bordered on anterior and posterior by a single lower plica, the broad interspaces broken by introduction of smaller median plicae corresponding to the median grooves on right plicae. Secondary radial costae beginning on tops of right plicae at shell heights between 4 and 12 mm and across both plicae and interspaces of both valves by a height of 40 to 55 mm. Disk flanks without radial or antimarginal costae. Right anterior auricle commonly with 5 to 7 costae at margin; other auricles with highly variable costation, the right posterior auricle commonly lacking or having only a few costae. Enlarged, distally concave scales, sometimes closed to form hollow knobs, limited to tops of the five major plicae of left valve, few in number and widely spaced, commonly fewer than 5 per plica, rarely absent or as many as 8 per plica. One or two commarginal ledges commonly present in distal fourth of disk. Prismatic stage of right valve extending to shell height of 1.8 to 2.3 mm. Microsculpture on left beak and early postprismatic stage of right valve before start of commarginal lamellae consisting of exceedingly fine antimarginal striae. Commarginal lamellae closely spaced throughout ontogeny, first appearing in interspaces of right disk at shell heights between 4 and 6 mm.

Internal Features – Dentition with dorsal teeth dominant, intermediate teeth very weak or absent, resilial teeth absent. Single crus present on inner surface of shell beneath each disk flank, a second crus sometimes present on ventral fourth of posterior auricles; other crura or marginal denticles generally absent on inner surfaces of auricles. Inner surfaces of plicae with carinate edges and commonly with numerous radially elongate marginal denticles. Ostracum inside pallial line consisting entirely of lathic calcite with coarse irregular patches of folia; crossed lamellar aragonite absent in mature shells.

Color – Basal pigment red, orange-red, or orange, either solid or broken by exceedingly fine white mottling and/or by bold oblique bars or chevrons of white; dark pigment commonly present on ventral sides of enlarged scales. Pigment more subdued on right valve than on left, the bold patterns generally restricted to left valve. Beaks commonly with fine intersecting diagonal white lines. Interior of shell commonly pigmented outside pallial line and more rarely



FIGS. 1-9. Holotype of *Somalipecten cranmerorum* Waller, new genus and species, USNM 859034, length 53.8 mm, from off Somalia, 150-300 m. **1-6**, Left exterior, dorsal, right exterior, anterior, left interior, and right interior views, ammonium chloride coating. **7**, Left exterior, uncoated. **8**, Detail of commarginal lamellae in central interspace of right valve at heights between 14.7 and 17.1 mm, coated with ammonium chloride. **9**, Right exterior, uncoated.

10

11

12

13

FIGS. 10-13. Views of two paratypes of *Somalipecten cranmerorum* Waller, new genus and species, coated with ammonium chloride. **10,** Right exterior of the largest paratype, USNM 859035, length 80.5 mm, from off Somalia, 150-300 m. **11,** Closed scale with artificial perforation and an open scale on a central plica of left valve of another paratype returned to Mr. Dan, width of open scale 4.8 mm, shell height at level of open scale 57 mm. **12-13,** Left exterior and right hinge area of the largest paratype, USNM 835095, shell length 80.5 mm, hinge length 37 mm., arrows in Fig. 13 point to dorsal hinge teeth.

inside pallial line by the same color present on exterior.

Comparison: Somalipecten cranmerorum, new species, differs from all of the fossil species mentioned in the above discussion of *Somalipecten*, new genus, in having fewer major plicae. The smallest number of plicae among the fossil taxa occurs in *Somalipecten wyllei* (Cox, 1929), which has an additional pair of plicae on each valve, stronger intermediate hinge teeth, and no enlarged scales on the left valve. *S. cranmerorum* superficially resembles the more coarsely plicate varieties of *Flexopecten glaber* (Linnaeus, 1758) living in the Mediterranean, but that species lacks nodes and enlarged scales and differs in hinge details, as discussed above in the comparison of genera. None of the extant or extinct species of *Nodipecten* have as closely spaced commarginal lamellae, and they have much more massively developed dorsal and intermediate hinge teeth.

Ecology: The habitat of the new species is known only from the data provided by Taiwanese fishermen, who said that the shells were trawled off Somalia at depths of 150 to 300 m. Because they have not divulged the exact locality, it is not known whether the specimens are from the Gulf of Aden or the Indian Ocean side of Somalia. Mr. T. C. Lan of Taipei, Taiwan, who obtained the specimens from the Taiwanese fishermen, has provided a list of associated species, some of which would appear to shed light on the locality of the pectinids. *Strombus oldi* Emerson, 1965, was originally described from the Indian Ocean side of Somalia in the vicinity of Obbia and Mogadiscio (Emerson, 1965), and recently it also has been found off Oman in the Arabian Sea (David Hargreave, *pers. com.*, 1986). It is not known to occur in the Red Sea or the Gulf of Aden. *Cypraea broderipi* Sowerby, 1832, *Cypraea marginalis* Dillwyn, 1817, and *Vasum truncatum* (Sowerby, 1892) are known mainly from the Indian Ocean and not the Red Sea (Abbott and Dance, 1982), and *Mimachlamys townsendi* (G. B. Sowerby III, 1895) is known mainly from the Arabian Sea off Pakistan and from the Gulf of Oman. Although these data suggest that *S. cranmerorum* is from the Indian Ocean side of Somalia, the fossil species that is morphologically the closest, *S. wyllei* (Cox, 1929), is from a raised beach on the Red Sea coast in Sudan.

The epifauna of the shells of *S. crannerorum* gives some clues to living habits. The lower (right) valves of many of the uncleaned specimens are encrusted by cheilstome bryozoans at least in the dorsal region and in some cases extensively over the valve. This indicates that the lower valve was not buried in fine sediment and that the scallop must have lived attached by a byssus above the bottom or on a hardground bottom. The presence of calcareous algae on the upper valve suggests that the specimens lived in the photic zone, as does also their association with algal grazers such as *Strombus*.

Thirteen of the 52 specimens of *S. crannerorum* examined have circular corroded patches within which a borehole occurs over the anterodorsal disk flank over the approximate position of the scallop's mouth. These features are identical to the scars produced by the calyptreacean gastropod *Capulus danieli* (Crosse, 1858) described by Orr (1962; see also Matsukuma, 1978) from another Indo-Pacific member of the Decatopectinini, *Bractechlamys vexillum* (Reeve, 1853). On the basis of gut contents, absence of damage to soft parts other than the mantle through which the boring passes, and evidence of repair and continued survival, Orr concluded that the snail-scallop relationship is one of antagonistic symbiosis, not true parasitism, the snail stealing food, probably in mucus strings, from the mouth region of the scallop. On all but one of the scarred and bored scallops, the shell damage is on the left umbo. The fact that gastropod was able to survive on the lower valve is additional evidence that the scallop lives attached above the sediment surface.

Etymology: This species is named in honor of Roberta D. Cranmer and her late husband, Charles E. Cranmer, of Louisville, Kentucky, whose personal involvement and quiet philanthropy have greatly benefited many people and organizations, a number of which have made significant contributions to malacology.

Holotype: USNM 859034, a pair of matching valves, height 50.0 mm, length 53.8 mm, convexity across closed valves, 15.5 mm, collected by Taiwanese fishermen off Somalia at a depth between 150 and 300 m.

Material: In addition to the holotype, USNM 859034, 51 paratypes were studied, all paired valves from the same locality at 150-300 meters off Somalia. Twelve of these paratypes are deposited in the U.S. National Museum of Natural History under the catalogue numbers 859035 (the paratype illustrated herein) and 859036 (eleven unillustrated paratypes). Thirty-one of the remaining paratypes were returned to Mr. Donald Dan, and one paratype was sent to each of the following eight museums: American Museum of Natural History, New York; Natural History Museum of Los Angeles County, Los Angeles; British Museum (Natural History), London; Museum National d'Histoire Naturelle, Paris; Rijks-museum van Naturlijke Historie, Leiden; Australian Museum, Sydney; Western Australian Museum, Perth; and National Science Museum, Tokyo.

Acknowledgments

The possibility that the scallop shells from off Somalia were of a new species was first considered by Mr. Donald Dan of Maryland and Mr. Al Demartino of Naples, Florida, who brought specimens to my attention. I am particularly grateful to Mr. Dan for providing a large number of specimens for study, for underwriting the cost of donating some of these to the U.S. National Museum and other museums, and for providing encouragement and numerous helpful suggestions. Mr. Shin Rong Hwang of Taipei supplied Mr. Dan with the specimens obtained from the fishing-boat captain, and Mr. T. C. Lan of Taipei provided information on associated species. Mr. C. Patrick Nuttall and Dr. Noel Morris kindly provided access to and assistance with the fossil collections in the British Museum (Natural History). Drs. Harald Rehder and Richard S. Houbrick, Department of Invertebrate Zoology, Smithsonian Institution, and Dr. John Pojeta, Jr., U.S. Geological Survey, Washington, D.C., kindly reviewed the manuscript and offered suggestions for its improvement. My assistant, Mr. Warren C. Blow, prepared the prints and plates.

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A NEW SPECIES OF *TRITONIA* (NUDIBRANCHIA) FROM SOUTHERN CALIFORNIA AND BAJA CALIFORNIA

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ABSTRACT

Tritonia myrakeenae *is described as a new species from the Californian marine faunal province and is distinguished anatomically from the north Pacific and north Atlantic species of* Tritonia.

Although the opisthobranch gastropod fauna of the northeastern Pacific has been monographed extensively by numerous authors (e.g., recently by Marcus, 1961 a; MacFarland, 1966; Keen, 1971; McDonald, 1983; *et al.*), there are still numerous new distributional records (e.g., Bertsch, 1981; Behrens, 1982; Gosliner & Millen, 1984) and new species descriptions (e.g., Gosliner, 1981; Behrens, 1984; and Millen, 1985) being published. These add significantly to the known species of opisthobranchs that are endemic to this coastline or its various marine faunal provinces, or that are shared with other marine zoogeographic regions. In this paper we describe a new species of *Tritonia* that occurs in the Californian marine faunal province; the existence of this species was first reported over 5 years ago (Behrens, 1980).

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Order **Nudibranchia**
Suborder **Dendronotacea**
Family **Tritoniidae** Lamarck, 1809

Tritonia myrakeenae Bertsch & Mozqueira, *n. sp.*

Synonymy: Tritonia sp. Behrens, 1980: 102-103 (includes a color photograph of the living animal).

Type Locality: Southeast end of Isla Cedros, Baja California, Mexico, rocky reef west of lighthouse, in Bahía Sudeste: 28°2′30″N; 115°12′W.

Type Material: Holotype: Approximately 7 mm long while alive, 4.5 mm preserved; intertidal zone, rocky reef SE end of Isla Cedros; *leg.* H. Bertsch and Soa Tsung, 26 December 1985. Deposited in the collection of the Los Angeles County Museum of Natural History, Dept. of Malacology, No. LACM 2135.

Paratype: Approximately 6 mm long while alive, 4 mm preserved; intertidal zone, rocky reef SE end of Isla Cedros; *leg.* H. Bertsch and Soa Tsung, 26 December 1985. Deposited in the collection of Los Angeles County Museum of Natural History, Dept. of Malacology, No. LACM 2136.

Paratypes: Three specimens, 3.5, 4, and 4.5 mm preserved lengths; intertidal zone in front of Hotel Puesta del Sol, El Sauzal, approximately 8 km north of Ensenada, Baja California, Mexico (31°52′N; 116°41′W); *leg.* A. Mozqueira, September 1984. Deposited in the collections of California Academy of Sciences, Dept. of Invertebrate Zoology, No. CASIZ 061379.

Additional Records and Range: The authors and Jesus Pineda have found specimens infrequently in the intertidal region at El Sauzal (in front of Hotel Puesta del Sol), Baja California, during June, September, October and November 1983, and February and March 1984. Behrens (1980: 102) reported the occurrence of *Tritonia myrakeenae* (as *Tritonia* sp.) from "Santa Barbara to San Diego, California." All known records of this species are only from the intertidal region. At this time, the known range of *Tritonia myrakeenae* is from Santa Barbara, southern California, U.S.A., to the SE tip of Isla Cedros, near the southern limit of the state of Baja California, Mexico.

Description: A thin, elongate, delicate-appearing tritoniid, 6-18 mm in total length (alive). Oral veil with 4-7 (rarely branching) tentacular processes. Foot broadly expanded laterally beyond sides of body; anterior margin gently rounded, bilabiate; posteriorly extending out flat past the body, terminating in a pointed tip. Retractile rhinophores surrounded by basal sheath; the rhinophore stalk bears 10-22 vertical processes which encircle the shaft below the tip. Dorso-lateral edge with a delicate, undulating free margin from which grow the branchial processes (often 9 on each side). Each branchial appendage branches distally into 3-5 filaments.

Color a very pale dirty orange-brown (see color photo in Behrens, 1980: 103); oral veil and sides of foot clear of color, partly opaque. Distinctive white patches occur on the dorsum (often as a matched pair on each side of the midline); Behrens (1980: 103) illustrates an animal with 4 transverse groups of opaque white patches (or streaks) arranged down the length of the back. Specimens from Ensenada and Isla Cedros (Figure 1) had fewer white splotches (usually just a pair located about ⅓ of the body length distant from the anterior end).

Radula (Figure 2A) about 1.1 mm long, 0.65 mm across at widest portion. Radular formulae of 2 specimens collected 26 September 1983 at El Sauzal were: 22 (10.1.1.1.10) and 25 (8-10.1.1.1.8-10) (widest row damaged but appeared to have 12 outer lateral teeth). Central rachidian tooth prominent (approximately 63 microns wide), with 3 posteriorly-directed cusps (Figures 2B and 3B). First lateral tooth well differentiated from the others, its structure a hooklike cusp curling over the side of the rachidian (Figures 2B and 3B). Succeeding laterals all fairly straight, blade-like cusps.

Jaws elongate (Figure 3A), each about 1.3 mm long and 0.37 mm wide; a row of pointed mam-

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FIG. 1. *Tritonia myrakeenae, spec. nov.*, dorsal view of living animal. Drawing by C. Yanes.

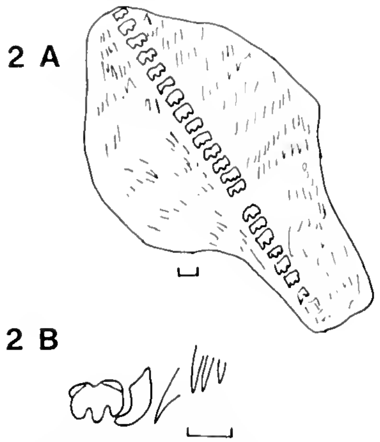

FIG. 2. Camera lucida drawings (scale represents 50μ) of: 2A. Major shape and features of entire radula, and 2B. Rachidian tooth, innermost lateral, and four outer lateral teeth of *Tritonia myrakeenae*.

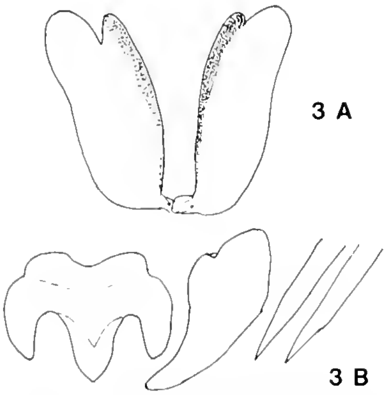

FIG. 3. *Tritonia myrakeenae*, sketches of jaws (3A) and selected radular teeth (3B, rachidian, innermost lateral tooth, and two outer lateral teeth).

millate denticles begins on the inner margin at the joined region of the jaws, continuing as a row along the entire inner edge, increasing about ⅓ of the length to 3-5 rows; the inner denticled margin terminates distally in a small blunt process or free flange.

Discussion: Tritonia myrakeenae is readily distinguished from other north Pacific species of *Tritonia*. *Tritonia hawaiiensis* Pease, 1860, has much more prominent and more highly branched branchial processes and tints of orange-pink and dirty light-purple (Bertsch & Johnson, 1981: 84-85) which are absent in our new species. *Tritonia insulae* (Baba, 1955) has vermilion-tinted gills and a different radular formula: 30 (40-46.1.1.1.40-46). *Tritonia diomedea* Bergh, 1894, has a distinct white line bordering the edge of the foot, and a larger radular formula. *Tritonia festiva* (Stearns, 1873) has a series of white lines and loops reticulating on the dorsum and a radula with more teeth in each row. *Tritonia pickensi* Marcus & Marcus, 1967, has a distinct white swath running down the center of the dorsum with lateral extensions to the branchial processes; although it has a similar radular formula, the shape of the rachidian tooth (narrower and deeper indentation between the cusps) and the presence of small denticles on the cusp of the first lateral tooth (Bertsch & Gosliner, 1984) are differentiating features.

Species of *Tritonia* in the North Atlantic are also easily distinguished from *T. myrakeenae*. The tropical *T. wellsi* Marcus, 1961 (b), is pink and white, and the shapes of the teeth are different (cf. Marcus & Marcus, 1967: 100, fig. 130), and *T. bayeri* Marcus & Marcus, 1967, has an opaque white diffuse network over its dorsum. *Tritonia nilsodhneri* Marcus, 1983, is rose-pink; *T. manicata* Deshayes, 1853, has red, black or olive-green spots on the dorsum; *T. plebeia* Johnston, 1828, has white stippling but is darker colored with brown mottling and has more teeth per half row (21-33); *T. lineata* Alder & Hancock, 1848, has 2 conspicuous longitudinal white lines running lengthwise down the dorsum; although *T. hombergi* Cuvier, 1803, has white splotches, its body shape is different (tubercled dorsum, more prominent bilobed oral veil) and the radula is completely different (denticles on teeth of young specimens and 27-158 teeth in a half row). Thompson & Brown (1984) give further anatomical characteristics that distinguish these latter 5 species from *T. myrakeenae*. Mrs. Marcus (1983) details the anatomy of other Tritoniidae, none of which are comparable with *Tritonia myrakeenae*.

Etymology: This new species is named in honor of the distinguished malacologist, Dr. A. Myra Keen (1905-1986), colleague and friend, who included nudibranchs in *Sea Shells of Tropical West America*, second edition (this was the first major review of all known nudibranchs and other opisthobranchs from the Panamic marine faunal province). Her persistent scholar-ship and encouragement of research has helped us to know (and hopefully to protect) the mollusks of western North America.

Acknowledgments

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We especially thank Jesus Pineda for collecting assistance in Ensenada, and the Cedros Island Have Mule Will Travel research expedition team (including Miss Soa Tsung) of December 1985-January 1986.

The illustration of the living animal of *Tritonia myrakeenae* (Figure 1) was drawn by Señorita Clara Yañes.

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UNIONIDAE OF THE UPPER CONNECTICUT RIVER, A VANISHING RESOURCE[1]

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Introduction

It was my good fortune to meet William J. Clench in the winter of 1949-50, shortly after having become irrevocably committed to shell collecting. His personality was so enthusiastic and friendly and the Mollusk Department was so impressive that I soon made frequent trips to the Museum of Comparative Zoology at Harvard, known familiarly as the "MCZ", and later became a Saturday volunteer. It was not long after that I resolved to seek a career in malacology. I shall always be grateful to Bill Clench and to Ruth Turner for the inspiration to make that decision and for their numerous acts of kindness since that time.

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[1] In memory of my good friend and teacher, William J. Clench.

I well remember our first collecting trip to the Connecticut River. The occasion was the 1952 annual field trip of the Boston Malacological Club; the site was the Connecticut River at South Hadley, Massachusetts; the leader was Dr. Clench; the weather was warm and sunny; and the water was low. Bill, as his friends called him with affection and respect, led us to a large sandbar in the middle of the river. Beautiful mussels were everywhere in 2 or 3 feet of water and the *Lampsilis cariosa* were the most massive that I had ever seen.

During the following years Arthur and Louise Clarke collected widely in New England and at several localities in the Connecticut River System. There we found *Alasmidonta heterodon*, strange *Alasmidonta undulata*, and several other species which, to my neophyte eyes, were especially marvelous. Although the Connecticut River fauna had recently been reported upon (Clench and Russell, 1939, 1940), it still merited additional investigation. It was not until nearly 30 years had passed, however, that I was able to do it.

It is appropriate that the results of that survey, although principally of regional interest, should be dedicated to Bill Clench. In a larger sense, however, all of my research has been influenced by his teaching and it will always continue to be so. I would also like to thank The Nature Conservancy for funding the field work in 1983 and my wife Judith, and Drs. L. L. Master and T. French, for valuable field assistance. Preparation of the manuscript was supported by ECOSEARCH, Inc.

Methods and Results

The primary objective of the 1983 program was to determine the present distribution and abundance of *Alasmidonta heterodon* (Lea) in the Connecticut River System of New Hampshire and Vermont. During the course of that work tabulation of habitat attributes and of the identity and abundance of all other mollusks encountered were also made. The detailed results concerning *A. heterodon* will be reported as part of a status survey, now underway, of that species throughout its entire range, but the general results for 1983 are reported here.

The principle field activities were carried out over an 18-day period in August and early September, 1983. Collecting equipment included a motor-assisted canoe, wet suits, viewing boxes, and a small Kolkwitz dredge. A total of 36 survey areas were studied. These are shown in Map 1 and, to conserve space, are abbreviated and listed below in narrative form.

Station List: 1, Third Conn. L, E side, N.H.; 2, Conn R between Third and Second Conn. L; 3, Second Conn. L, S side; 4, First Conn. L, N side, N.H.; 5, Conn. R just above Francis L, N.H.; 6, Conn. R above Canaan, Vt.; 7, Conn. R 1.0 mi N of Tinkerville, Columbia Twp., N.H.; 8, 9, Conn.

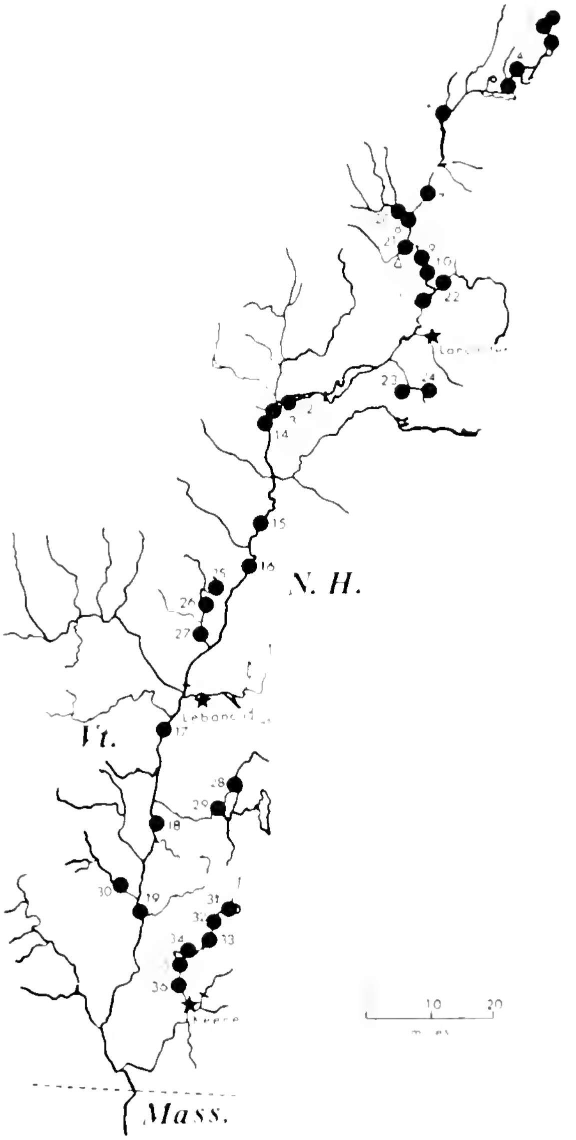

FIG. 1. The upper Connecticut River System with 1983 study sites indicated.

R, by canoe from N Stratford to 2.4 mi above Stratford, N.H.; 10, Conn. R, 2.4 mi above Stratford, N.H.; 11, Conn. R, flooded marginal pool, above bridge at Guildhall, Vt.; 12-14, Conn. R, by canoe from Comerford Dam to bridge at Barnet, Vt.; 15, Conn. R, S Newbury, Vt., ¼ mi above Oxbow Bridge; 16, Conn. R, 1.0 mi NW of Piermont, N.H.; 17, Conn. R, Hartland, Vt.; 18, Conn. R, Weathersfield Bend, 4 mi S of Ascutney, Vt.; 19, Conn. R, below bridge from N Walpole, Vt. to Bellows Falls, N.H.; 20, Nulhegan R, 0.5 mi W of Bloomfield, Vt.; 21, Paul Stream, 1.1 mi above mouth, Brunswick Twp., Vt.; 22, Upper Ammonoosuc R, Groveston, N.H.; 23, Forest L, Dalton Twp., N.H.; 24, outlet of Hazen's Pond, 2.5 mi E of Whitefield, N.H.; 25, lake at town park, Thetford Twp., Vt; 26 Mud Pond, Thetford Center, Vt.; 27, Ompompanoosuk R, 0.5 mi S of Union Village, Vt.; 28, Croydon Branch, 1.0 mi S of Croydon, N.H.; 29, Sugar R, 2 mi SW of Croydon; 30, Williams R, 0.5 mi N of Rockingham, Vt.; 31, Ashuelot Pond outlet, 3.0 mi NE of Marlow, N.H.; 32, Ashuelot R, 0.4 mi W of Ashuelot Pond; 33, Asheulot R just above Marlow, N.H.; 34, Ashuelot R, between Shaw's Corner and Roundy's Corner, N.H.; 35, Ashuelot R, 3.0 mi S of Surry Mountain Dam; 36, Ashuelot R, 2.4 mi NW of center of Keene, N.H.

In most cases living specimens were tabulated and promptly returned to their habitats. In the tabulation below, each station number is followed by a symbol which reflects the number or abundance of specimens seen there. Numbers of living (no parenthesis), recently-living (in parenthesis), and subfossil (in parenthesis, with S) specimens are cited separately. Other symbols are: A = abundant and C = common. No mollusks were found at stations 4, 5, 6, 12, 13, 14, 20, 22, 24, 27-31, 33, and 34.

Species List

Unionidae. *M. margaritifera:* sta. 32, (2S). *E. complanata:* 8,(1S); 15,3; 16,(25); 17,ca.500+(77); 18,2+(1); 19,(5S); 23,12+(1); 35,A; 36,A. *An. cataracta:* 1,12+(6); 2,6+(2); 3,41+(3); 11,(1); 23,2+(1). *Al. heterodon:* 17,(5); 35,1+(2); 36,(1). *Al. undulata:* 1,1+(9); 3,2; 9,(1S); 17,(24); 35,2+(3); 36,4. *St. undulata:* 3,1; 17,(4); 35,1; 36,3+(1). *Lamp. r. radiata:* 17,ca.300+(28); 19,(4S).

Sphaeriidae *Sphaerium striatinum:* 17,11.

Viviparidae. *Campeloma decisum:* 10,3; 16,27; 17,2; 36,18. *Cipangopaludina chinensis:* 25,A; 26,A.

Lymnaeidae. Juv. lymnaeid, sp.?: 7, 1.

Physidae. *Physa heterostropha:* 11,A; 16,1.

Planorbidae. *Helisoma anceps:* 7,1; 8,1; 11,C; 16,4; 17,4.

Ancylidae. *Ferrisia rivularis:* 9,A; 18,A.

Discussion and Conclusions

According to Johnson (1915), Clench and Russell (1939, 1940), and Clarke (1981), and specimen-associated data in the MCZ, USNM, and ANSP, 10 species of freshwater mussels occurred in the Connecticut River prior to and during part of the first few decades of this century. They are *Elliptio complanata, Anodonta cataracta, An. implicata, Alasmidonta heterodon, Al. undulata, Al. varicosa, Strophitus undulatus, Lampsilis cariosa, L. ochracea* and *L. r. radiata.* Three of these (*An. implicata, L. cariosa* and *L. ochracea*) were not known to ascend the river above Massachusetts. Many widely-distributed species of Sphaeriidae, prosobranchs, 'and pulmonates were also known to occur there (Johnson, 1915; Clench & Russell, 1939) and another unionid (*Ligumia nasuta*) is also known from the vicinity of Keene, N.H., presumably in the Ashuelot River drainage (Walker and Coolidge, 1908). The principle objective of this paper is to discuss the unionids of the main river, but the records listed above from some tributaries (e.g. the introduced gastropod, *Cipangopaludina chinensis*) may also be of interest.

Early in the course of our work it became obvious that the molluscan fauna, and especially the unionids, of the Connecticut River has been greatly harmed by human activities. Dams, the construction of which began in the 1930's, have altered this once free-flowing river so that it is now chiefly a series of impoundments within which water levels are drastically manipulated by computer controlled dams for the generation of electricity and for flood control. Pollution from the pulp and paper industry has further exacerbated the situation. The probable distributions of the unionids in the upper Connecticut River, as they existed prior to historical degredation of the river, are shown in Figure 2.

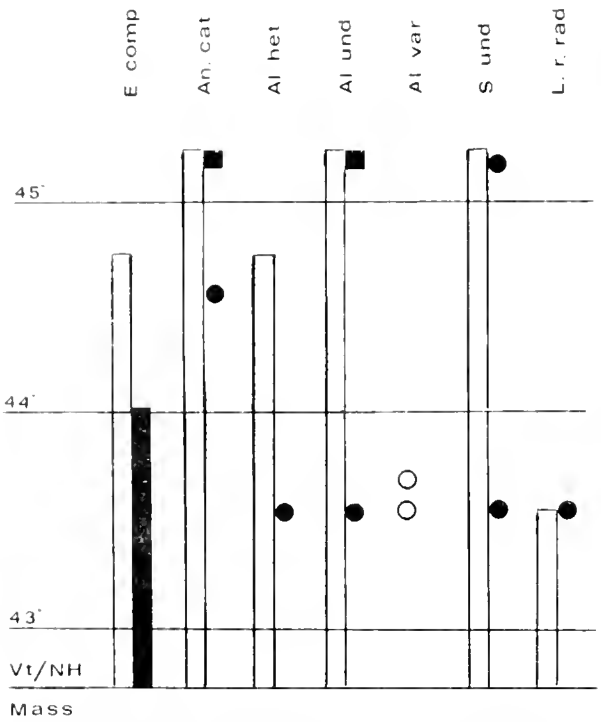

FIG. 2. Probable distribution of unionids in upper Connecticut River prior to pollution and impoundment (white bars and open circles) contrasted with their 1983 distributions (black bars and black spots). Locations are expressed in terms of north latitude. Pre-impoundment distributions are based on subfossil specimens (stations 8 and 19), live specimens collected by W. J. Clench from Conn. River near Monroe, N.H., and Wells River, Vt., in 1940, other records at MCZ, USNM, and ANSP, and Clench and Russell (1939, 1940).

The distribution of those species as observed in 1983 are also shown on that figure.

Based on the presence or absence of freshwater mussels, it is useful to consider the upper Connecticut River as now comprised of 3 faunal regions. Region 1 (stations 1-3) includes the uppermost part of the system, i.e., the Second and Third Connecticut Lakes and the intervening portion of the Connecticut River. (The uppermost Fourth Connecticut Lake is small and inaccessible by road; it was not sampled). Significantly, the water levels in this part of the system are not manipulated but are left to fluctuate moderately and naturally. This region contains large populations of *Anodonta cataracta*, (specimens of which have a peculiar subarctic facies), of *Alasmidonta undulata* morph *sowerbyana* (an ecophenotype which has been shown (Clarke, 1981) to be attributable to slow growth in cold, hard-water habitats) and a small population of *Strophitus undulatus*. *Elliptio complanata* does not occur here.

Region 2 (stations 4-14) includes the area from First Connecticut Lake and Lake Francis downstream for more than 100 miles to near the mouth of the Ammonoosuc River in Grafton Co., N.H. Although one apparently fresh pair of valves of *An. cataracta* occurred in a flooded pool adjacent to the Connecticut River (station 11), no freshwater mussels occurred alive in this whole stretch of the main river. Lakes drained by at least one tributary (Johns River in Coos Co., N.H.) do contain both *Elliptio complanata* and *An. cataracta*, however. Water levels in First Connecticut Lake and in Lake Francis are artificially lowered by about 18 feet during the winter to provide for flood control and water levels in the Connecticut River throughout Region 2. They are also drastically manipulated in response to needs for electric power generation.

Region 3 (stations 15-19) begins just below Region 2 and continues, also for more than 100 miles, to near the Massachusetts border. Within this region water levels are also controlled for power generation and lake-like impoundments occur in a nearly unbroken series. With the exception of one small natural area, in which a native mussel fauna of at least 5 species still survives, the fauna throughout the whole region has apparently been reduced to one species, *Elliptio complanata*. The single unspoiled locality below Sumner's Falls in Hartland, Vt. (station 17) is probably the site of the several historical records from Hartland (see Johnson, 1915). Here the river tumbles over a broad escarpment and, some distance below the falls where reoxygenated water loses its turbulence, a small population of *Alasmidonta heterodon* exists and large populations of other species still flourish. Convenient access here is only possible by boat and then only during the infrequent and unpredictable periods of computer permitted low-flow. It is hoped that this inaccessability will contribute to the survival of *A. heterodon* here and to the conservation of the unusually healthy mussel community in which it occurs.

It is interesting that the ubiquitous and abundant species *Elliptio complanata* is entirely absent from Region 1, a situation which we first observed in 1955. To my knowledge there are few other substantial areas within the geographical range of that species (northern Ontario and Nova Scotia to Georgia), where ecological diversity occurs and mussels are found, which do not contain *E. complanata*. It appears probable that the absence of *E. complanata* is attributable to the inability of its only known host fish, the yellow perch, to ascend the turbulent and shallow portion of the Connecticut River below the Second Connecticut Lake.

In summary, our work has indicated that the upper Connecticut River now supports mussel populations of good species diversity in only two small areas, viz. the uppermost Connecticut Lakes and their vicinity, and an unusual locality at Hartland, Vt. Other work in 1983, which is still incomplete, demonstrates a similarly bleak but uneven situation for the lower Connecticut River. The diverse mussel community at South Hadley, Massachusetts, which we observed in 1952 is now gone and only a few specimens of *Elliptio complanata* now occur there. A healthy molluscan community containing *E. complanata*, *An. cataracta*, *An. implicata*, and *Al. undulata* and the pleurocerid *Goniobasis virginica* still occurs in a short reach of the Connecticut River from the southern border of Massachusetts to Warehouse Point, Connecticut, however.

Clearly the mussel fauna of the whole Connecticut River now survives in only a very few remnant communities. Conservationists and government agencies are urged to help in reversing this unfortunate trend toward extinction.

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MORPHOLOGICAL ANOMALIES IN THE SHELL OF FIELD-COLLECTED *BIOMPHALARIA GLABRATA* (SAY, 1818)

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ABSTRACT

We report the occurrence of phenotypic abnormal shells of the freshwater snail Biomphalaria glabrata *(Say, 1818) in different habitats, actual and potential foci of transmission of schistosomiasis mansoni, in the Dominican Republic. There is the possibility that genetic factors cause the abnormalities in the shell, and that they are inherited through cross-fertilization.*

Introduction

During the normal growth of a shell of a common planorbid snail it increases in diameter in the same plane, by the addition of new whorls one at the side of the other resulting in a discoidal form (planispiral). Sometimes, however, this growth process shows anomalies which present the malacologist with problems in the iden-

TABLE 1. Prevalence of abnormal shells among natural populations of *Biomphalaria glabrata* in the Dominican Republic.

Locality	No shells examined	No normal shells	No (%) abnormal shells
Higuey	124	111	13 (10.4)
Sabana de la Mar	209	182	27 (13)
Nisibon	46	46	0
Haina	156	153	3 (2)
Jarabacoa	48	44	4 (8.3)
Hato Mayor	226	212	14 (6)
San Francisco de Macoris	25	24	1 (4)

tification of a particular species. Richards (1970, 1971) observed adult *Biomphalaria glabrata* with projecting spires in genetic stocks showing frequent embryos with the first whorl open, and with high embryonic mortality. Phenotypic anomalies in the shell have also been reported by Andrade and Carvalho (1973) in *B. straminea* (Dunker, 1848) raised in the laboratory in Brazil and by Gomez (1973) in *B. glabrata* collected in the Dominican Republic. Andrade and Carvalho stated that deformation of the last whorl was the most frequent anomaly, while Gomez observed abnormalities of various types.

In this paper we report on phenotypic deformations in the shell of *B. glabrata* in populations occurring in various actual and potential foci of transmission of schistosomiasis mansoni in the Dominican Republic. A total of 834 shells were examined and they were obtained from the following localities: 124 from Higuey, 209 from Sabana de la Mar, 46 from Nisibon, 156 from Haina, 48 from Jarabacoa, 226 from Hato Mayor, and 25 from San Francisco de Macoris.

Results

As shown in Table 1, of 124 snails collected in Higuey 13 demonstrated conchological anomalies for a prevalence of 10%. Among 209 snails which came from Sabana de la Mar, 27 (13%) were abnormal, whereas those from Nisibon did not show any deviations. Three of the 156 snails collected in Haina exhibited shell abnormalities, as well as 4/48 from Jarabacoa, 14/226 from Hato Mayor, and 1/25 from San Francisco de Macoris.

The most frequent anomaly was the deflection of the last whorl to the left and the inclination of the preceding whorl to the right (Fig. 1). In some shells the deflection of the last whorl was pronounced to about 180°, in such a way that

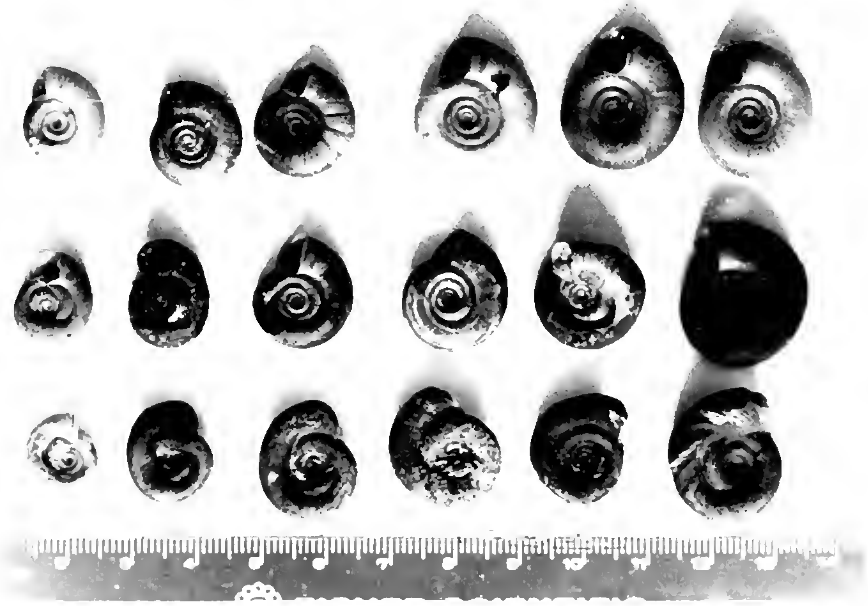

FIG. 1. *Biomphalaria glabrata* from the Dominican Republic. Top row; normal shells, left (under or umbilical) side. Middle row; abnormal shells, left (under or umbilical) side. Bottom row; abnormal shells, right (upper) side.

the aperture was detached from the preceding whorl, giving the shell a helicoidal appearance. As a result the early whorls overlapped, and the umbilicus became much narrower than in normal shells. In addition to the abnormalities in the form of the shell it was common to observe the deposition and incrustation of calcareous material in the abnormal shells. Scarifications of the umbilicus were never observed.

Discussion

Sturrock and Sturrock (1971) showed that in St. Lucian *B. glabrata* infected with *Schistosoma mansoni* there is a pronounced distortion of the aperture to the right (upper) side, that is, distortion in the opposite direction from that of the shells we are reporting upon from the Dominican Republic. The distortion in the infected snails reported by the above authors, evidently resulting from anatomical changes due to the infection rather than being genetical, first appeared at the end of the prepatent period of the infection and were associated with the liberation of cercariae from the snail.

In his studies on the genetics of *B. glabrata*, Richards (1970, 1973) indicated that five single gene characters have been demonstrated, namely, basic pigmentation, pearl formation, antler tentacles, everted preputium and swollen tentacles, and adult insusceptibility to infection with *S. mansoni*. In addition to the above, several multifactorial inherited growths have been observed including pulmonary cavity growths, tentacle and eye variations and median head bulbs. Other multifactorial genetic characters include apertural lamellae, spire formation (Richards, 1971), mantle pigment and susceptibility of juvenile *B. glabrata* to infection with *S. mansoni* (Richards and Merritt, 1972). The presence of abnormal shell growth in different natural populations of *B. glabrata* in the Dominican Republic suggests that genetic factors cause the formation of these anomalies. The absence of such factors in certain populations (Nisibon) and their low frequency in others may indicate their association with a sublethal gene whose penetration may inhibit high frequencies. However, cross-breeding experiments are needed to determine the validity of this speculation and the type of genetical inheritance involved in the formation of abnormal shells.

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NEW MOLLUSK JOURNALS

Heldia, Münchner Malakologische Mitteilungen, a West German mollusk journal, under the editorship of Gerhard Falkner (ISSN 0176-2621) was launched in 1984. Annual subscription is DM 25 (about U.S. $12.00). Write: Postfach 26 01 23, 8000 Munich, West Germany. Most articles in Band 1 have been on land and freshwater mollusks, but some new marine species are described (*Conus montillai* Röckel, 1985).

Apex, Informations Scientifiques de la Société Belge de Malacologie (a quarterly), vol. 1, no. 1, 36 pp., 3 pls. Editor: R. Duchamps. Annual subscription of 900 B.F. for *Apex* and *Arion* (their news and popular publication) should be sent by international money order or bank check in Belgium Francs to: M. J. Buyle, Av. M. Maeterlinck, 56, bte 8, Bruxelles, Belgium B-1030. The first number contains new marine Rumanian gastropods by Grossu and new Australian Volutidae by Poppe.

THE ECOLOGY OF FRESHWATER GASTROPODS IN THE CENTRAL CANADIAN REGION

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ABSTRACT

The ecology of freshwater gastropods was surveyed at more than 400 permanent aquatic habitats located within the area bounded by 47° and 54° N and 94° and 106° W during 1972 to 1984. Parameters examined were: water body type, sediment type, gastropod community diversity, submerged macrophyte diversity, surface water pH, total dissolved solids, total alkalinity, chloride, sulphate, nitrate/nitrite and soluble reactive phosphorus. Many species showed distributions with respect to these parameters that differed from the total site sampling distributions. Gastropods in the study area appeared to form a continuum according to habitat type, with Stagnicola palustris, Physa jennessi *and* Fossaria modicella *at the higher extremes of water chemistry, and* S. reflexa, Bulimnea megasoma, Marstonia decepta *and* Helisoma campanulatum *at the lower end of the scale. Species able to tolerate high dissolved inorganic values also showed broad tolerance ranges for these parameters. Regional variation in tolerance ranges may be a complex function of adaptation combined with the inter-relationships between various aspects of the habitats themselves.*

The physical environment is believed to account for much of the observed distribution patterns of freshwater gastropods (e.g. Aho, 1966). The environmental factors governing molluscan occurrence have been the subject of many studies in various parts of the world. Of particular importance have been the contributions of Macan (1950, 1957) and Dussart (1976) in England, Ökland (1979) in Norway and Aho *et al.* (1981) in Finland. In North America much ecological information has been presented by Harman and Berg (1971), Clarke (1973, 1981), Pip (1978, 1985) and others.

Various aspects of the aquatic environment may influence snail distribution, for example water chemistry, degree of water flow or turbulence, water body size, substrate type and biotic factors such as type and abundance of aquatic vegetation and composition of the gastropod community (as competition may be a factor, e.g. Aho *et al.* (1981)). The problem is complicated further in that local differences may exist in the tolerance ranges of a given species with respect to a particular parameter, and thus the relative importance of different parameters may show regional variation (Pip, 1985). However, such variation is difficult to detect and evaluate since few data are available in the literature in consolidated form regarding the ecological characteristics of individual species in different geographical areas.

The present paper presents the results of ecological surveys carried out from 1972 to 1984 at more than 400 permanent aquatic habitats located within the area bounded by 47° and 54°N and 94° and 106°W (eastern Saskatchewan, Manitoba, northwestern Ontario, northern North Dakota and Minnesota), with sampling locations being more concentrated in the eastern portion of this area. The parameters examined included water chemistry (pH, total dissolved solids, total alkalinity, chloride, sulphate, nitrate and nitrite, and soluble reactive phosphorus), water body size and type, substrate type, and diversity and species composition of the gastropod and submerged aquatic macrophyte communities. Analyses of the latter parameter, i.e. community composition, have been reported elsewhere (Pip, 1978, 1985).

Materials and Methods

Surveys were conducted during May to September of each year. All sites sampled contained water year-round and aquatic communities appeared established. Most of the sites were sampled only once. However 11 sites throughout the region were monitored for water chemistry parameters at 2-week intervals during an entire sampling season in order to estimate the range of seasonal variation at a given type of site. Approximately 50 additional sites were scored for all parameters at least twice in different years.

At each site all species of snails encountered while wading or canoeing within a search time of 1 hour were recorded. Submerged plants were collected by hand and by dredging with a rake; these were taken to the laboratory, washed and examined for additional snails. Plant community diversity was scored by including only plants that were at least partially submerged. Large water bodies were sampled at a number of stations and each was treated as a separate site because of the heterogeneity of such waters.

A surface water sample was collected at each site, immediately placed on ice in a lightproof container and frozen within a maximum of 48 hours after collection. The water chemistry parameters were determined on the thawed samples using methods recommended by the American Public Health Association (1972). The pH was measured directly in the field using a portable pH meter.

When compiling the water chemistry data, if a number of water chemistry values were available for the same site, the two extreme values of each parameter at that site were included in the tolerance range of the species which occurred at such a site.

Results

A total of 38 species was identified as occurring at two or more water bodies within the study area. In addition to these identifiable species, a number of *Physa* lots were collected whose identity could not be established. These were of several morphological types, each of which was present at a number of sites.

Water body type was classified according to area, if lentic, or depth, if lotic (Table 1). The most heterogeneous group was that of ponds; this group included water bodies of various origins and basin types, such as natural ponds, oxbows, artificial excavations (ditches, farm ponds, quarry pits, road fill excavations, etc.), beaver ponds, spring fed pools and bog pools.

Many gastropods appeared to show distributions which were markedly different from the overall site sampling distribution. In all subsequent discussion, only species for which N>5 will be considered. Although almost all species could occur in lakes, this water body type was the major type of habitat for all of the amnicolids, and *Valvata* spp., *Stagnicola catascopium*, *Fossaria decampi* and *Helisoma campanulatum*. Ponds were the major water body type for *Stagnicola caperata*, *Fossaria exigua*, *Planorbula campestris*, *Armiger crista*, and to a lesser extent, *Stagnicola palustris*, *Aplexa hypnorum* and *Physa jennessi* (ssp. *skinneri* Taylor, 1953). *Bulimnea megasoma* appeared to favor rivers above other habitat types when compared to the overall sampling distribution. In general, running waters were preferred over lentic habitats by *Stagnicola reflexa*, *Bulimnea megasoma*, *Ferrissia rivularis* and *Planorbula armigera*. *Gyraulus deflectus* occurred often in both running waters and lakes but appeared to avoid ponds.

Distribution of gastropods with respect to substrate type (Table 2) showed that *Ferrissia rivularis* and *Stagnicola reflexa* were commonly found in granitic Precambrian Shield basins, although they also occurred on clay and coarse sediments respectively. *Planorbula campestris* occurred mostly on coarse and silt sediments. Sand appeared to be preferred by *Valvata sincera*, *V. tricarinata*, *Cincinnatia cincinnatiensis*, *Marstonia decepta*, *Probythinella lacustris*, *Stagnicola catascopium*, *Fossaria decampi*, *Helisoma campanulatum* and *Promenetus umbilicatellus*. *Fossaria exigua* and *Stagnicola caperata* favored both sand and clay, while clay was the major sediment type for *Stagnicola palustris*, *Fossaria modicella* and *Helisoma pilsbryi*. *Physa jennessi* preferred both silt and clay. *Physa gyrina*, *Lymnaea stagnalis*, *Helisoma anceps*, *H. trivolvis*, *Planorbula armigera* and *Gyraulus parvus* appeared to

TABLE 1. Percentage distribution according to habitat type in the study area. N = no. of observations

Species	Lakes >10 ha	Ponds <10 ha	Rivers >2m deep	Creeks <2m deep	N
Campeloma decisum Say, 1816	50		50		4
Valvata sincera Say, 1824	57	29		14	7
V. tricarinata Say, 1817	84	14	2		44
Cincinnatia cincinnatiensis Anthony, 1840	73	4	23		26
Marstonia decepta F.C. Baker, 1928	100				8
Probythinella lacustris F.C. Baker, 1928	86		14		7
Amnicola limosa Say, 1817	71	7	19	3	69
A. walkeri Pilsbry, 1898	80		20		5
Lymnaea stagnalis Linne, 1758	40	47	6	7	246
Acella haldemani "Deshayes" Binney, 1867	100				3
Bulimnea megasoma Say, 1824	30	35	26	9	23
Stagnicola palustris Muller, 1774	29	57	6	8	170
S. catascopium Say, 1817	92	8			12
S. caperata Say, 1829	14	86			7
S. reflexa Say, 1821	29	29	29	13	7
Fossaria dalli F.C. Baker, 1907	50	25		25	4
F. decampi Streng, 1896	75	12.5	12.5		8
F. exigua Lea, 1841	7	86	7		14
F. modicella Say, 1825	35	52	9	4	46
F. parva Lea, 1841	20	80			5
Physa gyrina Say, 1821	47	36	10	7	253
P. jennessi Dall, 1919	36	58		6	33
Aplexa hypnorum Linne, 1758	22	62	5	11	37
Ferrissia parallela Haldeman, 1841			100		3
F. rivularis Say, 1817	45	19	23	13	31
Helisoma trivolvis Say, 1816	42	43	7	8	189
H. pilsbryi infracarinatum F.C. Baker, 1932	42	37	21		19
H. corpulentum Say, 1824	50		50		4
H. campanulatum Say, 1821	81	4	15		75
H. anceps Menke, 1830	47	44	3	6	106
Planorbula armigera Say, 1821	41	29	16	14	68
P. campestris Dawson, 1875	29	71			7
Promenetus exacuous Say, 1821	51	31	11	7	55
P. umbilicatellus Cockerell, 1887	43	43		14	7
Armiger crista Linne, 1758	33	67			9
Gyraulus parvus Say, 1817	43	45	5	7	161
G. circumstriatus Tryon, 1866	41	48	4	7	27
G. deflectus Say, 1824	59	16	14	11	44
TOTAL SITES	40.5	43.0	9.0	7.5	412

be substrate-indifferent.

The mean gastropod community diversities where each species was found were higher than the mean overall site diversity (Table 3) because all species except *Stagnicola reflexa* occurred to some extent in a proportion of highly diverse communities. For species with N>5, *Fossaria decampi* and *Probythinella lacustris*, both primarily lacustrine species, showed the highest diversity values. Low mean diversities were seen for communities in which *Stagnicola reflexa*, *Ferrissia rivularis*, *Physa gyrina*, *Stag-*

TABLE 2. Percentage distribution according to substrate type in the study area.

Species		Bedrock		Gravel/ coarse sand	Sand	Silt	Clay	Organic	N
	Granitic	Limestone	Shale						
Campeloma decisum					75		25		4
Valvata sincera				14	57		29		7
V. tricarinata	4		2	11	46	2	20	15	46
Cincinnatia cincinnatiensis	15		4		62		19		26
Marstonia decepta					88		12		8
Probythinella lacustris	29				57		14		7
Amnicola limosa	19			12	39	1	16	13	69
A. walkeri				33.3	33.3			33.3	6
Lymnaea stagnalis	6.5	2	1	17	24	6.5	23	20	246
Acella haldemani					100				3
Bulimnea megasoma	19			19	24		14	24	21
Stagnicola palustris	2	2	2	21	23	9	29	12	172
S. catascopium	8	8		8	50		18	8	12
S. caperata					57		43		7
S. reflexa	43			43			14		7
Fossaria dalli		50				25		25	4
F. decampi	12.5				75		12.5		8
F. exigua	7			7	43	7	36		14
F. modicella	2	2	2	13	22	11	34	14	45
F. parva				20		20	20	40	5
Physa gyrina	12	2	1	15	28	5	22	15	251
P. jennessi				9	21	21	34	15	33
Aplexa hypnorum		3	3	34	18	5	26	11	38
Ferrissia parallela	33						67		3
F. rivularis	37			7	13		33	10	30
Helisoma trivolvis	4	2	1	18	24	9	25	17	189
H. pilsbryi infracarinatum	16	4			32		32	16	19
H. corpulentum	25			25	50				4
H. campanulatum	16	1		10	49	4	6	14	73
H. anceps	8			19	28	2	19	24	107
Planorbula armigera	9	3	3	15	21	3	24	22	67
P. campestris				43	14	29	14		7
Promenetus exacuous	15		4	13	16	7	29	16	55
P. umbilicatellus	14	14			58			14	7
Armiger crista					11	23	33	33	9
Gyraulus parvus	5	1	1	16	26	9	21	21	161
G. circumstriatus	8	4		23	34	4	8	19	26
G. deflectus	12		2	9	35	5	12	25	43
TOTAL SITES	10.8	2.0	0.9	15.9	27.0	5.9	19.6	17.9	408

nicola palustris, *Lymnaea stagnalis*, *Helisoma anceps*, *Bulimnea megasoma*, *Physa jennessi*, *Fossaria exigua* and *Helisoma trivolvis* were present. The maximum recorded gastropod community diversity was 17.

Mean macrophyte community diversity was high for *Valvata sincera*, *Gyraulus deflectus*, *Helisoma campanulatum*, *Bulimnea megasoma* and all amnicolids except *Probythinella lacustris*. Low mean macrophyte diversities (<6) were seen for *Physa jennessi*, *Fossaria modicella*, *Probythinella lacustris*, *Fossaria exigua*, *Stagnicola palustris* and *S. caperata*. Of the above species, mean diversity values were low for both gastropod and macrophyte communities for *Physa jennessi*, *Fossaria exigua* and *Stagnicola palustris*. As has previously been noted by Pip (1985), there was little correlation between the two kinds of diversity at the different site types, aside from the tendency of ponds to contain few species of both snails and plants.

The widest range for surface water pH was observed for *Helisoma trivolvis* (5.5 pH units, equal to the total sampling range) (Table 4), followed by *H. anceps*, *Ferrissia rivularis*,

TABLE 3. Mean gastropod and submerged macrophyte diversity of communities in which each species was found in the study area.

Species	Gastropod diversity	N	Macrophyte diversity	N
Campeloma decisum	13.3	3	17.3	3
Valvata sincera	9.6	7	10.4	7
V. tricarinata	8.3	46	8.1	46
Cincinnatia cincinnatiensis	7.7	27	12.2	25
Marstonia decepta	7.3	8	14.6	8
Probythinella lacustris	10.0	7	5.0	7
Amnicola limosa	7.7	68	10.6	68
A. walkeri	6.0	5	11.6	5
Lymnaea stagnalis	5.5	246	6.9	246
Acella haldemani	11.0	3	16.7	3
Bulimnea megasoma	5.6	21	10.1	19
Stagnicola palustris	5.5	173	5.4	166
S. catascopium	9.2	13	6.4	11
S. caperata	6.1	7	5.8	6
S. reflexa	4.0	7	9.9	6
Fossaria dalli	7.8	4	8.0	4
F. decampi	11.0	8	8.1	8
F. exigua	5.8	14	5.4	13
F. modicella	7.1	47	5.0	44
F. parva	6.6	5	5.0	5
Physa gyrina	5.4	250	7.3	246
P. jennessi	5.7	33	4.8	31
Aplexa hypnorum	6.7	36	6.2	33
Ferrissia parallela	10.5	2	17.0	2
F. rivularis	5.3	31	7.6	30
Helisoma trivolvis	5.8	189	7.0	189
H. pilsbryi infracarinatum	7.2	19	9.0	18
H. corpulentum	5.0	4	9.5	4
H. campanulatum	6.4	74	11.6	73
H. anceps	5.6	108	7.2	102
Planorbula armigera	6.7	68	8.5	63
P. campestris	7.7	6	3.7	6
Promenetus exacuous	7.7	55	7.6	55
P. umbilicatellus	4.9	7	8.9	7
Armiger crista	9.7	9	3.8	9
Gyraulus parvus	6.0	165	7.2	158
G. circumstriatus	6.6	27	7.5	27
G. deflectus	7.3	44	11.7	41
TOTAL SITES	4.6	403	6.8	397

Gyraulus deflectus, *Stagnicola palustris*, *Fossaria modicella* and *Gyraulus parvus* (all at > 1 pH units). The narrowest ranges (< 2 units) were seen for *Planorbula campestris*, *Marstonia decepta* and *Fossaria decampi*; these three species however were sampled at relatively few sites. The highest sampled pH of 10.5 was tolerated by *Stagnicola palustris*, *Fossaria modicella*, *Helisoma trivolvis*, *Promenetus exacuous*, *Armiger crista* and *Gyraulus parvus*, while the lowest pH of 5.0 was observed for *Bulimnea megasoma*, *Ferrissia rivularis*, *Helisoma trivolvis*, *H. anceps* and *Gyraulus deflectus*.

The widest ranges for total dissolved solids, encompassing nearly the total range sampled, were seen for *Fossaria modicella*, *Stagnicola palustris* and *Physa jennessi* (Table 4), followed by somewhat smaller ranges (approx. 4500 mg/l) for *Lymnaea stagnalis* and *Helisoma trivolvis*. Narrow ranges (300 mg/l or less), all towards the bottom end of the scale, were seen for

TABLE 4. Minimum, maximum and mean values for pH and total dissolved solids for gastropods in the study area.

Species	pH				Total dissolved solids, mg/l			
	Min.	Max.	$\bar{x}$	N	Min.	Max.	$\bar{x}$	N
Campeloma decisum	7.1	8.1	7.8	3	58	123	87	3
Valvata sincera	6.2	9.2	7.4	6	134	384	264	6
V. tricarinata	6.7	9.8	8.3	48	33	1794	432	47
Cincinnatia cincinnatiensis	7.3	9.8	8.3	25	33	875	170	24
Marstonia decepta	7.7	9.2	8.4	9	60	208	134	7
Probythinella lacustris	7.9	9.5	8.5	5	104	1300	494	5
Amnicola limosa	6.1	9.8	8.1	80	16	1794	235	79
A. walkeri	7.0	9.0	7.9	6	55	219	99	5
Lymnaea stagnalis	6.2	10.0	8.1	260	16	4549	337	255
Acella haldemani	7.4	8.5	8.0	3	68	143	111	3
Bulimnea megasoma	5.0	9.0	7.2	29	16	271	93	29
Stagnicola palustris	6.2	10.5	8.2	174	38	5533	535	170
S. catascopium	7.3	9.5	8.6	12	37	1300	509	11
S. caperata	6.6	8.4	7.8	3	196	919	504	3
S. reflexa	6.6	8.8	7.7	7	16	80	58	7
Fossaria dalli	7.5	8.3	7.8	3	89	280	212	3
F. decampi	7.9	9.5	8.6	6	104	1300	354	6
F. exigua	6.6	9.8	7.8	14	129	1763	371	13
F. modicella	6.2	10.5	8.3	49	33	5533	751	47
F. parva	6.7	9.5	8.1	4	152	1596	565	4
Physa gyrina	6.1	10.1	8.0	267	16	2399	272	261
P. jennessi	7.1	10.5	8.4	28	60	5533	799	28
Aplexa hypnorum	6.6	9.5	7.8	35	37	1402	424	35
Ferrissia parallela	7.1	7.3	7.2	2	78	219	149	2
F. rivularis	5.0	9.5	7.6	38	15	1300	169	37
Helisoma trivolvis	5.0	10.5	8.0	197	16	4549	345	196
H. pilsbryi infracarinatum	6.6	9.5	7.7	15	16	743	169	15
H. corpulentum	8.0	8.4	8.2	5	42	80	67	5
H. campanulatum	6.9	9.5	8.1	91	30	334	104	89
H. anceps	5.0	9.8	8.0	113	18	1333	237	111
Planorbula armigera	6.2	9.7	7.8	68	16	1794	339	67
P. campestris	7.5	8.8	7.9	6	138	459	273	6
Promenetus exacuous	6.9	10.5	8.2	60	40	1794	413	60
P. umbilicatellus	6.7	9.4	8.1	6	80	734	267	6
Armiger crista	7.3	10.5	8.4	10	219	1794	836	10
Gyraulus parvus	6.2	10.5	8.1	176	24	2399	317	172
G. circumstriatus	6.6	9.8	8.3	26	18	2108	418	26
G. deflectus	5.0	9.4	7.8	48	32	1571	176	47
TOTAL SITES	5.0	10.5	8.0	446	10	5533	302	440

Stagnicola reflexa, *Marstonia decepta*, *Valvata sincera*, *Bulimnea megasoma* and *Helisoma campanulatum*.

Total alkalinity ranges (Table 5) were widest (> 700mg/l $CaCO_3$) for *Stagnicola palustris*, *Gyraulus deflectus*, *G. circumstriatus* and *Physa jennessi*. Narrow ranges (<100 mg/l $CaCO_3$), all again towards the bottom end of the scale, were seen for *Stagnicola reflexa* and *Valvata sincera*, both of which were represented by small numbers of samples. Thirteen species occurred at alkalinity values as low as 0-4 mg/l $CaCO_3$, while only three were observed at the maximum sampled value of 800 mg/l $CaCO_3$.

All species tolerated chloride values of 0 mg/l (Table 5), but only *Stagnicola palustris*, *Fossaria modicella* and *Physa jennessi* could be found throughout the complete range sampled. *Valvata sincera* and *Stagnicola reflexa* apparently avoided chloride altogether, although again these were represented by small sample numbers. *Fossaria decampi* and *Marstonia decepta* showed chloride ranges of < 10 mg/l.

TABLE 5. Minimum, maximum and mean values for total alkalinity and chloride for gastropods in the study area.

Species	Total alkalinity, mg/l $CaCO_3$ Min.	Max.	$\bar{x}$	N	Chloride, mg/l Min.	Max.	$\bar{x}$	N
Campeloma decisum	64	128	97	3	0	0	0	3
Valvata sincera	70	166	119	6	0	0	0	6
V. tricarinata	0	448	144	47	0	480	70	47
Cincinnatia cincinnatiensis	14	239	91	24	0	18	3	23
Marstonia decepta	70	220	122	8	0	8	1	8
Probythinella lacustris	70	159	132	5	0	238	48	5
Amnicola limosa	4	448	96	78	0	480	34	77
A. walkeri	11	172	63	5	0	8	2	5
Lymnaea stagnalis	0	560	135	255	0	592	25	254
Acella haldemani	72	100	81	3	0	0	0	3
Bulimnea megasoma	9	172	54	29	0	56	3	28
Stagnicola palustris	4	800	180	172	0	1234	51	172
S. catascopium	84	184	134	11	0	430	130	11
S. caperata	106	224	173	3	0	7	2	3
S. reflexa	0	72	31	7	0	0	0	7
Fossaria dalli	72	202	129	3	0	4	1	3
F. decampi	70	284	138	6	0	2	0.3	6
F. exigua	36	560	183	13	0	77	10	13
F. modicella	48	448	194	48	0	1234	115	48
F. parva	108	230	167	4	0	21	5	4
Physa gyrina	0	560	122	263	0	592	24	262
P. jennessi	62	768	196	28	0	1234	79	28
Aplexa hypnorum	4	448	179	33	0	438	17	33
Ferrissia parallela	128	172	150	2	0	0	0	2
F. rivularis	4	220	68	38	0	238	9	37
Helisoma trivolvis	0	654	144	195	0	480	22	195
H. pilsbryi infracarinatum	10	316	106	15	0	261	18	15
H. corpulentum	10	41	29	5	0	0	0	5
H. campanulatum	10	280	71	89	0	15	0.5	88
H. anceps	4	448	115	111	0	470	23	111
Planorbula armigera	0	560	147	67	0	480	49	67
P. campestris	148	280	210	6	0	13	3	6
Promenetus exacuous	4	654	153	60	0	480	45	59
P. umbilicatellus	12	266	107	6	0	22	4	6
Armiger crista	80	448	241	10	0	480	146	10
Gyraulus parvus	0	654	134	174	0	592	28	174
G. circumstriatus	25	800	222	26	0	602	46	26
G. deflectus	20	800	99	47	0	394	13	46
TOTAL SITES	0	800	122	440	0	1234	24.4	440

All species (except *Stagnicola caperata*) were observed in the absence of measurable sulphate (Table 6), but, as for chloride, only *Stagnicola palustris*, *Fossaria modicella* and *Physa jennessi* were found throughout the entire range sampled. *Valvata sincera*, *Stagnicola reflexa*, *Fossaria decampi* and *Bulimnea megasoma* appeared to be relatively intolerant of sulphate.

For nitrate and nitrite (Table 6), *Cincinnatia cincinnatiensis*, *Planorbula armigera* and *Stagnicola palustris* occurred throughout all or most of the range sampled. Narrow ranges towards the lower end of the scale were seen for *Stagnicola reflexa* and *Marstonia decepta*.

Eleven species were observed to tolerate the highest phosphorus levels (Table 7). *Bulimnea megasoma* and *Stagnicola reflexa* appeared to favor low phosphorus concentrations.

Discussion

In the study area only marginally more species were found in lakes than in ponds. Although none of the species appeared to be restricted to either lakes or ponds, many

TABLE 6. Minimum, maximum and mean values for sulphate and nitrate/nitrite for gastropods in the study area.

Species	Sulphate, mg/l Min.	Max.	$\bar{x}$	N	Nitrate/nitrite, mg/l Min.	Max.	$\bar{x}$	N
Campeloma decisum	0	0	0	3	0	–	0.7	3
Valvata sincera	0	2	0.5	7	1.0	3.3	1.6	6
V. tricarinata	0	170	51	54	0	2.4	1.3	48
Cincinnatia cincinnatiensis	0	170	21	25	0	7.5	1.1	25
Marstonia decepta	0	109	13	9	0	1.5	0.8	9
Probythinella lacustris	0	170	69	6	0	1.2	0.5	5
Amnicola limosa	0	170	23	85	0	2.7	0.9	78
A. walkeri	0	15	4	5	0	1.5	0.9	5
Lymnaea stagnalis	0	334	28	263	0	5.5	1.2	258
Acella haldemani	0	0	0	3	0.8	1.0	0.9	3
Bulimnea megasoma	0	15	3	30	0	5.3	0.7	28
Stagnicola palustris	0	3403	65	182	0	7.2	1.6	174
S. catascopium	0	113	32	12	0.1	1.7	1.1	12
S. caperata	1.6	157	61	3	1.0	2.3	1.5	3
S. reflexa	0	10	2	7	0	1.4	0.5	7
Fossaria dalli	0	39	13	3	0.8	1.3	1.1	3
F. decampi	0	14	4	6	0	2.4	1.2	6
F. exigua	0	161	29	14	0.2	3.3	1.0	14
F. modicella	0	3403	129	49	0	5.6	1.6	49
F. parva	0	148	37	4	0.2	2.4	1.1	4
Physa gyrina	0	334	24	271	0	5.5	1.1	265
P. jennessi	0	3403	190	28	0	6.8	2.2	28
Aplexa hypnorum	0	165	32	37	0	2.4	1.3	35
Ferrissia parallela	0	104	42	3	0.9	1.5	1.2	2
F. rivularis	0	161	18	36	0	5.3	0.6	36
Helisoma trivolvis	0	443	38	204	0	5.2	1.3	197
H. pilsbryi infracarinatum	0	64	5	15	0	2.8	0.7	15
H. corpulentum	0	5	2	5	0.1	1.4	0.6	5
H. campanulatum	0	108	3	92	0	2.4	0.8	90
H. anceps	0	167	18	114	0	5.3	1.1	112
Planorbula armigera	0	157	25	70	0	7.5	1.3	68
P. campestris	0	115	45	6	0.9	1.6	1.2	6
Promenetus exacuous	0	158	42	64	0	5.2	1.3	59
P. umbilicatellus	0	159	28	6	0.3	2.0	1.2	6
Armiger crista	0	128	63	11	0.1	2.9	1.4	10
Gyraulus parvus	0	170	32	181	0	5.2	1.2	176
G. circumstriatus	0	158	35	26	0.7	6.8	2.0	26
G. deflectus	0	108	8	49	0	5.3	1.2	47
TOTAL SITES	0	3403	31	456	0	7.5	1.1	445

gastropods showed strong tendencies to occur in one of these habitat types. Aho *et al.* (1981) observed a similar situation in Finland, where most snails could be found over a wide range of water body sizes. The majority of the species encountered in the present study were quite plastic in terms of the water body and substrate type in which they could occur. Such plasticity would be expected to be advantageous in that the species' potential for colonization of new habitats would be enhanced.

Most of the species (except perhaps *Stagnicola reflexa*) could function in highly diverse gastropod communities, but it is not surprising that many species were found frequently in less diverse groupings where interspecific competition would be reduced. Species found often at low community diversities were capable of surviving in more extreme habitats where other species failed. Species with low mean community diversity values, such as *Stagnicola reflexa* and *Bulimnea megasoma*, could occur in extreme habitats only at the lower end of the scale for most chemical parameters and their tolerance ranges for these parameters were narrow. On the other hand, species such as *Stagnicola*

TABLE 7. Minimum, maximum and mean values for molybdenum reactive phosphorus for gastropods in the study area.

Species	Molybdenum reactive P, mg/l Min.	Max.	$\bar{x}$	N
Campeloma decisum	0.48	1.6	0.9	3
Valvata sincera	0.23	7.0	2.3	6
V. tricarinata	0	44.0	6.1	47
Cincinnatia cincinnatiensis	0	14.9	2.9	23
Marstonia decepta	0	5.6	3.2	9
Probythinella lacustris	1.7	15.0	7.1	5
Amnicola limosa	0	44.0	4.1	78
A. walkeri	0	3.6	1.6	6
Lymnaea stagnalis	0	44.0	3.4	258
Acella haldemani	0.60	6.3	3.5	3
Bulimnea megasoma	0	2.3	0.7	27
Stagnicola palustris	0	44.0	4.4	174
S. catascopium	0.45	15.0	3.3	12
S. caperata	0.51	3.2	2.3	3
S. reflexa	0	2.4	0.7	7
Fossaria dalli	0.74	5.0	2.3	3
F. decampi	0.56	15.0	4.7	6
F. exigua	0.04	5.5	1.3	14
F. modicella	0	44.0	6.5	49
F. parva	0	3.1	1.1	4
Physa gyrina	0	44.0	3.4	265
P. jennessi	0	15.7	3.4	28
Aplexa hypnorum	0.04	21.3	6.1	35
Ferrissia parallela	0.62	1.6	1.1	2
F. rivularis	0	15.7	2.4	35
Helisoma trivolvis	0	44.0	3.6	197
H. pilsbryi infracarinatum	0.04	5.6	1.1	15
H. corpulentum	0.46	1.8	0.9	5
H. campanulatum	0	10.6	2.2	90
H. anceps	0	21.3	2.5	112
Planorbula armigera	0.21	44.0	5.1	68
P. campestris	4.0	12.4	7.0	6
Promenetus exacuous	0	44.0	5.1	59
P. umbilicatellus	0.35	8.3	3.9	6
Armiger crista	0.62	44.0	15.7	10
Gyraulus parvus	0	44.0	3.6	176
G. circumstriatus	0.14	12.4	3.0	26
G. deflectus	0	10.6	2.6	46
TOTAL SITES	0	44.0	2.2	445

palustris, *Physa jennessi*, *Helisoma trivolvis*, *H. anceps*, *Lymnaea stagnalis* and *Ferrissia rivularis* could occur at very wide ranges of some or all of the parameters examined. Some of the species in the latter group were also very common in the study area, suggesting that, in conjunction with their ability to tolerate a wide range of conditions, they may also be effective colonizers of new habitats.

A low value for macrophyte community diversity may be indicative of extreme habitat conditions and/or of new habitats in which succession has not peaked. *Bulimnea megasoma*, which showed a low gastropod and high macrophyte community diversity, was characteristic of habitats in the eastern portion of the study area, where water parameter values may be extremely low but plant diversities are high because of the large numbers of macrophyte species which occur in the Precambrian Shield region (Pip, 1979, 1984). Low diversity values for both gastropods and macrophytes, as seen for *Physa jennessi*, *Fossaria exigua* and *Stagnicola palustris*, probably reflected not only extreme habitat conditions, but also the pond water body type which was predominant for these species. Macrophyte diversity is characteristically low in ponds. Some regional differences in both gastropod and macrophyte community diversities appear to exist for a given snail species (Pip, 1985).

The species present in the study area formed a continuum with respect to the habitat types in which they were found. At one end of this continuum could be placed *Stagnicola palustris*, *Physa jennessi* and *Fossaria modicella*. These species frequented ponds and a clay substrate. The variability of water quality in such habitats was associated with very wide tolerance ranges of these species for pH, total dissolved solids, total alkalinity, chloride and sulphate.

At the other end of the scale were *Stagnicola reflexa*, *Bulimnea megasoma*, and, to a lesser extent, *Marstonia decepta*. The first two species were found most frequently in lotic habitats, while the last species was found in lakes. All were found primarily in Precambrian Shield habitats and were characterized by narrow tolerance ranges at the lower end of the scale for total dissolved solids, total alkalinity, chloride, sulphate, nitrate and nitrite and phosphorus. Mean parameter values were also low for *Helisoma campanulatum*, although this species could tolerate somewhat broader ranges for some parameters than could the latter three species, and possible because of this reason it was the commonest of this group. These species may be regarded as oligotrophic/dystrophic specialists.

In general, species which could tolerate high water chemistry parameter values tended to have wide tolerance ranges. Although species with wide tolerance ranges could survive in habitats with lower parameter values, they frequented sites with higher levels of dissolved inorganics, as seen from their mean values. Species such as *Armiger crista*, *Physa jennessi* and *Fossaria modicella* show high mean values for total dissolved solids and this may be one reason why these species are extremely rare east of the Precambrian Shield boundary, where water parameter values are low. *Planorbula campestris* may also belong to this group but was insufficiently sampled in the present study.

A number of workers (e.g. Aho, 1966, 1978; Dussart, 1976; Ökland, 1979; Pip, 1978; Dillon and Benfield, 1982) have found that calcium hardness, total alkalinity and pH are important factors in determining the distribution patterns of many freshwater gastropods. Ökland and Ökland (1980) found that few gastropods occurred below pH 6.0 in Norway, with only a few species, not stated, being able to tolerate values as low as 5.2 (Ökland, 1979). Aho (1978) observed that fewer species occurred at lower than higher pH values in Finland. The findings of the present study supported this observation up to moderately alkaline values. However in the study area five species could occur at pH values as low as 5.0. Mackie and Flippance (1983) found that in southern Ontario *Helisoma anceps* and *Amnicola limosa* could occur at pH 5.5; this record for the latter species was lower than the minimum of 6.1 seen in the present study. The latter workers also reported a minimum of 6.0 for *Cincinnatia cincinnatiensis* and *Valvata tricarinata*, compared to 7.3 and 6.7 respectively in the present study. Ranges for all other gastropods reported by these workers fell within the ranges obtained in the present study.

Mackie and Flippance (1983) also found a lower total alkalinity level of 5 mg/l $CaCO_3$ for *C. cincinnatiensis* compared to a value of 14 in the present study. All other ranges found by the latter workers were within those given here.

The tolerance range of a given gastropod species for a particular parameter must be viewed in the context of the geographical area where it occurs. Aho (1966, 1978) found that with respect to pH and calcium content, snail species in Finland appeared to occur in lakes with lower values for these parameters than in Sweden or Britain. Similarly Pip (1985) reported that populations in Precambrian Shield waters often seemed to tolerate lower values of dissolved inorganics than did populations to the west of the Shield boundary. Apparently many species may undergo adaptation according to the water quality characteristics predominant in the region.

The gastropod communities found in Precambrian Shield waters in the study area appear to tolerate lower minimum pH values than the communities reported by Ökland (1979) in Norwegian lakes. Perhaps this difference is related to the type and duration of acid conditions in the two areas. The acidity of undisturbed Precambrian Shield lakes is derived largely from dissolved organic matter; sulphates are typically absent. The acidity of the lakes studied by Ökland (1979) is a comparatively recent development as a result of acid precipitation. Thus snails in the former case have had more opportunity to adapt and the acidity is of different chemical origin. Ökland (1979) suggested that the importance of a given water quality parameter such as pH may be related to the level of other factors present. For example Pip (1985) found that the relative importance of specific factors may change in different geographical regions. Thus the tolerance range for a particular parameter may be a complex function of genetic and physiological traits combined with the relationships between different chemical entities in the water itself. It is also possible that additional habitat characteristics, such as substrate and the kinds of other organisms present in the community, for example vegetation, may further mitigate or aggravate the response of a given snail population to a specific parameter. A better understanding of the factors which affect snail distribution in a given area can only be achieved when comparable data becomes available for a number of geographical regions.

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PSEUDOSUCCINEA COLUMELLA (LYMNAEIDAE) IN THE DOMINICAN REPUBLIC AND TRANSMISSION OF FASCIOLIASIS IN THE CARIBBEAN REGION

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ABSTRACT

Pseudosuccinea columella *(Say, 1817) is reported for the first time from the Dominican Republic and from the island of Hispaniola. It occurs together with* Fossaria cubensis *(Pfeiffer, 1839) in Puerto Rico, Cuba, Jamaica, and Venezuela in addition to the Dominican Republic in the Caribbean region. The two lymnaeid species can be differentiated by shell and animal characteristics. Fascioliasis is transmitted in this region principally by* F. cubensis, *but the occurrence of* P. columella *in some countries and its probable introduction into others may extend the range of this disease.*

Pseudosuccinea columella (also referred to as *Lymnaea columella* and *Lymnaea (Pseudosuccinea) columella*), a North, Central and South American species, has apparently been introduced into certain islands of the Caribbean and in other regions such as Europe, Africa, Australia and New Zealand. Malek and Chrosciechowski (1964) and Malek and Cogswell (1980) reported its occurrence in Venezuela, Colombia, Costa Rica, Panama and Brazil and reviewed its geographical distribution. Paraense (1982) also outlined its distribution in the neotropical region.

In our freshwater snail survey in the Dominican Republic we encountered *P. columella*, but it was less common (3 localities) than the other lymnaeid, *Fossaria cubensis* (Pfeiffer, 1839) (28 localities). Previous reports of the molluscan fauna of the Dominican Republic did not include *P. columella* (see Crosse, 1891), nor did Alvarez and Cordero (1977) in their work on fascioliasis report *P. columella*; they only discussed *F. cubensis*.

The two lymnaeid species can be differentiated morphologically as follows: The shell of *P. columella* has a low spire, much shorter than the high and elongated aperture, with a large and expanded body whorl. The surface is sculptured with microscopic raised spiral periostracal threads. Lateral teeth of the radula are tricuspid. The penis sheath is short, less than half the length of the preputium. The prostate is long and narrowly, roundly cylindrical, with the proximal end somewhat enlarged. *P. columella* is aquatic, with a tendency to be amphibious.

The adult shell of *Fossaria cubensis* is small, with well-impressed sutures and usually indistinct spiral lines. The spire is conic, broadly pyramidal or acute. the aperture is much smaller when compared to that of *P. columella*. The columella is smooth; the inner lip of the aperture is folded backward, forming a moderate or broad flat expansion. The lateral teeth of the radula are bicuspid. The penis sheath is two-thirds the length of the preputium; the prostate is ovate and rounded at the extremities. *F. cubensis* is amphibious.

Reports of *P. columella* in addition to *F. cubensis* from other Caribbean islands are from Puerto Rico (van der Schalie, 1948; Harry and Hubendick, 1964; Leon-Dancel, 1970) and from Cuba (Aguayo and Jaume, 1949). Specimens received from Ms. Charmine Crawford from Jamaica are also *P. columella* and *F. cubensis*. The two species are also known to occur in Venezuela (Malek and Chrosciechowski, 1964). *P. columella* has not been reported from St. Lucia (Malek, 1965; Barnish *et al.*, 1980), Guadeloupe (Pointier, 1974, 1976), Martinique (Guyard and Pointier, 1979), or Haiti (Robart *et al.*, 1976); however, *F. cubensis* is present in these countries. Pilsbry (1910) described the subspecies *F. cubensis aspirans* as *Lymnaea cubensis aspirans* from Barbados, West Indies.

The liver fluke *Fasciola hepatica*, which causes fascioliasis in the Americas, occurs in cattle and sheep-raising countries, parasitizing these animals and other herbivores. Human fascioliasis has also been reported from almost every American country, including islands of the Caribbean. There are several early reports of high prevalence rates on Cuba and records of some human cases. There are also records of fascioliasis in the Dominican Republic (Ueno *et al.*, 1973; Alvarez and Cordero, 1977), Puerto Rico (Frame and Bendezu, 1978; Hillyer, 1981; Bendezu *et al.*, 1982), Martinique (Gretillat, 1966, 1967), St. Lucia (Malek, 1965, 1980; Barnish *et al.*, 1980), and Jamaica (Anonymous, 1960). Malek (1965) signaled the occurrence of fascioliasis in St. Lucia and later (1980) gave details of prevalence rates in several estates in the north, center and south and in the abattoir in Castries, the capital. Malek (1965) predicted the occurrence of lymnaeid snails on the island and shortly after the report was written *F. cubensis* was encountered in 4 localities. The snails from St. Lucia were infected experimentally with *F. hepatica* miracidia of St. Lucian origin, and were later photographed (Malek, 1980). *F. cubensis* from St. Lucia was also susceptible to the schistosome, *Heterobilharzia americana* (Malek, 1967).

From all reports it seems that in the Caribbean region the principal snail intermediate host of *F. hepatica* is *F. cubensis*. *P. columella*, although susceptible to experimental infection (Leon-Dancel, 1970), has not been found naturally infected where it occurs in the Caribbean region, although natural infection has been reported in Brazil (Ueta, 1980). There is also a record by Van Volkenberg (1939) (cited in Leon-Dancel, 1970) and one by Hillyer (1981) in which *P. columella* was stated to be an intermediate host in Puerto Rico. The natural and experimental infections in *P. columella* indicate that its presence in some Caribbean countries, and its likely introduction in others, may extend the range of fascioliasis in the region.

References in the literature suggesting that snails other than lymnaeids, for example *Physa cubensis* in Cuba or terrestrial snails, can act as intermediate hosts for *F. hepatica* are erroneous. Some authors tend to implicate snails other than lymnaeids as transmitters of fascioliasis when they fail to locate lymnaeids such as *F. cubensis* or *P. columella* in the Caribbean region. Moreover, Leon-Dancel *et al.* (1971) tested the susceptibility of *Physa cubensis* and *Aplexa marmorata* in Puerto Rico and found them refractory to infection with *F. hepatica*.

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ANNOUNCING THE C.O.A. 1986 CONVENTION

The Conchologists of America's 14th annual convention will be held at the Sheraton Yankee Trader Hotel at Fort Lauderdale, Florida, from July 15 through July 19, 1986. The convention will be hosted by the Broward Shell Club, and the C.O.A. welcomes all shell collectors, whether novice or advanced, as well as shell dealers and scientists from around the country and the world.

For further information and pre-registration packets, please contact Ruth Chesler, Convention Chairman, at 7401 S. W. 7th Street, Plantation, Florida 33317.

NEWS

JULY 1986 AMU MEETING

The American Malacological Union and the Western Society of Malacologists will have a joint meeting from July 1-5 at the Sheraton Hotel in the heart of historical Monterey, Calif. The three symposia will be on the biology of opisthobranchs, life history of cephalopods and molluscan morphological analyses. Housing, travel and registration details, already sent to AMU members, may also be obtained from President Dr. James Nybakken, Marine Laboratories, P.O. Box 450, Moss Landing, CA 95039-0450.

SOME ASPECTS OF THE EVOLUTION OF THE RUDIST PELECYPODS

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ABSTRACT

The evolution of the rudist pelecypods was remarkably rapid even as compared to many mammalian groups. One new genus appeared every 1,900,000 years in the Late Jurassic. In the Early Cretaceous, one new genus appeared every 1,370,000 years, but in the Late Cretaceous the rate of evolution accelerated greatly when one new genus appeared every 345,000 years. For the entire time-span for the existence of the rudists, one new genus appeared every 738,000 years. Like the dinosaurs, the first rudists were of modest size. Beginning in the Albian stage, some rudists attained a size as large as any pelecypods that have ever lived.

Some additional aspects of the evolution of the rudists are given here because they are either not mentioned or inadequately covered in a manuscript now in press (D. S. Jones and D. Nicol: *Origination, survivorship, and extinction of rudist taxa*). Some of the data used herein were updated by examining the Zoological Record from 1966 to 1981. The main source of data is the Treatise on Invertebrate Paleontology (C. Dechaseaux and A. H. Coogan, 1969).

The aspect that is particularly emphasized here is the rapid increase in diversity at the generic level, especially during the Late Cretaceous or the last 29 million years of the existence of the rudists. The 15 Jurassic and Cretaceous stages listed in Table 1 are based primarily on ammonite zones and are not all of the same duration. The duration in years of each stage was taken from Palmer, 1983. The 15 stages can be subdivided into three groups for studying the changes of rates of evolution: the three Jurassic stages (Oxfordian through Tithonian), the Early Cretaceous stages (Berriasian through Albian), and the Late Cretaceous stages (Cenomanian through Maastrichtian).

Rudist evolution began at a rather modest rate in the Late Jurassic with a new genus appearing approximately every 1,900,000 years. The evolutionary rate did not accelerate greatly during Early Cretaceous time when a new genus appeared every 1,370,000 years. However, beginning with the Cenomanian, the earliest stage of the Late Cretaceous, evolution speeded up greatly, and a new genus arrived every 345,000 years. The evolutionary rate for the total 15 stages, or the complete life span of the rudists, is the appearance of a new genus every 738,000 years. This would be considered exceedingly rapid evolution amongst the pelecypods in a stable marine environment and is comparable to rapid evolutionary rates in many

TABLE 1. The 15 Jurassic and Cretaceous stages with their duration in millions of years, number of new genera per stage, and new genera per year. Oxfordian–Tithonian, Late Jurassic; Berriasian–Albian, Early Cretaceous; Cenomanian– Maastrichtian, Late Cretaceous.

Stages	Duration in years	New Genera	New genera per year
Maastrichtian	8,000,000	17	470,000
Campanian	9,500,000	13	730,000
Santonian	2,500,000	15	166,000
Coniacian	1,000,000	10	100,000
Turonian	2,500,000	13	192,000
Cenomanian	5,500,000	16	344,000
Albian	15,500,000	10	1,556,000
Aptian	6,000,000	7	857,000
Barremian	5,000,000	8	625,000
Hauterivian	7,000,000	0	---0---
Valanginian	7,000,000	5	1,400,000
Berriasian	6,000,000	4	1,500,000
Tithonian	8,000,000	4	2,000,000
Kimmeridgian	4,000,000	0	---0---
Oxfordian	7,000,000	6	1,167,000
Totals	94,500,000	128	738,000

groups of mammals.

The rapid acceleration of evolution of the rudists during the Late Cretaceous appears to be based on two phenomena. First, the three larger and more rapidly evolving families (Caprinidae, Radiolitidae, and Hippuritidae) either did not appear until the Late Cretaceous or did not become diverse until that time. Second, the rudist faunas became more provincial and ecologically complex in the Late Cretaceous. Endemism of the rudist genera increased greatly in the Late Cretaceous, and the rudist communities were generically most diverse in the Caribbean region during the Maastrichtian (Kauffman and Sohl, 1974).

As more paleontological study is done in the more remote areas with Jurassic and Cretaceous rocks in the Tethyan realm, a greater number of new genera discovered will be in the Late Cretaceous rather than in the Early Cretaceous and Late Jurassic.

In the rates of evolution within the 15 stages in Table 1, it is worthwhile to point out a few additional features. After a good start in the Oxfordian Jurassic, the evolution of the rudists slowed somewhat with a gap of no new genera in the Kimmeridgian, a time span of four million years. This slowing of the rate of evolution continued into the first three stages of the Early Cretaceous with a climax in the Hauterivian when, again, no new genera have so far been discovered. The unusual aspect of the Hauterivian gap is that it encompassed approximately seven million years.

Beginning in the Barremian, evolution accelerated greatly and this may have been caused partially by the onset of the two most diverse families, the Caprinidae and Radiolitidae. The rate of evolution then slowed in the next two stages which end in Early Cretaceous times. New genera appeared with exceeding rapidity in the Cenomanian and continued unabated until the Campanian and then accelerated again in the Maastrichtian. In the latest Cretaceous, new rudist genera were still appearing at a very rapid rate.

Although extinction of genera occurred rapidly in the Late Cretaceous, the large number of new genera in each stage tended, with some exceptions, to increase the total number of genera in each stage to a maximum of 43 in the Maastrichtian. This total of 43 includes the holdovers from earlier stages as well as the new arrivals. The present total of rudist genera is 128 so that within a period of no more than eight million years, one third of all the rudist genera became extinct. Five of the seven rudist families also became extinct in the Maastrichtian.

The decline and extinction of the rudists occurred in slightly less than 8.5% of their total geologic history. This sudden demise of the rudists at their zenith at the end of the Cretaceous is unlike the extinctions of the trilobites, graptolites, conodonts, and rostroconchs where there was a long period of decline in diversity before extinction. Even the ammonites and dinosaurs experienced a longer period of decline than the rudists. It is most difficult and highly speculative to explain such a sudden extinction in a group of marine pelecypods that had been so highly successful.

The rudist pelecypods, like the dinosaurs, began with small-sized species. Some of the early rudists were about 20 mm long, and small-sized rudists are also found at the end of the Cretaceous in Maastrichtian strata. Particularly among the diverse families Caprinidae and Radiolitidae, some stocks attained large size as early as the Albian, and large species continued to occur into the Maastrichtian. However, even by Albian time, 50 million years had passed, which is more than half of the total time span of the rudists. *Titanosarcolites* attained a length of more than 2 m, *Bournonia* reached a diameter of more than 0.6 m, and the shell wall of *Durania* attained a thickness of at least 10 cm (B. F. Perkins, 1969, p. N751). These large rudists were among the largest pelecypods that have ever lived.

Acknowledgments

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A NEW *SOMATOGYRUS* FROM THE SOUTHWESTERN OZARKS WITH A BRIEF REVIEW OF THE HYDROBIIDAE FROM THE INTERIOR HIGHLANDS (GASTROPODA: PROSOBRANCHIA)

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ABSTRACT

A previously unknown Somatogyrus *is described from the Elk River, McDonald County, Missouri. With this description, the number of Hydrobiidae presently recorded from the Interior Highlands increases to 15, including 11 regional endemics. Nine species are endemic to the Ozark Plateaus, while two* Somatogyrus *are restricted to the Ouachita Mountains. Five of the Ozark endemics are obligate troglobites. Troglobitic* Amnicola antroecetes *(Hubricht) is considered distinct from epigean* A. aldrichi *(Call and Beecher).*

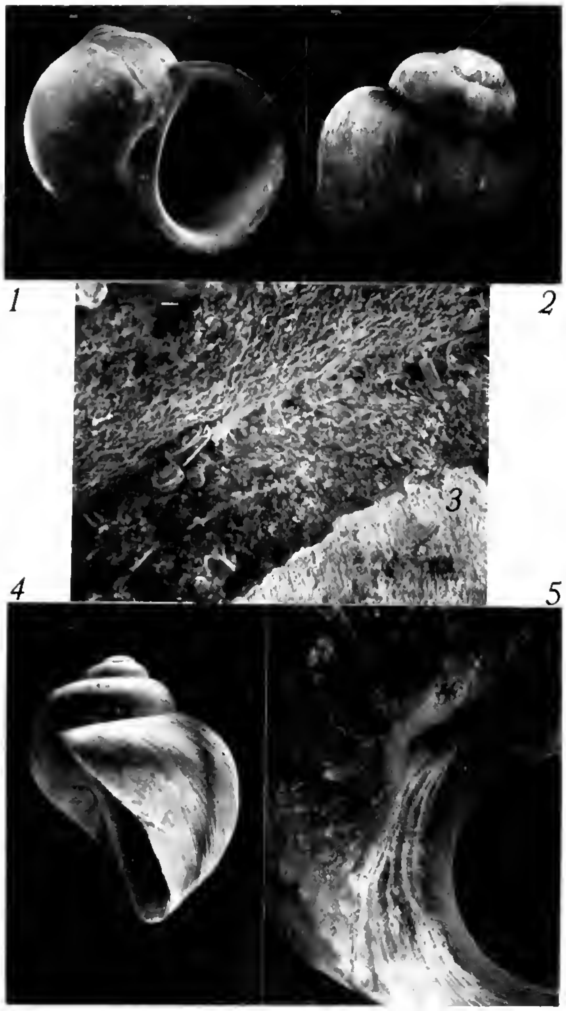
Excepting the Unionoidea, little study has been afforded the aquatic Mollusca of the Interior Highlands. Among the poorer known groups, regional accounts of the Hydrobiidae are rare. The primary sources of published records have been original descriptions of several endemic species (e.g. Walker, 1915; Hinkley, 1915; Hubricht, 1979), although the occasional collection of hydrobiids has been noted in a few species surveys (e.g. Sampson, 1913; Wheeler, 1918; Gordon, 1981). A recent faunal survey of drainage basins in southwestern Missouri and northwestern Arkansas (Gordon, 1980) recovered several species of Hydrobiidae. A previously unknown *Somatogyrus*, collected from the Elk River, McDonald County, Missouri, is here described.

Family Hydrobiidae Troschel 1857

Subfamily Lithoglyphinae Fischer 1885

Somatogyrus rosewateri *new species*

Shell description of holotype – Shell subglobose, medium size for *Somatogyrus*, solid, dextral, 4.25 whorls, turbinate, subhyaline; body whorl .90 times axial height, greatly inflated; penultimate whorl .34 times width of body whorl (Fig. 1; see Table 1 for holotype measurements and range of paratypes). Spire very short, depressed, broadly conic; sutures moderately impressed; protoconch flattened (Fig. 2). Periostracum greenish (may be masked by color of visceral mass showing through shell) with shallow, oblique growth striae; protoconch ornamented with fine, spiral ridges (Fig. 3). Aperture broadly ovate, .74 times axial height, .80 times height and .55 times width of body whorl, plane of aperture at 30° to shell axis. Peristome complete across parietal wall by a callus which continues and thickens across columella (callus in some individuals may be slightly reflected over columella, partially obscuring umbilicus); lip straight along parietal wall, curving concavely near the umbilicus and along columella, parietal-columellar junction non-angular. In lateral view (Fig. 4), periphery of parietal lip



FIGS. 1-5. *Somatogyrus rosewateri* n. sp. **1**, apertural view of paratype (3.9 × 3.8 mm.); **2**, juvenile paratype; **3**, suture and protoconch sculpture of paratype. The barely visible white bar in the upper left is 10 microns in length. **4**, lateral view of paratype (4.2 × 3.8 mm.); **5**, umbilical view of paratype (shell, 3.6 × 3.5 mm.).

approximately parallel to plane of aperture, columella straight but recedes towards base, and parietal-columellar junction forms an obtuse angle. Umbilicus relatively open for *Somatogyrus* (Fig. 5); passes into a shallow, canal-like depression continguous to the columellar lip. Basal lip slightly receded due to angle of aperture; area of base-columellar junction projects forward about equal to the distance of the basal lip recession (Fig. 4).

Operculum chitinous, ovate, horn-colored; paucispiral, consisting of about three whorls; nucleus subcentral, located slightly left of midline in lower third; outer surface sculptured with many fine growth striae, peripheral margin without striae and edge appears slightly ragged (Fig. 6).

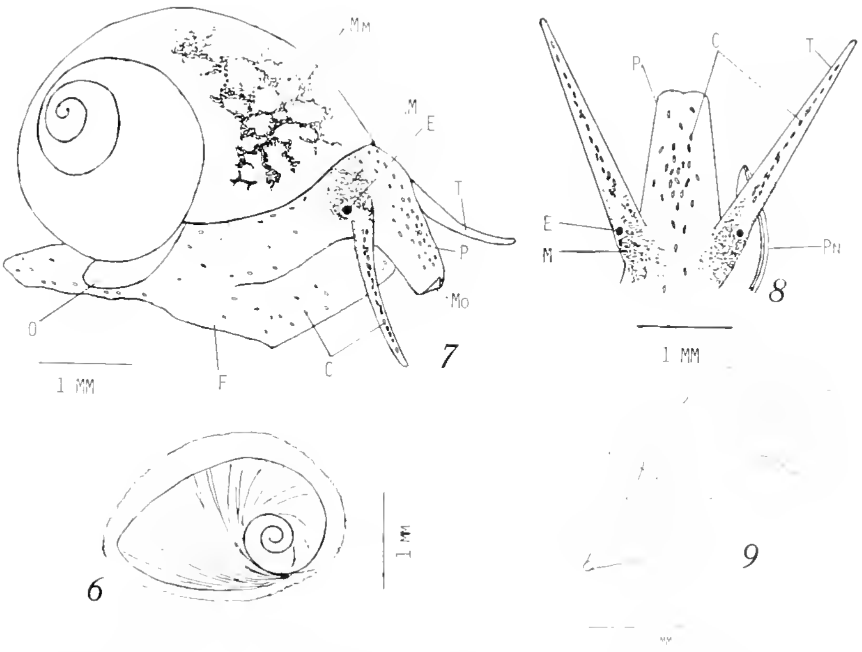
Soft parts—Living animals translucent (odontophore complex visible through proboscis), whitish. Mantle collar and dorsal aspects of proboscis, head, tentacles, and foot speckled with sub-epidermal gold to orangish gold chromatocytes (Fig. 7); dorsal surface and ⅓ thickness of visceral mass infused with golden color. Dense concentrations of melanin at base of tentacles, extends dorso-medially in front of eyes a short distance and posteriorly on to dorsum of head (Fig. 8); a narrow line of melanin runs laterally from in front of eye forward about ¼ to ⅓ length of tentacle; dorsal and lateral surfaces of mantle with mottled patterns of melanin (Fig. 7), 35% of paratypes (n=52) lacked mantle melanin. Shells of living snails appear amber to orangish due to visceral and mantle pigmentation showing through shell, darkens to brown in spire; melanistic snails have slightly browner tint. Penis unpigmented. Preserved animal white.

Foot broad (Fig. 7); anterior truncated, extending forward to eyes; posterior tapers to a rounded point. Head (Fig. 8) extends anterior of shell to expose eyes; proboscis relatively long and slender, curved ventrally; tentacles long and slender, eyes positioned ventro-laterally at base. Penis (Fig. 9) slender, simple; tapers to a fine, blunt point; dorso-ventrally flattened, dorsum slightly convex, venter flatly concave; vas deferens positioned near posterior margin. Penis arises a short distance inside mantle cavity above and behind the right tentacle, tends to curve counter clockwise; when extruded, emerges from shell directly behind right tentacle and extends below it (Fig. 8).

Type locality—Missouri, McDonald County, Elk River at Missouri Department of Conservation Mt. Shira Public Fishing Access, 1.6 km south of Ginger Blue (R33W, T21N, sections 1 and 2). Holotype: University of Colorado Museum of Zoology (UCM) no. 32812; collected 24 October 1985 by Mark E. Gordon. Allotype: UCM no. 32813; same data as holotype. Paratypes: ten specimens each deposited at UCM, U.S. National Museum of Natural History, Academy of Natural Sciences of Philadelphia,

TABLE 1. Dimensions of holotype, allotype, and paratypes of *Somatogyrus rosewateri* (measurements in mm): H = height, W = width, BH = body whorl height, PW = penultimate whorl width, A = aperture, AH = aperture height, AW = aperture width.

	H	W	W/H	BH	BH/H	W/BH	PW	PW/W	AH	AW	AW/AH	Plane of A
Holotype (♀)	3.9	3.8	.97	3.5	.90	1.09	1.3	.34	2.8	2.1	.75	30°
Allotype (♂)	3.4	3.4	1.00	3.1	.91	1.10	1.0	.29	2.5	1.9	.76	---
Paratype	3.7	3.6	.97	3.2	.86	1.13	1.2	.33	2.3	2.1	.91	---
" "	4.0	3.7	.93	3.5	.88	1.06	1.2	.32	2.7	1.7	.63	34°
" "	4.1	3.9	.95	3.6	.88	1.08	1.2	.31	2.8	2.4	.86	29°
" "	4.0	3.8	.95	3.6	.90	1.06	1.1	.29	2.9	2.2	.76	---
" "	3.9	3.7	.95	3.4	.87	1.09	1.2	.32	2.5	2.1	.84	34°
" "	3.8	3.8	1.00	3.4	.89	1.12	1.3	.34	2.4	2.1	.88	35°
" "	3.8	3.5	.92	3.4	.89	1.03	1.3	.37	2.5	2.1	.84	30°
(Fig. 1)	3.9	3.8	.97	3.5	.90	1.09	1.1	.29	2.5	2.1	.84	30°
(Fig. 3,4)	4.2	3.8	.90	3.7	.88	1.03	1.3	.34	2.8	2.2	.79	30°
(Fig. 5)	3.6	3.5	.97	3.3	.92	1.06	1.0	.29	2.5	1.9	.76	27°



FIGS. 6-9. *Somatogyrus rosewateri* n. sp. **6**, operculum; **7**, animal extruded from shell (composite drawing from live and relaxed specimens; body slightly distended from relaxation with sodium pentobarbital): C = chromatocytes, E = eye, F = foot, M = melanin, Mm = mantle melanin showing through shell, Mo = mouth, O = operculum, P = proboscis, T = tentacle; **8**, dorsal view of head: Pn = penis; **9**, penis: V = vas deferens.

Museum of Comparative Zoology, University of Michigan Museum of Zoology, and Field Museum; same data as holotype.

Distribution – Found only in the middle section of Elk River (Fig. 10). To date, this species has been collected from only the type locality and below an old mill dam at Noel, McDonald County, Missouri. It was not recovered from

FIG. 10. Distribution of *Somatogyrus rosewateri* (solid triangle is the type locality).

areas upstream of the type locality nor the river channel downstream from the Missouri-Oklahoma border which has been inundated by a reservoir on the Neosho River (Grand Lake O' the Cherokees). The known range of this species occurs in the Springfield Plateau region of the Ozarks.

Habitat – Specimens were collected at the type locality from a series of riffles. Substrate was composed of gravel and cobble-sized materials (mainly chert). At Noel, habitat was below the outfall of a small mill dam. Substrates were primarily stepped and broken bedrock with some cobble. Gradients at both sites were fairly high and water quality was quite good (Table 2).

Etymology – This species is named in memory of Dr. Joseph Rosewater, late Curator of Mollusks, U.S. National Museum of Natural History.

Discussion

The comparative difference between *S. rosewateri* and previously described species in the genus are shown in Table 3.

TABLE 2. Physico-chemical measurements made at type locality, Elk River: 20 November, 1979.

Water temperature	15° C
Turbidity	1.6 NTU
Specific conductance	260 µmhos/cm
Alkalinity	140 mg/l total $CaCO_3$
pH	8.15
Nitrate	1.5 mg/l
Color	negligible

Besides *Somatogyrus rosewateri*, the only other hydrobioids collected from the Elk River basin were the nymphophiline *Cincinnatia integra* (Say) and the pomatiopsid *Pomatiopsis lapidaria* (Say) (Gordon, 1980). Two other *Somatogyrus* are known from the Ozark Plateaux. *Somatogyrus depressus* (Tryon), an inhabitant of the upper Mississippi River valley, occurs in the Osage River, central Missouri (Thompson, 1984) and *S. crassilabris* Walker, an Ozark endemic, is apparently known only from its original collection from the North Fork of the White River, Arkansas. In discussing phylogenetic relationships among North American Lithoglyphinae, Thompson (1984) noted difficulties in pursuing such studies due to a relatively large number of undescribed species and a paucity of morphological data for described species. For *Somatogyrus*, he did list several characters useful for specific comparisons. Available data for the three Ozark species and two Ouachita Mountains endemics (Table 3) suggests that the Ozark species may be fairly closely related. Walker (1915) also considered *S. wheeleri* Walker closer to *S. crassilabris* than to its Ouachitan congener. However, both Ouachita Mountains endemics may have evolved from other lineages (e.g. Alabama River). Considerably more information is necessary before such speculative, phylogenetic relationships may be confirmed. In some instances, complete analyses may no longer be possible. Many hydrobiids, such as *S. crassilabris*, *S. amnicoloides* Walker, and *S. wheeleri*, are known only from their type localities. Habitat alterations, such as reservoir construction, may have been deleterious for species with such highly restricted distributions.

Fifteen species of Hydrobiidae have been documented from the Interior Highlands (Table 4). Four are wide-ranging species. In the case of *Probythinella lacustris* (Baker) (mistakenly listed as *P. binneyana* (Hannibal) in Gordon, 1981) and *Somatogyrus depressus*, their southern distributional limits occur in the Ozarks. *Cincinnatia integra* and *Birgella subglobosa* (Say) have considerably larger ranges than the previous, more northerly distributed species (see Burch and Tottenham, 1980; Thompson, 1984). The remaining eleven species are endemic to the Interior Highlands. *Somatogyrus*

TABLE 3. Variation in shell morphology among Interior Highlands *Somatogyrus* (data adapted from Baker, 1928; Burch and Tottenham, 1980; Hinkley, 1915; Walker, 1915; and this study).

	depressus	crassilabris	rosewateri	wheeleri	amnicoloides
Shell obesity (W/H)	.78-1.00	.77-.92	.90-1.00	.93	.78
Size medium (< 4 mm)(0) small (> 4 mm)(1)	0	0	0	0	1
Spire depressed (>15% H)(0) elevated (<15% H)(1)	0	0	0	1	1
Protoconch flattened (0) elevated (1)	0	0	0	1	0
Parietal-columellar wall junction of lip smooth curve (0) angular (1)	0	0	0	0	1
Umbilicus narrow (0) open (1)	0	0	1	1	0
Widest expansion of outer lip periphery above mid-height (0) below mid-height (1)	0	0	0	0	1
Aperture apex relation to parietal wall fused (0) detached (1)	0	0	0	1	0

amnicoloides and *S. wheeleri* are presently the only endemic hydrobiids that have been identified from the Ouachita Mountains province. Four epigean and five troglobitic species are endemic to the Ozark Plateaus. The majority (eight) are restricted to the eastern half of the province. The only endemic, western Ozark hydrobiid presently recognized is *S. rosewateri;* however, a single specimen of *Somatogyrus* has been collected from the headwaters area of the White River, Arkansas (Gordon, 1980). This specimen was too eroded to allow identification beyond genus and subsequent collecting failed to recover additional specimens.

Most of the Ozark endemic, obligate troglobitic Hydrobiidae have been referred to Amnicolinae: *Amnicola*. Burch and Tottenham (1980) noted that this classification was tentative due to the lack of anatomical data for these species. However, *Antrobia culveri* Hubricht was relegated to the Lithoglyphinae without justification by Burch and Tottenham (1980). The anatomy of this species remains all but unknown. The brief description of the radula presented by Hubricht (1971) does not appear to meet the radular criterion for Lithoglyphinae established by Thompson (1984) and differs from that of *Amnicola* only by the size of the central tooth mesocone. Hubricht (1971) described the penis of *Antrobia* as "simple, tapering to a point, without appendages." This morphology is characteristic of the lithoglyphine penis (Thompson, 1984) and is probably the basis for the classification in Burch and Tottenham (1980). Unfortunately, Hubricht (1971) did not describe the number of ducts penetrating the penis. Thompson (1984) considered the Amnicolinae, with two penial ducts, remote in

TABLE 4. Hydrobiidae known from the Interior Highlands.

- Hydrobiinae
  - *Probythinella lacustris* (Baker, 1928)
- Lithoglyphinae
  - *Somatogyrus amnicoloides* Walker, 1915
  - *Somatogyrus crassilabris* Walker, 1915
  - *Somatogyrus depressus* (Tryon, 1862)
  - *Somatogyrus rosewateri* new species
  - *Somatogyrus wheeleri* Walker, 1915
- Nymphophilinae
  - *Birgella subglobosa* (Say, 1825)
  - *Cincinnatia integra* (Say, 1821)
  - *Marstonia ozarkensis* (Hinkley, 1915)[1]
- Amnicolinae
  - *Amnicola aldrichi* (Call and Beecher, 1886)[2]
  - *Amnicola antroecetes* (Hubricht, 1940)[3]
  - *Amnicola cora* Hubricht, 1979[3]
  - *Amnicola prosperpina* Hubricht, 1940[3]
  - *Amnicola stygia* Hubricht, 1971[3]
  - *Antrobia culveri* Hubricht, 1971[3]

[1] *Pyrgulopsis ozarkensis* is placed in *Marstonia* following the suggestion of Thompson (1977).

[2] Burch and Tottenham (1980) included *Amnicola missouriensis* Pilsbry, 1898 as a valid species. Although this group requires further anatomical investigation, the argument of Hubricht (1940) for synonymizing this species under *A. aldrichi* is followed.

[3] Troglobitic.

relationships to the hydrobiid subfamilies possessing single-duct penes (e.g. Lithoglyphinae). Additionally, Thompson (1984) suggested that the simple, non-appendaged penis was a generalized, primitive condition in the Lithoglyphinae but may occur as a "derived condition through the secondary loss of previously existing characters" for some taxa in other hydrobiid subfamilies (e.g. Hershler and Davis, 1980: Hydrobiinae; Hershler, 1985: Littoridininae). Considering similarities of the antrobian radula, shell, and operculum to *Amnicola*, morphology of the penis may represent a secondarily derived character state in *Antrobia*. In conjunction with the above, a conservative classification would retain *A. culveri* in the Amnicolinae until phylogenetic relationships can be resolved.

The only endemic, epigean amnicoline presently recognized is *Amnicola aldrichi* (Call and Beecher), which exhibits a habitat preference for springs. Hubricht (1940) described three subspecies for *A. aldrichi: aldrichi* s.s., *insolita* Hubricht, and *antroecetes* Hubricht. "Deeper sutures, strongly shouldered whorls, and a free lip (Hubricht, 1940)" differentiated *insolita* from *aldrichi* s.s. Hubricht's illustration and description of a free lip indicate a slightly uncoiled body whorl. This condition occurs occasionally within the Gastropoda and has been shown to sometimes represent distinct, geographical subspecies (e.g. Clarke, 1973: *Valvata sincera ontariensis* Baker). Recently collected specimens (juveniles-adults) from one of Hubricht's *insolita* localities (2 November, 1985; Meramec Spring, 8 km southeast of St. James, Phelps County, Missouri) were examined and found to exhibit considerable variability with regards to the distinguishing characters for *insolita*. In no case was there any evidence of an uncoiled body whorl. Palmer (1985 and references within) demonstrated that shell variation in gastropods can be strongly influenced by environmental conditions and/or intraspecific genetic plasiticity and does not necessarily reflect divergence (i.e. speciation). The distribution of *insolita* (from Hubricht, 1940) is not geographically distinct from that of *aldrichi* s.s. Considering the above, *insolita* does not appear to warrant subspecific status in the modern sense (see Mayr, 1966).

Morton (1967) and many others have discussed problems related to constructing molluscan classifications from single-based systems (e.g. shell morphology). As noted above, variation in shell characters does not always imply speciation (Palmer, 1985). Conversely, lack of shell morphological variance is not always indicative of conspecificity or close phylogenetic relationships, but may mask divergent or convergent evolution (Davis, 1979; Dillon and Davis, 1980; Vail, 1980; Thompson, 1984). Hubricht (1940) was unable to readily differentiate shells of his third subspecies, *Amnicola aldrichi antroecetes*, from slender examples of *aldrichi* s.s. Both the previously discussed "subspecies" are epigean forms with pigmented bodies and functional eyes; however, *antroecetes* is an unpigmented, blind, obligate troglobite. Hubricht (1940) failed to be consistant in his methodology for distinguishing the subspecies of *A. aldrichi; insolita* by shell characters vs. *antroecetes* by anatomy and operculum. Even though *insolita* is considered invalid, this deviation still suggests that different levels of organization were being examined. Thompson

(1984) indicated that "a high degree of anatomical uniformity" exists within groups of the Hydrobiidae (e.g. Lithoglyphinae). The loss of pigmentation and eyes represents a rather radical divergence from the epigean anatomy of *aldrichi* s.s. To consider these troglobitic adaptations to be ecophenotypic variation implies an amazing genetic plasticity and an "use it or lose it" evolutionary interpretation. Ecophenotypic variation does not meet modern criteria for subspecific status (Mayr, 1966); however, previous relegation of *antroecetes* as a subspecies reflects the over-reliance on shell characters for constructing phylogenies. *Amnicola antroecetes* should be considered a distinct species. Interestingly, *A. antroecetes* has a rather wide distribution when compared to other regional troglobitic gastropods (restricted to single or connected caves). Other troglobitic taxa (e.g. Amblyopsidae; Isopoda: *Caecidotea*) exhibit similarly wide ranges in the Interior Highlands. This may be related to the karst geology of the region. Hubricht (1940) did note some size variation at different localities but correlated this to food availability. However, due to its wide range he suggested that *A. antroecetes* may represent a composite group. Further investigation is obviously warranted for the *A. aldrichi* complex and, for that matter, the Hydrobiidae throughout the Interior Highlands.

Acknowledgments

The uniqueness of *Somatogyrus rosewateri* was confirmed by Fred G. Thompson, Florida State Museum, University of Florida. SEM's were prepared with the assistance of Claudia S. Bailey and specimens of *Amnicola aldrichi* were provided by Michael L. Mathis, both Department of Zoology, University of Arkansas.

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FAVARTIA BREVICULA (SOWERBY, 1834) AND TWO NEW SPECIES OF *FAVARTIA* FROM THE WESTERN PACIFIC (GASTROPODA: MURICIDAE)

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ABSTRACT

Murex breviculus *Sowerby, 1834, is reexamined and a lectotype is selected from the syntypic lot.* Murex tetragonus *Broderip, 1833, is discussed and it is our conclusion the name is a* nomen dubium. *Two new species of* Favartia *Jousseaume, 1880, are described, one from the Solomons one from the Philippines.*

The identity of *Murex breviculus* Sowerby, 1834, has never been in doubt and the figure in the *Conchological Illustrations* (Sowerby, 1834, pl. 63, fig. 37) clearly defines the species. The illustration agrees with the brief but adequate description published later in the *Proceedings of the Zoological Society of London* (1841:146-147). The syntypic lot consisting of three specimens was borrowed from the British Museum. A lectotype was selected and the two remaining specimens are considered paralectotypes. For purposes of clarity all three specimens from the type lot are illustrated herein through the courtesy of the Trustees of the British Museum (Natural History).

The identity of *Murex tetragonus* Broderip, 1833, on the other hand has never been established. Broderip's description in the Proceedings of the Zoological Society of London for 1832, was based on a single "very much waterworn" specimen. Broderip did not figure this species, but Sowerby (1834) figured *M. tetragonus* in the *Conchological Illustrations* (pl. 61, fig. 25 and pl. 63, fig. 36). We were informed by Ms. Kathie Way of the Molluscan Section, British Museum, that they were unable to locate any type material of *M. tetragonus* Broderip.

Institutional abbreviations used in this paper are: ANSP = Academy of Natural Sciences Philadelphia. BM(NH) = British Museum Natural History. SDNHM = San Diego Natural History Museum.

Muricidae Rafinesque, 1815
Muricopsinae Radwin and D'Attilio, 1971

Favartia Jousseaume, 1880

Type Species: *Favartia brevicula* (Sowerby, 1834) by original designation

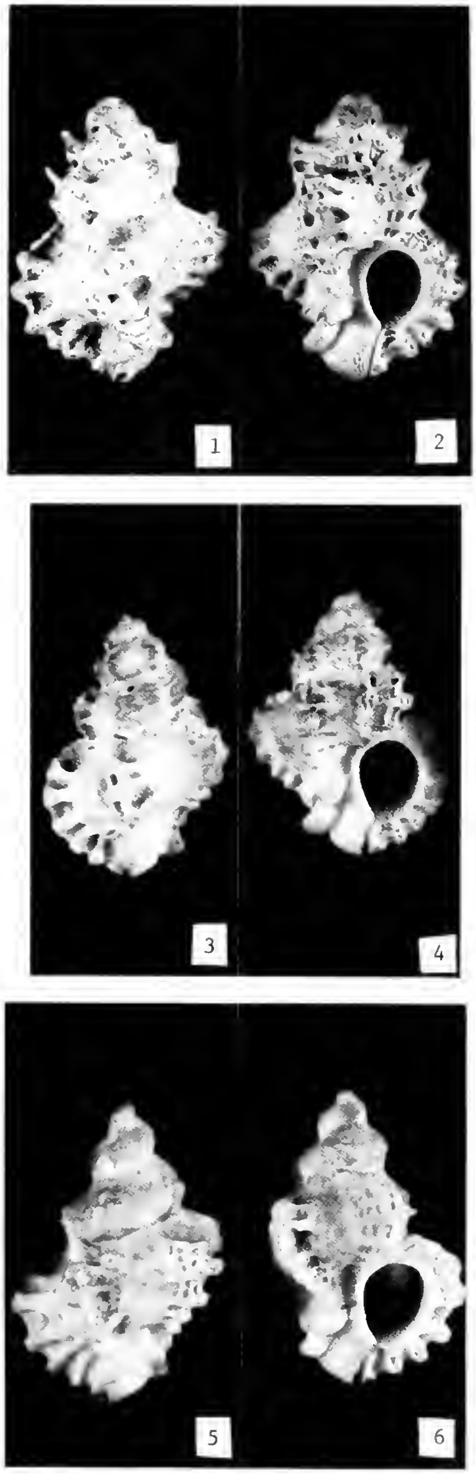
Favartia brevicula (Sowerby, 1834)

Murex breviculus Sowerby, 1834: Conch. Ill. Pl. 63, fig. 37

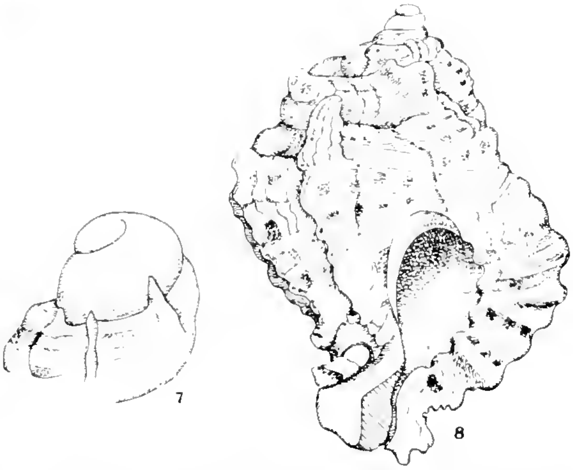
Figs. 1-8, 13

The syntypic lot of *Favartia brevicula* (Sowerby, 1834) borrowed from the British Museum (NH) consisted of three beach eroded specimens reg. #1974088.

The lectotype, measuring 26 mm × 20 mm, was selected because it had the least amount of erosion. Shell is broadly biconic, the number of whorls indeterminate because of the erosion of the spire. Whorls convex, aperture subcircular, smooth within, inner lip erect, outer lip crenulate, reflecting external cords, anal sulcus not apparent, canal narrowly open, broad, moderate in length, terminally sharply recurved; three older canal terminations on fasciole; four broad varices crossing shoulder and abutting whorl above; narrow intervarical areas appear smooth on lectotype; leading edge of varices reaching midway in the intervarical area; varices deeply cut and depressed on both leading and receding side; where varix crosses the shoulder it is bladelike and strongly recurved; the leading side of the varix with longitudinal lamellae undulating between the spiral cords; five thick spiral cords on body whorl, obsolete in narrow intervarical areas, the first three about equal size, the two anterior ones small and grouped as a pair. Two minor cords on the canal separated by a gap from the body cords at the base of the body whorl. Color of types is dull-white.



FIGS. 1-6. *Favartia brevicula* (Sowerby, 1834). **1**, Dorsal and **2**, apertural views of lectotype BM(NH) #1974088 (26.0 × 20.0 mm.); **3** and **4**, paralectotype BM(NH) #1974088 (23.75 × 17.0 mm.); **5** and **6**, paralectotype BM(NH) #1974088 (26.75 × 20.0 mm.).



FIGS. 7 and 8. *Favartia brevicula* (Sowerby, 1834) SDNHM 76669 small specimen from Bohol Straits, Philippine Islands. **7**, protoconch; **8**, general shell morphology (11.0 mm × 7.4 mm.).

Type Locality—Unknown. The species if found throughout the western and south Pacific to east Africa.

Dimensions—

	Length Width
BM(NH) #1974088 - Lectotype	26.0 mm × 20.0 mm
BM(NH) #1974088 - Paralectotype	23.75 mm × 17.0 mm
BM(NH) #1974088 - Paralectotype	26.75 mm × 20.0 mm

Discussion—Sowerby (1879) in the *Thesaurus Conchyliorum* appeared to change the description of *F. brevicula*. Instead of having four varices as described in the original description, he stated there were five varices for *F. brevicula*. Although the three syntypes for *F. brevicula* have only four varices and in most of the specimens examined there were only four varices, among the material at our disposal, we found nine specimens with five varices from dif-

FIGS. 19 and 20. *F. tetragona* Broderip, 1833, taken from Sowerby (1834). **19**, from pl. 61, fig. 25; **20**, from pl. 63, fig. 36.

ferent localities and ranging in size from 11.5 mm to 23.0 mm. The number of varices appears to be a variable character.

Favartia tetragona (Broderip, 1833)

Murex tetragonus Broderip, 1833: Proc. Comm. Sci. Corresp. Zool. Soc. London, 174.

Figs. 19, 20

The single specimen available to Broderip was in poor condition and the only one he ever saw. It was never figured by Broderip and the description is not definitive. The original description is as follows:

> MUREX TETRAGONUS. *Mur. testâ pyramidali, albidâ, quadrifariam varicosâ, transversim costatâ, subcancellatâ; aperturâ violaceâ, prominente; labii limbo unduloso-crenulato; canali brevi, recurvâ: long. 1¼, lat. ⅝ poll.*
>
> *Hab.* ?
>
> Mus. Sowerby.
>
> This specimen, the only one I ever saw, is very much waterworn, but the leading characters of the species are uninjured.— W. J. B.

According to Broderip the habitat was unknown. The specimen was deposited in Museum Sowerby and its whereabouts today is unknown. The illustrations by Sowerby in 1834 (Pl. 63, fig. 36 and Pl. 61, fig. 25) do not show a waterworn shell as described by Broderip, but do show a very pyramidal-shaped shell, with a broad base and flaring lip. Figs. 19 and 20 are copied from Sowerby (1834).

Lacking typological material the morphology of this taxon must rely entirely on Broderip's description and the figure by Sowerby. Reeve (1845: Pl. 26, fig. 18) figured the broad coarse shell of *Murex breviculus* Sowerby placing *M. breviculus* in the synonymy of *M. tetragonus*, the earlier name, stating he could not discover "any specific differences between *Murex tetragonus* and *breviculus*". Sowerby who did the illustrations for the *Conchologia Iconica* did not dispute the synonymy. However, in 1879, in the *Thesaurus Conchyliorum*, Sowerby included both binomens (*Murex tetragonus* sp. 187, fig. 228 and *M. breviculus* sp. 188, fig. 229), and in comparing the two species stated at that time that *M. breviculus* was a shorter and thicker shell than *M. tetragonus* and had five varices. This differed from *M. tetragonus* which was described as having four varices. In 1879 Sowerby also stated for *M. tetragonus* that the latticed varices follow from whorl to whorl so confluently as to form four oblique walls up the spire and he stated for *M. breviculus* "ad spiram interruptis".

The identification of *M. tetragonus* has never been established. As stated above Reeve (1845) synonymized *M. breviculus* with *M. tetragonus*, the earlier name. Tryon (1880: pl. 36, fig. 424, 425) agreed with Reeve, figuring both the broad heavy shell of *M. breviculus* and what looks like a copy of Sowerby's figure of *M. tetragonus*, both under the name of *M. tetragonus*.

In recent works the following authors figured what they believed to be *F. tetragona* as follows:

Smith, M. (1939: pl. 6, fig. 2) figured *F. brevicula*.

Cernohorsky (1967: pl. 15, fig. 20) figured an undetermined species.

Fair (1976: pl. 20, fig. 295) figured an undetermined species.

Radwin and D'Attilio (1976) mistakenly described *F. tetragona* as having three varices and figured it on pl. 14, fig. 3. This is the new species described here as *F. trivaricosa* and shown also in text fig. 96 of Radwin and D'Attilio.

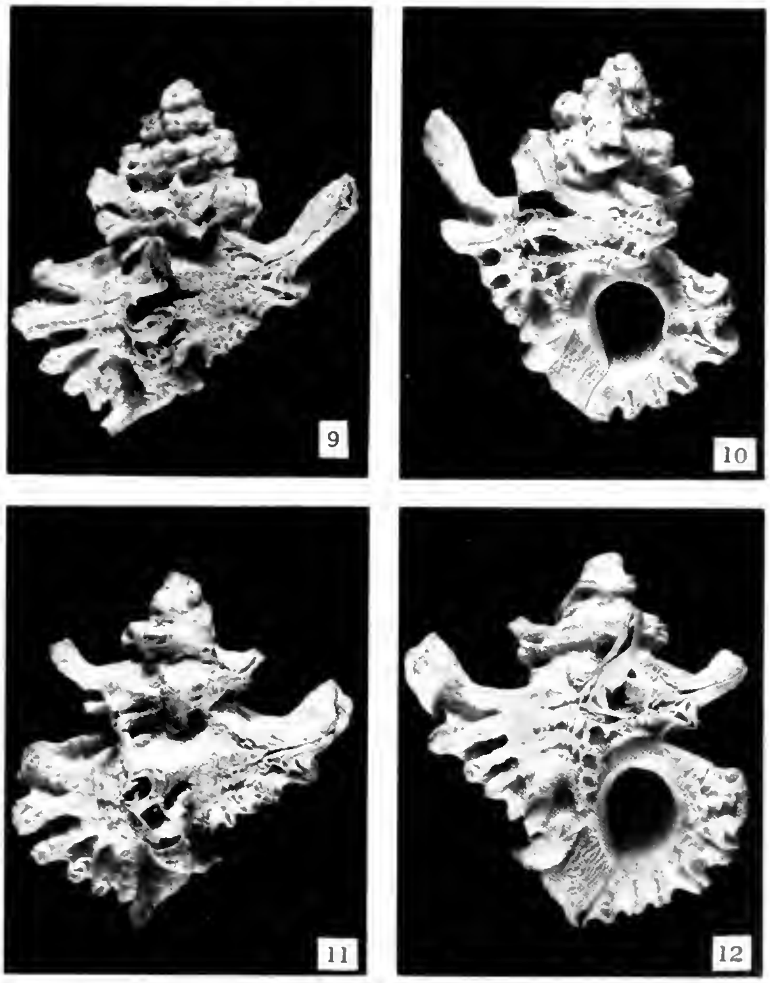
Inasmuch as there is apparently no type extant for *F. tetragona*, the identity of the species has not been established in 150 years. We have not been able to associate Sowerby's figure with any species of *Favartia* known to us and we believe this species is of dubious merit, therefore we are placing it among the doubtful names. It is interesting to note that no authors, to date, have mentioned Broderip's description of the aperture being prominently violet.

Favartia robertsoni new species

Figs. 9-12, 14, 15, 16

Shell medium size, broadly fusoid, spire moderately high, anterior truncate, approximately five whorls, early whorls eroded; protoconch not determined; weakly shouldered, somewhat tabulate; shoulder area between the varices depressed and concave, especially on receding side of the varix; suture impressed; body whorl broader than high; aperture subovate; peristome erect; outer lip undulate, reflecting external transverse cords; canal broad, very narrowly open, short, terminally tube-like, bent backward nearly at right angle; siphonal fasciole retaining two older canal terminations.

Varices thick, four per whorl; intervarical



FIGS. 9-12. **9, 10,** *Favartia robertsoni* n. sp. holotype SDNHM 86944 (26.0 × 26.5 mm.). **11** and **12,** paratype D in the Donald Pisor collection (26.6 × 27.2 mm.).

areas with moderately raised cords; varices extending over shoulder obliquely to left and terminating at suture.

Spiral sculpture as follows: one broad cord at the shoulder prolonged prominently into a blunt spine, the margin nearly closed on the leading side; a similar broad cord below extending beyond the varix, but not prolonged into a spine, up to the penultimate varix. On the mature apertural varix these two cords do not project beyond the remaining sculpture of the varix. Four secondary cords on the body whorl diminishing in size anteriorly; varix deeply excavated between the cords on receding side; cords on body whorl more or less weakly raised; three minor cords on shoulder obsolete except near apertural varix. Leading side of varices recurved and with scabrous lamellae producing a surface with squarish pits; weak scabrous lamellae on surface of spiral cords between varices.

Color: Creamy white entirely except for the holotype with is a dead collected shell lightly stained with rust.

Type Locality–Malaita Island, Solomon Islands.

Dimensions–	Length	Width
Holotype SDNHM 86944		
Ataa, Malaita Island, Solomon Is.	26.0	26.5 mm
Paratype A, SDNHM 86942		
Marau Sound, Guadalcanal, Solomon Is.	17.0	15.9
Paratype B, ANSP 289568		
Malaita Island, Solomon Islands	20.5	20.2

FIGS. 13-16. **13,** Outline drawing of *Favartia brevicula* (Sowerby, 1834) SDNHM 78704 (19.6 × 15.2 mm.). FIGS. 14-16, *Favartia robertsoni* D'Attilio and Myers. **14,** paratype B ANSP 289568 (20.5 × 20.2 mm.); **15,** paratype C ANSP 289568 showing microsculpture of receding side of varix; **16,** leading side of varix.

Paratype C, ANSP 289568		
Malaita Island, Solomon Islands	14.4	14.1
Paratype D, Donald Pisor collection.		
Malaita Island, Solomon Islands	26.6	27.2
Paratype E, Glass and Foster collection		
Marau Sound, Guadalcanal, Solomon Is.	24.5	1.75

Etymology—This species is named for Dr. Robert Robertson, Curator and holder of the Pilsbry Chair of Malacology, Academy of Natural Sciences Philadelphia, whose malacological insight the senior author has long admired.

Discussion—The varices appear the same except when fully mature; it is only at maturity that the final varix shows its character as in the above description. Comparison is made with its nearest congener, *F. brevicula* (Sowerby, 1834), which has a thicker, coarser shell with a broader more obese body whorl and larger aperture. *F. brevicula* lacks the extended long heavy spine on the varices previous to the mature apertural varix. It also has no noticeable keel on the shoulder and has five equal cords on the body whorl in contrast to the two major cords and four secondary cords of *F. robertsoni.*

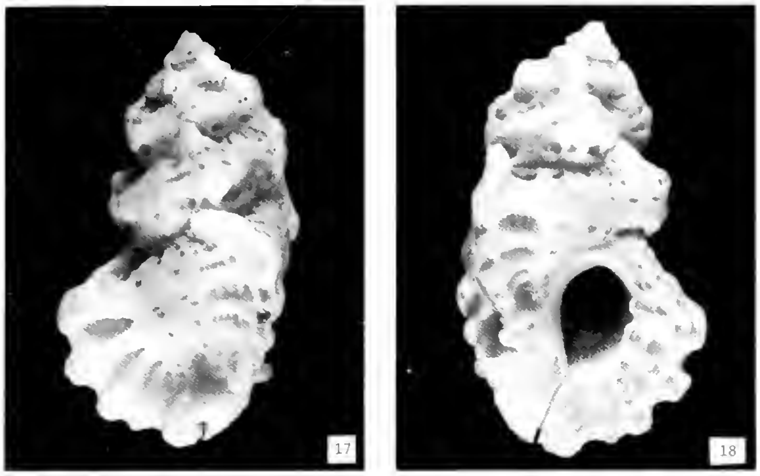
F. robertsoni new species was figured in Radwin and D'Attilio (1976) pl. 23, fig. 11 and pl. 24, fig. 2 as *F. brevicula* (Sowerby, 1834).

Favartia trivaricosa new species

Figs. 17, 18

Shell small fusoid, spire high, anterior truncate, approximately seven whorls; protoconch eroded, not determined; suture impressed. Aperture ovate, peristome erect anteriorly, but appressed posteriorly on the inner side; outer lip crenulate reflecting external transverse cords, canal short very narrowly open, terminally tubelike and bent backward nearly at right angle, siphonal fasciole retaining one older canal termination.

Varices moderately thick, three per whorl on the final and penultimate whorl, four on the earlier whorls; varices extending over shoulder and terminating at suture. Intervarical areas with axial sculpture in the form of low, flat, thickened lamellae. Spiral sculpture as follows: one cord above the shoulder and four broad cords on the body whorl. Leading side of the varices recurved and with seabrous lamellae, deeply excavated between the cords on the receding side. A combination of the axial



FIGS. 17 and 18. *Favartia trivaricosa* n. sp. holotype SDNHM 86943 (15.0 × 9.4 mm.).

lamellae crossed by these spiral cords results in square pits in the intervarical areas. When worn only the pits are visible.

Color: Dull-white varices with very pale-tan intervarical areas; aperture pale lavender.

Type Locality–Bohol Straits, Philippine Islands.

Dimensions–	Length mm.		Width mm.
Holotype SDNHM 86943			
Bohol Straits, P. I. (ex Foster and Glass)	15.0	×	9.4
Paratype A, SDNHM 82094			
Cebu Island, P. I.	13.5	×	9.4
Paratype B, SDNHM 73702			
Bohol Straits, P. I.	13.0	×	9.5
Paratype C, SDNHM 76668			
Mactan Island, P. I.	12.0	×	6.6
Paratype D, SDNHM 82276			
Mactan Island, P. I.	14.3	×	9.7
Paratype E,			
Glass and Foster collection, P. I.	13.0	×	8.7

Other Material Examined–One specimen in the June King collection from Bohol Straits, P. I. (11.0 × 6.0 mm.); one specimen in the Rose D'Attilio collection from Wading Island, Fiji Islands (18.3 × 11.4 mm).

Discussion–Comparison is made with the following species of *Favartia:*

F. alveata (Kiener, 1842) from the West Indies which has five to seven varices instead of three as does *F. trivaricosa*, and spiral cords ornamented with scales appressed to their surface.

F. brevicula (Sowerby, 1834) which is a broad heavy larger shell with four or five broad sculptured varices and smooth intervarical areas.

F. cyclostoma (Sowerby, 1841) which is a large shell with five varices.

F. minatauros Radwin and D'Attilio, 1976 from Mauritius which has an obtuse spire and a swollen body whorl.

F. munda (Reeve, 1849) from Japan which has four to five varices.

F. trivaricosa new species was mistakenly figured in Radwin and D'Attilio (1976) pl. 14, fig. 3 and text fig. 96 as *F. tetragona* (Broderip, 1833).

Etymology–This new species is named for the three varices on the body whorl which distinguish it from several of its congeners. Latin *tri* (three) plus *varicosa* (varices).

Acknowledgments

We wish to thank the following for the loan of typological and comparison material: Academy of Natural Sciences Philadelphia; American Museum of Natural History, British Museum (Natural History); Rose D'Attilio; June King and Donald Pisor of San Diego, California; and Charles Glass and Robert Foster of Santa Barbara, California. We also thank David K. Mulliner for the photography used in this paper. William K. Emerson and Walter E. Sage, III kindly reviewed the paper.

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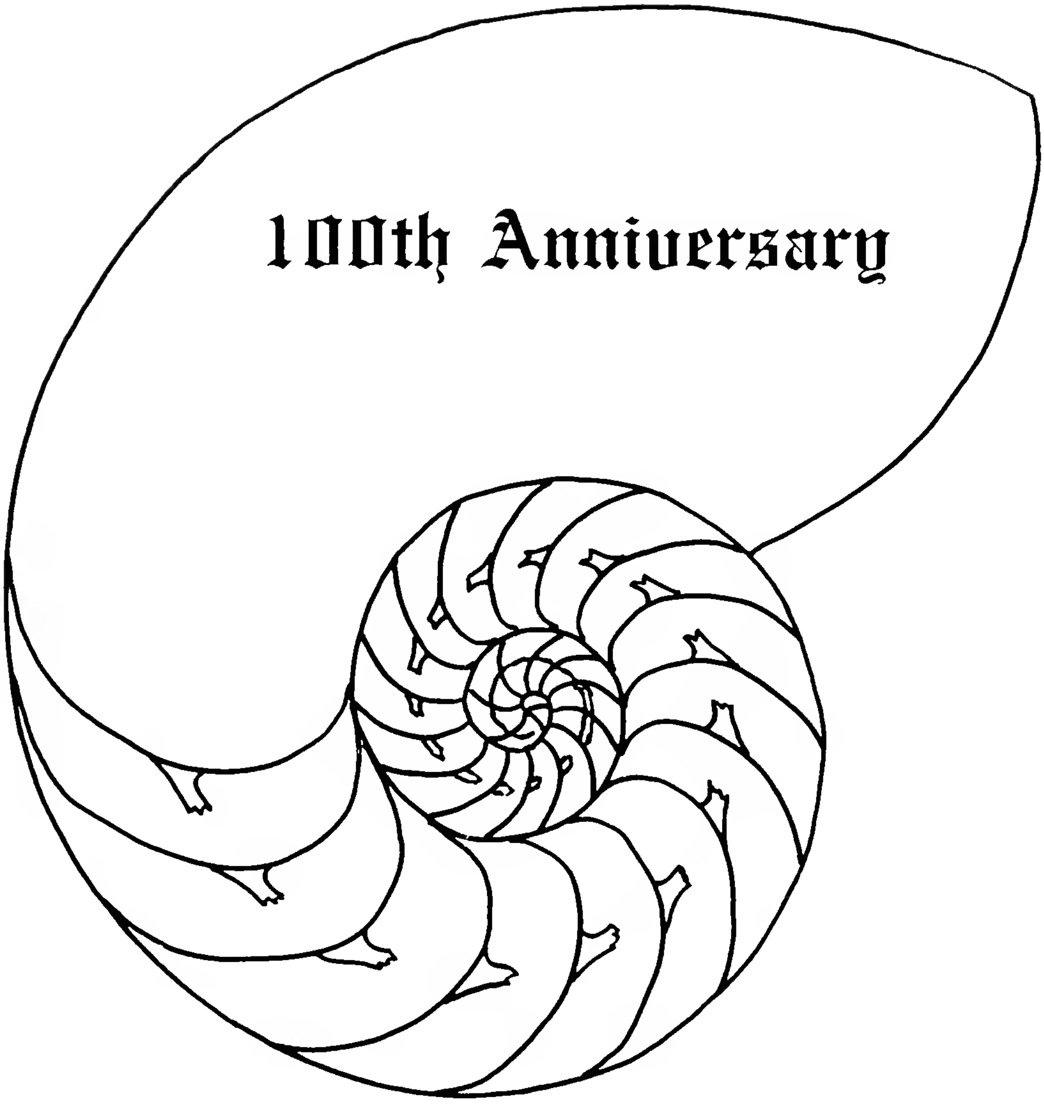

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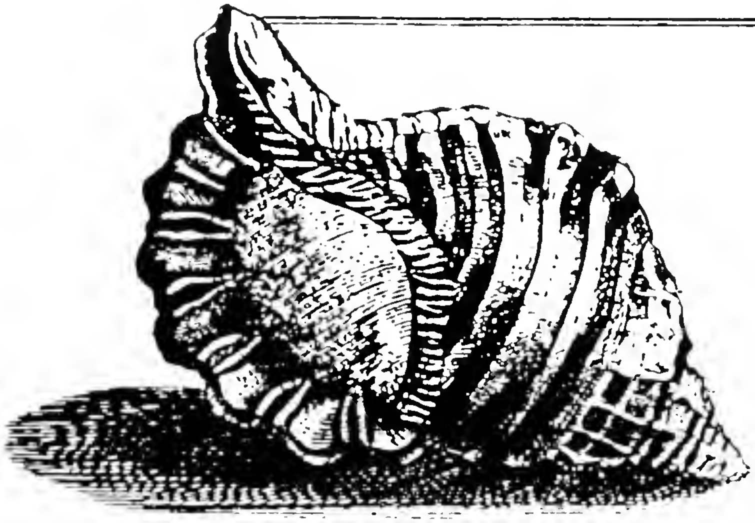

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And what ancient Roman author gave us the words, *Tellina*, *Purpura* and *Nerita*?

Who has the world's record for collecting the most new species of marine and land shells?

NOTES ON THE MORPHOLOGY OF *ADMETE VIRIDULA* (GASTROPODA: CANCELLARIIDAE)

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Smithsonian Institution
Washington, DC 20560

ABSTRACT

The anatomy and shell morphology of Admete viridula *(Fabricius, 1780), a boreal cancellariid, are described. This species, the type of* Admete *Kroyer, 1842, differs from members of the Cancellariinae and Trigonostominae in having a thinner shell composed of a single aragonitic layer, a reduced kidney and jaw, and a long, expanded prostate gland, as well as in lacking a radula, separate sperm ingesting gland and dorsally recurved albumen gland. Based on cladistic analysis of 20 shell and anatomical characters, we suggest that the family Admetinae is an early offshoot from primitive cancellariid stock, that the subfamily Trigonostominae contains the most primitive cancellariids studied anatomically to date, and that Cancellariinae comprise a comparatively recent radiation with specialized chemosensory capabilities.*

The composition and taxonomic history of the superfamily Cancellariacea have been briefly discussed in previous papers (Harasewych & Petit, 1982, 1984). The relationship of this group to other prosobranchs is still uncertain, as is the phylogenetic arrangement of the nearly 100 nominal supraspecific taxa proposed almost exclusively on the basis of shell characters.

Recent supraspecific taxa have, in general, been clustered around three morphological types, represented by the genera *Cancellaria*, *Trigonostoma* and *Admete*, that have been given subfamily status by Cossmann (1899). Members of the Cancellariinae and Trigonostominae inhabit tropical and temperate waters while Admetinae is generally limited to polar regions with some species inhabiting deeper waters of the temperate zone. The gross anatomy of *Cancellaria reticulata* (Linné, 1767), the type of Cancellariinae, and *Olssonella smithii* (Dall, 1888) a trigonostomine, have previously been described (Harasewych and Petit, 1982, 1984).

No general anatomical studies of any admetine are known to us, although brief descriptions of the animal of *Admete viridula* (Fabricius, 1780) were given by Möller (1842: 88, as *A. crispa* Möller) and Jeffreys (1876: 322). Simple drawings of the living animal were published by H. & A. Adams (1853: pl. 29, fig. 5; copied by Tryon, 1885: pl. 7, fig. 32), Troschel (1865: pl. 4, fig. 14) and Morse (1921: pl. 7, fig. 43). Troschel (1865: pl. 4, figs. 16, 17) figured the jaws of *A. viridula* and the synonymous *A. crispa*, referring to these structures as "hard apparatus" and suggesting that they may be toxoglossan radular teeth. The latter figure was copied by Fischer (1883: 595, fig. 359) and labelled as a radular tooth. Tryon (1885: pl. 7, fig. 33) copied Fischer's figure without comment. Thiele (1904: 172) identified Troschel's figures as jaws and reported the absence of a radula in *A. viridula*. The austral species *A. magellanica* Strebel, 1905, and *Waipaoa marwicki* Dell, 1956, were shown to lack radulae, respectively, by Powell (1951: 167) and Beu and Climo (1974: 327). Not all admetines are without radulae as evidenced by the figures of the radula of *Nothoadmete tumida* Oliver, 1982, that accompanied the description of that species. The gross anatomy and shell morphology of *Admete viridula* (Fabricius, 1780), the type species of *Admete* Möller, 1842 [as *A. crispa* Möller, 1842] are here described and compared to other cancellariid taxa.

The checkered nomenclatural history of this

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species is detailed by Bouchet & Warén (1985: 257), who point out that North American authors have used the junior synonym *Admete couthouyi* (Jay, 1839) for the species, based on incorrect statements by Dall (1887: 298; 1918: 318, 328) contending that the type of *A. viridula* was a turrid. Although this was refuted by Pilsbry (1938), Macpherson (1971: 107), citing Dall, followed other New World malacologists in using *A. couthouyi*.

Admete viridula is exceedingly variable as attested by the synonymy listed by Bouchet & Warén (1985: 258), to which additional nomina will eventually be added. While the Canadian specimens used for this study are not "typical" of the species, in conchological characters, they do fall within the range of variation accepted by Bouchet & Warén (1985: figs. 683-689) who examined thousands of North Atlantic specimens.

Materials and Methods

Anatomical data is based on 2♂ and 1♀ specimens from the Saguenay River, Quebec [48°24'48"N, 70°44'-70°48'W] Voucher Material-National Museum of Natural Sciences, Ottawa 43946.

Shell fragments for ultrastructural studies were broken from the outer lip with pliers. Specimens were then immersed in 10% hydrochloric acid (HCl) until the shells dissolved. Soft parts were rinsed in distilled water and returned to 70% ethanol for dissection. Portions of the reproductive systems and anterior proboscis were sectioned at a thickness of 6 μm, and the sections stained in hematoxylin and eosin. Dried shell fragments were powdered in a mortar and pestle, and the X-ray diffraction pattern determined on a Philips APD 3600 Automated X-ray Powder Diffractimeter.

Shell Morphology

External: Shell, reaching 20 mm in length, thin, ovate with conical spire and rounded anterior (Fig. 1). Protoconch (Figs. 3, 4) paucispiral, consisting of 1 whorl, with a smooth, chalky surface incised by fine, spiral lines. Transition to teleoconch marked by beginning of axial growth striae and an increase in shell thickness. Teleoconch with up to 5½ convex whorls. Early whorls (Fig. 2) strongly shouldered, becoming more rounded with increase in shell size. Suture deeply impressed. Spiral sculpture of 16-21 shallow, rounded cords on body whorl and 7-10 on the penultimate whorl. Axial sculpture of 14-24 ribs per whorl, increasing in number but decreasing in prominence as the shell becomes larger. Aperture elliptical, deflected from coiling axis by 20-28°. Outer lip smooth to slightly corrugated. Siphonal canal short but pronounced in juveniles (Fig. 2), commonly indiscernible in large adults (Fig. 1). Inner lip with 2 weak columellar folds and a siphonal fold. Color white to ivory, uniform within and without.

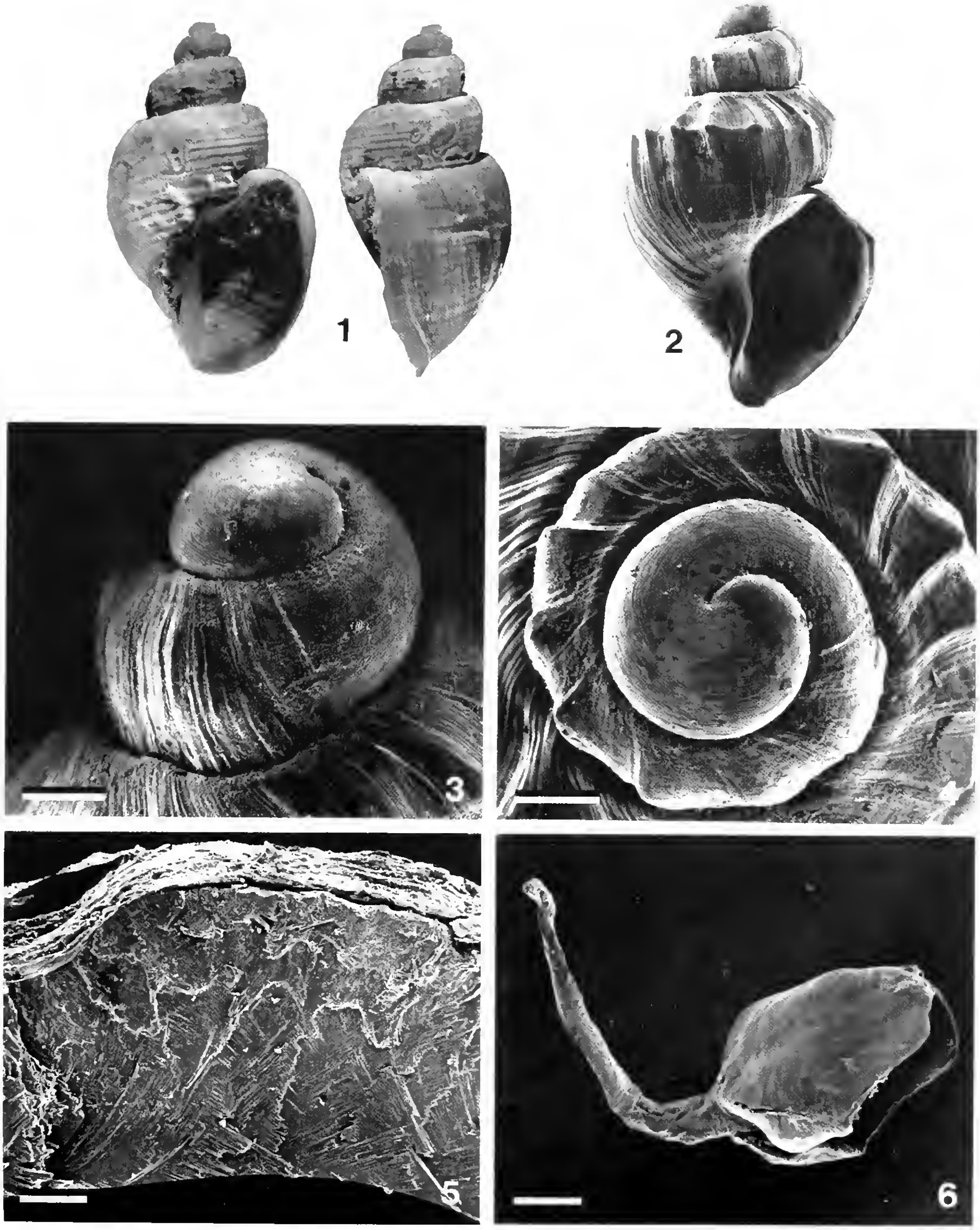
Internal: Fractured shells revealed the internal surfaces to be smooth and continuous, and to lack the apertural lirae and periodic increases in prominence of columellar folds found in other cancellariids (Harasewych and Petit, 1982, 1984).

Ultrastructure: A thin, brownish, lamellose periostracum overlies the shell, which appears to consist of a single layer of crossed-lamellar crystals (Fig. 5), oriented with lamellar planes parallel to the outer lip. X-ray diffraction analysis of powdered shell revealed it to consist primarily (>95%) of aragonite.

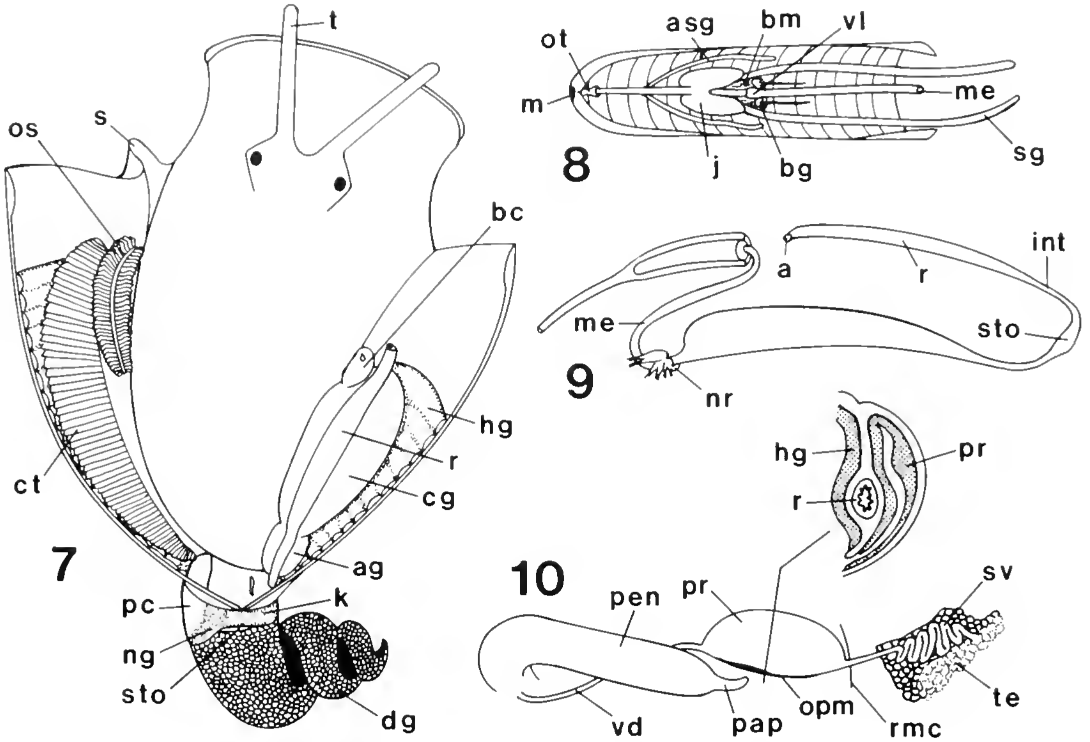
Soft-parts Morphology

External features: The soft-parts comprise 3 to 3⅓ whorls, of which the digestive gland (Fig. 7, dg) occupies about 2¼ whorls, the kidney (Fig. 7, k) less than ⅛ whorl and the mantle cavity just over ½ whorl. Preserved animals were orange tan in color, lacked any discernible markings and were retracted at most ¼ whorl into the aperture. The foot is broad and ovate, lacking an operculum. Tentacles (Fig. 7, t) are long, tubular and symmetrical. The mantle edge is smooth, the siphon (Fig. 7, s) short but distinct.

Mantle cavity: The mantle cavity is shorter and broader than in other cancellariids dissected, with pallial organs situated as in other higher prosobranchs. The osphradium (Fig. 7, os) is broad anteriorly (L/W = 3), tapers posteriorly, and consists of about 35 leaflets per side. Adjacent is the ctendium (Fig. 7, ct), twice as long and slightly narrower than the osphradium, composed of about 70 triangular leaflets. This organ and the voluminous, transversely pleated hypobranchial gland (Fig. 7, hg)



FIGS. 1-6. Features of the shells and jaw of *Admete viridula* (Fabricius). **1**, Apertural and right side views of specimen collected in the Saguenay River, Quebec. [48°24'48"N, 70°44'-70°48'W] sta. 62 30 (NMNS 43946) 3.0×. **2**, Scanning electron micrograph of juvenile specimen dredged in 673 m, off Martha's Vineyard, Massachussetts, U.S. Fish. Comm. sta. 994-97. (USNM 43232) 20.0×. **3**, Protoconch of specimen in figure 2, lateral view, scale bar = 200 µm. **4**, Protoconch of specimen in figure 2, axial view, scale bar = 200 µm. **5**, Fracture surface. Plane of fracture parallel to outer lip, scale bar = 100 µm. **6**, Lateral view of jaw, scale bar = 50 µm.



FIGS. 7-10. Anatomical features of *Admete viridula*. **7,** Female specimen removed from shell, partially uncoiled and mantle cavity opened mid-dorsally to display contents. **8,** Dissection of anterior portion of proboscis, opened mid-dorsally. **9,** Diagrammatic representation of the alimentary system. **10,** Male reproductive system.

a, anus; ag, albumen gland; asg, accessory salivary gland; bc, bursa copulatrix; bg, buccal ganglia; bm, buccal mass; cg, capsule gland; ct, ctenidium; dg, digestive gland; hg, hypobranchial gland; int, intestine; j, jaw; k, kidney; m, mouth; me, mid-esophagus; ng, nephridial gland; nr, nerve ring; opm, opening to mantle cavity; os, osphradium; ot, oral tube; pap, papilla; pc, pericardium; pen, penis; pr, prostate gland; r, rectum; rmc, rear of mantle cavity; s, siphon; sg, salivary gland; sto, stomach; sv, seminal vesicle; t, tentacle; tes, testes; vd, vas deferens; vl, valve of Leiblein.

span the roof of the mantle cavity. The pallial gonoducts and rectum (Fig. 7, r) are located along the right side of the mantle cavity, while its rear is formed by the pericardium (Fig. 7, pc) and kidney (Fig. 7, k). The kidney is small, being only twice the size of the pericardium. The nephridial gland (Fig. 7, ng) occupies nearly half the kidney along the pericardium.

Alimentary system: The broad, tubular pleurombolic proboscis can be extended nearly the length of the shell aperture, and is the same color as the foot. Broad retractor muscles extend from the columellar muscle, while thinner strands originate from the body wall. A short oral tube (Fig. 8, ot) extends from the mouth (Fig. 8, m) to the cuticularized, tubular portion of the jaw (Fig. 8, j), which expands posteriorly to envelope the lateral surfaces of the minute buccal mass (Fig. 8, bm). The longitudinally grooved buccal mass lacks a radula and has only a vestigial subradular membrane. A pair of short, extremely thin accessory salivary glands (Fig. 8, asg) lie alongside the buccal mass, emptying into the posterior portion of the oral tube through fine ducts. The wider and much longer salivary glands (Fig. 8, sg) join the buccal mass laterally, via short ducts, just anterior to the esophageal opening. A small valve of Leiblein (Fig. 8, vl) and a pair of buccal ganglia (Fig. 8, bg) are situated at the rear of the bucal mass. The narrow mid-esophagus (Figs. 8, 9, me) runs posteriorly from the valve of Leiblein, passing through the nerve ring (Fig. 9, nr) before expanding and becoming sacular. The esophagus narrows at the rear of the cephalic sinus and leads to a simple U-shaped stomach (Fig. 7, 9, sto) that is embedded in the anterior face of the digestive gland. Longitudinal folds

TABLE 1. *Admete viridula* (Fabricius), measurements of shell characters. Linear measurements in millimeters. (n = 10).

Character	Mean	Standard Deviation	Range
shell length	16.87	1.91	13.82-19.02
shell width	9.90	1.13	8.18-10.97
aperture length	10.21	1.42	8.13-11.58
aperture length shell length	0.604	0.023	0.567-0.641
#whorls, teleoconch	4.78	0.35	4.33-5.33
spire angle	55.2°	2.9°	45.5°-58.0°

line the stomach and pass into the intestine (Fig. 9, int), which runs through the kidney and along the right wall of the mantle cavity, expanding slightly to form the rectum (Figs. 7, 9, r). Neither an anal gland nor identifiable gut contents were detected in any of the specimens examined.

Female reproductive system: As the only female specimen available to us was poorly preserved, only the pallial portion of the oviduct is described. The oviduct passes through the kidney and expands to form a broad, laterally compressed albumen gland (Fig. 7, ag), which expands further to form the long, blunt, capsule gland (Fig. 7, cg). A small, ovate, bursa copulatrix (Fig. 7, bc) is situated below the anterior margin of the capsule gland. An ingesting gland was not found. Egg capsules of *Admete viridula* are figured by Bouchet and Waren (1985: fig. 687).

Male reproductive system: The testes (Fig. 10, te) consist of a yellowish mass of ascinous tubules embedded in the right side of the digestive gland and extend nearly a full whorl from its anterior edge. These tubules converge to form a testicular duct that immediately forms a serpentine seminal vesicle (Fig. 10, sv). The duct straightens at the anterior limit of the digestive gland, passes through the kidney and enters the mantle cavity ventral to the rectum. It greatly expands to form the prostate gland (Fig. 10, pr), which extends along the posterior third of the mantle cavity and communicates with it by a long ventral slit (Fig. 10, opm). From the anterior portion of the prostate gland, a tubular vas deferens (Fig. 10, vd) leads to the base of the penis (Fig. 10, pen), which is ovate in cross-section, extends approximately ⅔ the length of the mantle cavity and has a terminal papilla (Fig. 10, pap).

Nervous system: Admete viridula has a typical cancellariid nervous system (Bouvier, 1887: Harasewych and Petit, 1982, 1984), with the cerebral, pedal and pleural and subesophageal ganglia fused into a nerve ring, and the buccal ganglia (Fig. 8, bg) at the rear of the buccal mass.

Discussion

Cladistic analysis of the 20 shell and anatomical characters listed in Table 2 produced the cladogram in Figure 11. Despite the lack of agreement on the relationships of supraspecific taxa, nearly all classifications proposed to date separate the Admetinae from the remaining Cancellariidae (H. and A. Adams, 1853: Troschel, 1865; Fischer, 1883; Tryon, 1885; Cossmann, 1899; Thiele, 1929; Wenz, 1943), and this arrangement is supported by the present study.

Of the characters used to distinguish the Admetinae from other cancellariids, most con-

TABLE 2. Shell and anatomical characters used to distinguish between *Admete viridula*, *Cancellaria reticulata* and *Olssonella smithii*. Primitive states denoted by (0), derived states by (1).

1) Shell: (0) thick; (1) thin.
2) Internal varices: (0) pronounced; (1) reduced or absent.
3) Shell ultrastructure of: (0) 2 orthogonal layers; (1) 1 layer.
4) Protoconch of: (0) 2 whorls; (1) 1 whorl.
5) Tentacles: (0) symmetrical, unmodified; (1) asymmetrical, left tentacle modified.
6) Osphradium with approximately: (0) 35 leaflets/side; (1) 70 leaflets/side.
7) Ctenidium with: (0) < 125 leaflets; (1) > 200 leaflets.
8) Distance between osphradium and ctenidium: (0) normal; (1) large relative to either organ.
9) Kidney occupying: (0) > ¼ whorl; (1) < ⅛ whorl.
10) Proboscis: (0) tubular; (1) ventrally flattened, papillose.
11) Jaws with: (0) short posterior lobes; (1) long posterior lobes.
12) Buccal mass: (0) small; (1) large, filling retracted proboscis.
13) Radula: (0) present; (1) absent.
14) Outer cusps of radular teeth: (0) simple, smooth; (1) with secondary dentition.
15) Accessory salivary gland: (0) shorter than; (1) longer than; salivary gland.
16) Mid-esophagus posterior to nerve ring: (0) sacular; (1) convoluted tube.
17) Anal gland: (0) present; (1) absent.
18) Sperm ingesting gland: (0) present; (1) absent.
19) Albumen gland: (0) dorsally recurved; (1) laterally compressed.
20) Prostate gland: (0) long, expanded; (1) short, convoluted.

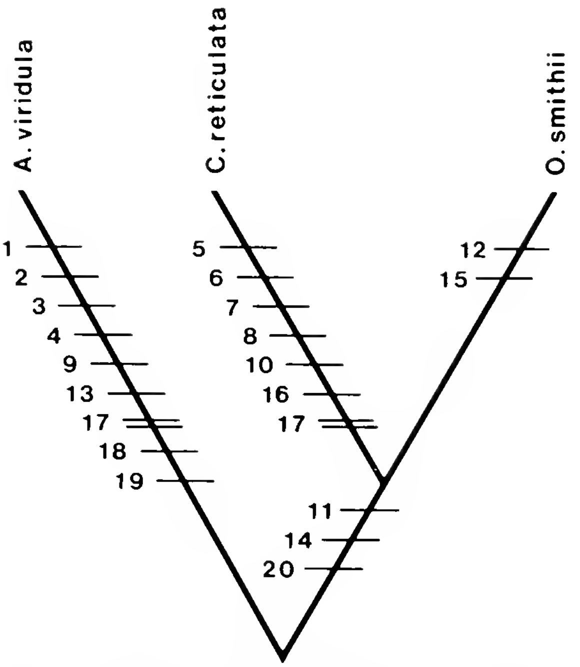


FIG. 11. Cladogram of phylogenetic relationships of cancellariid taxa. Single slashes across tree branches represent transformations of the corresponding character from the primitive (0) to the derived (1) state. Double slashes indicate transformations that occur more than once.

spicuous are their thin shells lacking pronounced surface sculpture and apertural lirae. This is likely a consequence of their polar habitat, as Graus (1974) has shown that decreased calcification in high latitudes is due to reduced availability of calcium carbonate in colder waters. Admetines also lack such antipredatory features as internal varices that are found in tropical and temperate cancellariids. The predominance of aragonite in the shell is plesiomorphic, as calcite is more easily formed (Wilbur, 1964) and more stable (Lowenstam, 1954) at low temperatures.

In terms of anatomical organization, *Admete viridula* differs from ancestral cancellariid morphology, most nearly approximated by *Olssonella smithii* of the taxa studied to date, in having a shallower mantle cavity, a reduced kidney, and in lacking color pattern. At least some of these may also be adaptations to cold water.

Cancellariines and Trigonostomines have uniserial "tricusped" radular teeth with elaborate secondary dentition on the outer cusps and a comparatively simple ventrally recurved central cusp (Harasewych and Petit, 1982, 1984; Petit and Harasewych, 1986). The radula of *Nothoadmete tumida*, the only known radulate admetine, has barbed central cusps and simple bulbous outer cusps (Oliver, 1982: figs. 3, 5). Presence of central cusp barbs in *Cancellaria atopodonta* Petit and Harasewych (1986: figs. 15, 16) suggests that this feature is primitive and occurred in the ancestor of all Recent cancellariids. The jaws of admetines lack the long posterior lobes found in cancellariines and trigonostomines. Although the diet of cancellariids remains unknown, we have suggested that they are piercing suctorial feeders based on the functional morphology of their alimentary systems (Harasewych and Petit, 1982, 1984; Petit and Harasewych, 1986). The loss of radula and reduction in the size of the buccal mass in most admetines suggests that they feed suctorially, but on a different group of prey organisms than other cancellariids.

The lack of an anal gland in *Admete viridula* and *Cancellaria reticulata* is likely a comparatively recent convergence, as this organ has been reported in *Cancellaria cancellata* (Graham, 1966).

Additional differences between admetines and other cancellariids are found in the reproductive systems. The prostate gland of *Admete viridula* is long and greatly expanded, while in *Olssonella smithii* and *Cancellaria reticulata* it is short and convoluted. *Admete viridula* also lacks the separate sperm ingesting gland and dorsally recurved albumen gland found in cancellariines and trigonostomines.

The phylogenetic arrangement in Figure 11 is supported by the fossil record, as several "admetines" have been reported from the Upper Cretaceous, and *Waipaoa*, known to be aradulate in the Recent fauna, dates back to the Oligocene. *Cancellaria, sensu stricto*, first appears in the Miocene and is characterized by modifications to the left cephalic tentacle, proboscis, osphradium and ctendium, organs involved in tactile and distance chemoreception.

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Mary Rice for making these facilities available. This is contribution number 158 of the Smithsonian Marine Station at Link Port. Critical review of the manuscript by Dr. R. S. Houbrick, National Museum of Natural History, Smithsonian Institution, is gratefully acknowledged.

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BOOK REVIEW

Washington Public Shore Guide: Marine Waters by James W. Scott and Melly A. Reuling. 1986. 348 pp., numerous photos, maps and habitat sketches. Cloth, $25.00; paperback, $14.95.

If you are planning on studying or visiting the shorelines of the State of Washington, this is a great bargain with many useful facts about the 2,400-mile saltwater shoreline of 14 counties. It largely ignores mollusks, a fact which offers a challenge to conchologists.—*R. T. Abbott.*

OBSERVATIONS ON THE FEEDING BEHAVIOR OF THE GASTROPOD *PLEUROPLOCA PRINCEPS* (FASCIOLARIIDAE) IN THE GALAPAGOS ISLANDS

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ABSTRACT

The feeding behavior of the gastropod, Pleuroploca princeps, *(Fasciolariidae) is reported. Eight species of gastropods were found to be preyed upon by* P. princeps; *two species of crabs were eaten as carrion. No signs of cannibalism were noticed, but intraspecific competition was observed.*

While working at the marine laboratory of the Charles Darwin Research Station, Isla Santa Cruz, Galápagos, Ecuador, I had the opportunity to collect the gastropod, *Pleuroploca princeps* (Sowerby, 1825), (Keen, 1971, p. 611, fig. 1324), and to study its feeding habits.

The only literature citation on the feeding habits of *P. princeps* is by Sorensen (1943, p. 4), who observed *P. princeps* feeding on *Phyllonotus bicolor* (now *Hexaplex erythrostomus* (Swainson)) in Bahia San Carlos, Gulf of California. Other observations on feeding habits are reported for *P. gigantea* (Kiener) in the western Atlantic by Menzel and Nichy (1958, p. 144), Paine (1963 a, pp. 66, 67; 1963 b, pp. 402, 403), and Cornellisson (1985, p. 125), and on *P. trapezium* (Linnaeus) and *P. filamentosa* (Röding) in the Indo-Pacific by Risbec (1932, pp. 374, 375), Maes (1967, p. 51), and Reyes (1981, p. 4). The major prey items in the diet of members of the family Fasciolariidae are gastropods, bivalves, sedentary polychaetes, cirripedes and carrion (Taylor, Morris and Taylor, 1980, p. 377, table 1).

Pleuroploca princeps is a characteristic faunal constituent of the Panamanian province and is one of the largest gastropods in the Colon Archipelago (Wellington, 1975, p. 59), attaining 250 mm. in length. This species is widely distributed in the Galapagos Islands. Several specimens were collected or observed around the islands of Santa Fé, Santa Cruz, Española, Floreana, Bartolomé, Cousins Rock and San Cristobal. Living specimens were noted in the subtidal zone and to depths of 21 meters (personal observation). They were found on lava rocks or on sandy bottoms but occur more frequently in areas where the lava boulders meet the sandy bottom.

The specimens of *P. princeps* used in this study were collected on lava boulders and sand at Isla Santa Fé (July, 1984) and Isla Santa Cruz (Oct. and Nov. 1984). The animals were kept in aquaria at the marine laboratory.

Feeding Behavior

Since *P. princeps* is a typical neogastropod, it feeds mainly on other gastropods (Table 1). During these observations no bivalves were offered as food. In aquaria, *P. princeps* were observed to feed on dead crabs such as *Grapsus grapsus* (Linnaeus) and *Petrolisthes edwardsii* (Saussure), (see Table 1 and Fig. 2). A specimen of *P. princeps* tried several times to attack a *Nerita scabricosta* (Lamarck) but could not reach the soft body of the prey with its proboscis because of the protection of the heavily calcified operculum of the nerite.

When *P. princeps* was at rest, the body and half of the shell was buried in the sandy substratum (personal observation). It was at this resting time that five specimens of *Thais melones* (Duclos) were introduced into the aquarium as food. By using what are thought to be chemoreceptors (*fide* Kohn, 1961), the predator detected the presence of the prey and began its search.

The eyes of *P. princeps* are poorly developed

TABLE 1. Species eaten by *Pleuroploca princeps* in aquarium.

Phylum	Class	Family	Species
Mollusca	Gastropoda	Cymatiidae	Cymatium partheopeum
		Thaididae	Thais melones Purpura columellaris Purpura pansa
		Muricidae	Muricanthus princeps
		Tonnidae	Malea ringens (pers. obs. J. de Roy)
		Cypraeidae	Cypraea cervinetta
		Conidae	Conus brunneus
Arthropoda	Crustacea	Grapsidae	Grapsus grapsus
		Porcellanidae	Petrolisthes edwardsii

and probably cannot visually detect prey. Consequently, this predator must feel its way to the prey with its massive foot (Fig. A). On contact, *P. princeps* wraps the prey in its foot and begins a series of usually two or three muscular contractions as observed in 20 cases. Raising its shell slowly and then lowering it very quickly against its prey (Figs. B and C), the predator succeeds in making the prey withdraw inside its shell. When the prey has withdrawn, the shell is maneuvered until the aperture is positioned upward and close to the predator's proboscis. At the same time, the predator's muscular foot closes the prey's siphonal canal which may last from a few minutes up to two days depending on the size, shape and strength of the prey (arrow in Fig. E). Figure 1 shows how *P. princeps* envelopes a *Cymatium parthenopeum* (von Salis) by the same method described above. When this series of movements is terminated, *P. princeps* prys up the prey's operculum with its proboscis, eventually penetrating the prey's body and devouring the soft parts (Fig. E). The whole animal is consumed and the muscular tissue attached to the operculum is rasped clean by radular action. Similar feeding habits were described for *Fasciolaria hunteria* (Perry), (Wells, 1958, p. 155) and for *Pleuroploca gigantea* (Paine, 1963 a, p. 67).

Competition and Cannibalism

In one of the aquaria, two adult specimens of *P. princeps* were deprived of food for a period of two weeks. During this time no signs of attack or cannibalism were noticed. No references to cannibalism by *Pleuroploca* have been located in the literature. In contrast, *Fasciolaria tulipa* (Linnaeus) (Snyder & Snyder, 1971, p. 257) and *F. hunteria* (Wells, 1958, p. 155) will cannibalize even when other sources of food are available. Nevertheless, after this period of starvation one specimen of *T. melones* was offered as food to these two specimens. At this moment, competition was observed between the two *P. princeps*. The specimen (approx. 100 mm.) that had enveloped the prey was then attacked by the other larger and heavier specimen (approx. 125 mm.) which "unwrapped" the prey and removed it from its first predator in a period of two minutes. The smaller predator tried to recover its prey four times without success.

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FIG. 1, Adult *Pleuroploca princeps* (shell approx. 125 mm.) enveloping a live *Cymatium parthenopeum* and closing the prey's siphonal canal with its muscular foot (see arrow); 2, Adult *Pleuroploca princeps* feeding on a dead Porcelain crab, *Petrolisthes edwardsii* (natural size).

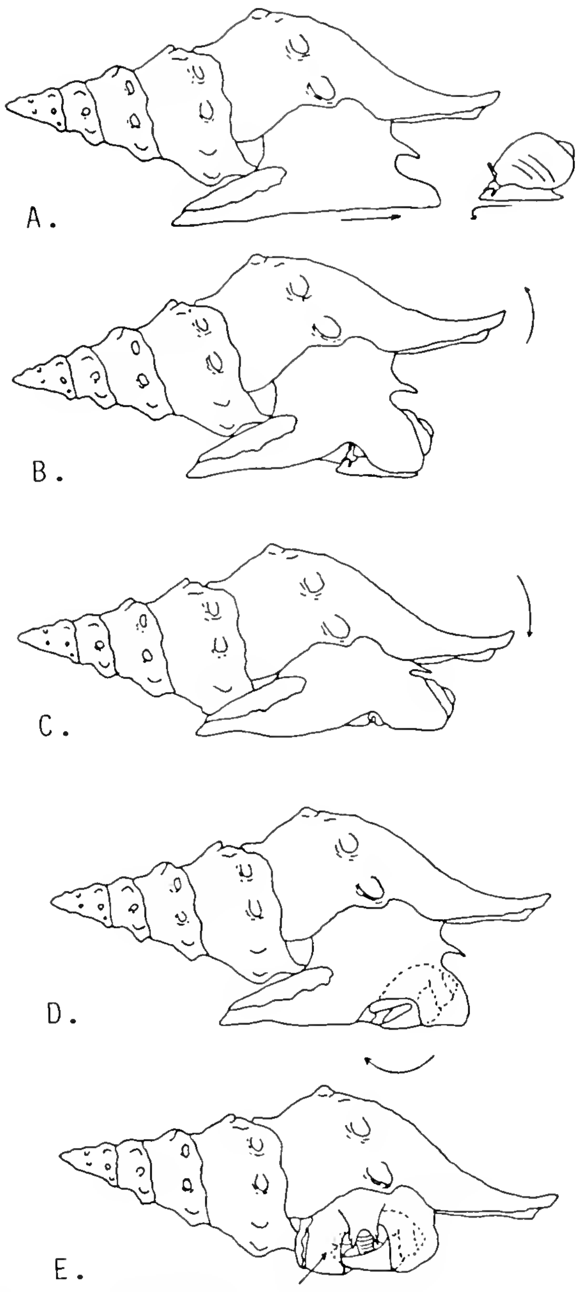

FIG. 3 A-E, Sequence of capturing movements of *Pleuroploca princeps.*

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A NEW SPECIES OF *MORUM* FROM THE ANDAMAN SEA (GASTROPODA: VOLUTACEA)

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ABSTRACT

Morum (Oniscidia) ninomiyai, *new species, is described from off Thailand in the Andaman Sea and is compared with closely related congeners.*

In 1981, the late Carl C. Withrow of Florida submitted to me for identification a specimen of an apparently new species of *Morum* from the Andaman Sea, off southern Thailand. This unique specimen was subsequently illustrated by Sally Diana Kaicher (1983) in her "Card Catalogue of World-Wide Shells", as an apparently undescribed *Morum*. The Andaman Sea specimen was again transmitted to me for study in 1983 by Taizo Ninomiya of Tokyo, who had obtained Mr. Withrow's collection of *Morum*. Mr. Ninomiya kindly permitted me to retain the specimen with the expectation that additional material might be forthcoming from his contacts in Bangkok. Fortunately, a second specimen resulted from the inquiries of Mr. Ninomiya, for whom I take great pleasure in naming this interesting discovery.

The new species is a member of an Indo-Pacific group within the subgenus *Oniscidia* Mörch, 1852, composed of the following taxa: *cancellatum* (Sowerby, 1824; type species); *grande* (A. Adams, 1855); *uchiyamai* Kuroda and Habe, *in* Habe, 1961; *joelgreenei* Emerson, 1981; and *watanabei* Kosuge, 1981.

The genus *Morum (sensu lato)* has long been classified with the mesogastropods in the Cassidae (Thiele, 1929; Boss, 1982; Emerson, 1985). Anatomical studies of *Morum*, however, indicate that this genus is referable to the neogastropod family Harpidae (Hughes, 1986, and personal communications). Dr. Hughes has in preparation a manuscript in which he rectifies the present taxonomic misplacement of the genus. Recent observations on New and Old World species of *Morum (sensu stricto* and *Oniscidia)*, moreover, confirm that these gastropods also autotomize the posterior portion of the foot (R. Goldberg, P. Williams and W. Liltved, personal communications), a well-known behavorial characteristic of the genus *Harpa* (Rehder, 1973).

It should be noted that Harpidae Bronn, 1849 (type genus *Harpa* (Röding, 1798); (Gastropoda), is a homonym of Harpidae Hawle and Corda, 1847 (type genus *Harpes* Goldfuss, 1839) (Trilobita). Raven (1985) has applied to the International Commission On Zoological Nomenclature to emend the spelling of this gastropod family to Harpaidae Bronn, 1849 and to place the emended taxon on the Official List of Family-Group Names in Zoology.

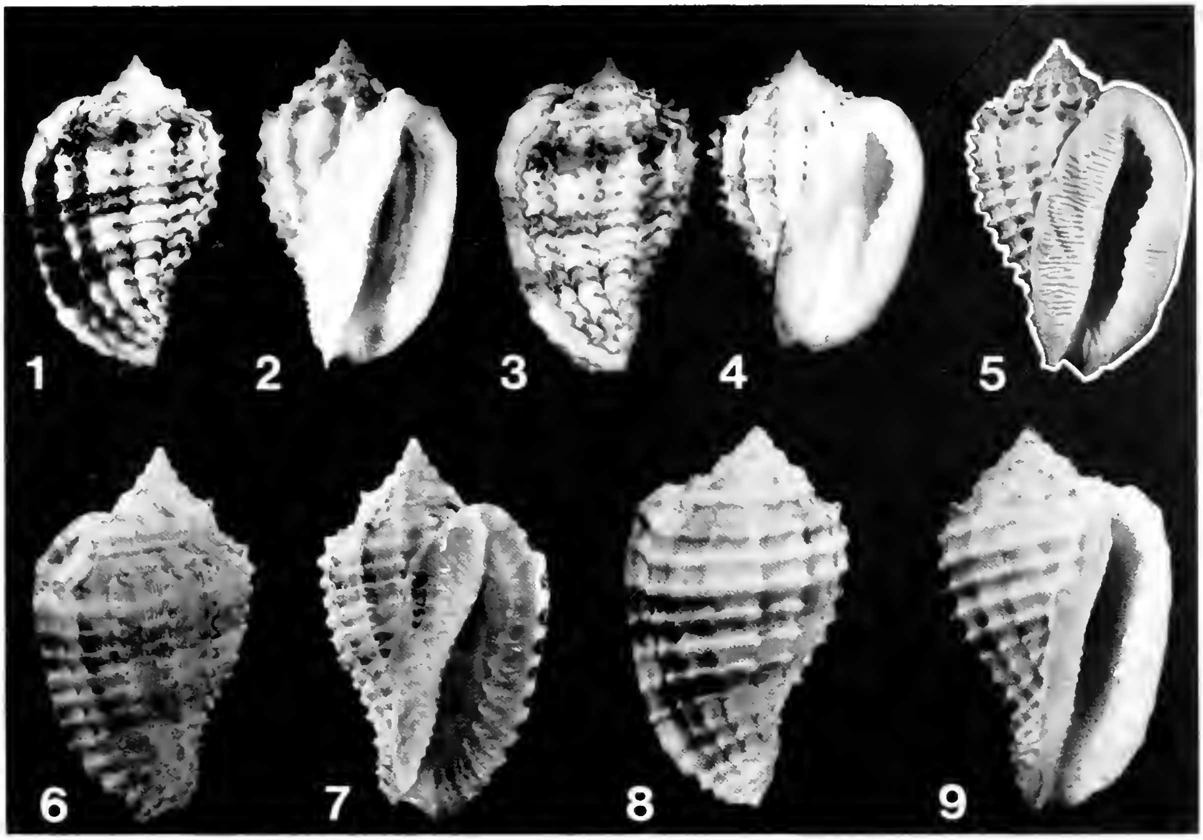
Morum (Oniscidia) ninomiyai, *new species*

Figs. 1-5

Morum sp. Kaicher, 1983, #3730, 3 figs., "off Thailand". (Illustrations of the paratype of this species.)

Diagnosis: Member of the *Morum (O.) cancellatum* (Sowerby, 1824)–*M. (O.) watanabei* Kosuge, 1981, complex. Distinguished by having the outer lip and the thin parietal shield sculptured by numerous, fine, thread-like ridges (Fig. 5).

Description: Shell medium size for genus, attaining 40+ mm in height, pyriform, attenuated at base. Spire low, extended; protoconch erect and papillate, composed of 1½ glossy, smooth whorls. Postnuclear whorls 5 in number, low conical, weakly shouldered below the suture, first and second whorls weakly cancellated, subsequent whorls strongly cancellated, with 14 prominent spinose axial ridges per whorl crossed by 10 moderately weak spiral cords to form a blade-like, hooked spine at the juncture of the spiral and axial ribs; spines most prominent at the shoulder. Intervarical areas with 8 to



FIGS. 1-5. *Morum (Oniscidia) ninomiyai*, new species. **1** and **2**, Holotype, AMNH no. 221241. **3-5**, Paratype, T. Ninomiya collection (Fig. **5**, coated to show sculptural details; photograph courtesy of S. D. Kaicher). **6-9.** *Morum (Oniscidia) cancellatum* (Sowerby, 1821); after Emerson, 1985, pl. 1, figs. 15-18. **6** and **7**, off Taiwan, AMNH no. 183783. **8** and **9**, Lectotype, BM(NH) no. 197744, "China Seas" (photographs courtesy of A. Beu). All figures except figure 5 approximately × 1.

10 evenly spaced axial lamellae. Aperture narrow, elongate, semicrescentic in outline. Parietal shield moderately large, thin with outer edge raised and covered by numerous, fine, irregular linear lirations, giving the appearance of fine threads. Outer lip thickened, crenulated and weakly toothed, with about 10 primary teeth forming inconspicuous linear projections on the inner labial margin, 2 secondary teeth formed between each pair of primary teeth. Anal sulcus shallow; siphonal canal short, widely open, weakly recurved. Operculum not known.

Color: Nucleus shiny, buff; postnuclear whorls with whitish base color, overlaid with flecks of reddish brown; 4 widely spaced, interrupted brownish spiral bands on body whorl (1 band on shoulder, 2 on either side of midbody area, 1 near the base). Aperture milky white; outer lip and parietal shield white and surface thinly glazed (in holotype).

Measurements: Holotype, 41.8 mm in height, 25.7 mm in width; paratype, 40.6 mm in height, 25.8 mm in width.

Type locality: off Phuket Island, Thailand (8°N, 98.22°E), Andaman Sea, dredged in 50 to 150 meters.

Type specimens: holotype, AMNH 221241 (Figs. 1, 2) from type locality; paratype, T. Ninomiya Collection, from "off Thailand, Andaman Sea, ex-Carl Withrow Collection, April 28, 1980", (Figs. 3-5).

Distribution: Known only from the type locality and adjacent waters.

Remarks: The new species superficially resembles specimens of *Morum (O.) cancellatum* (Figs. 6, 7, and 8, 9 (lectotype) and *M. (O.) watanabei* Kosuge (see Kosuge, 1981, pl. 33, figs. 1, 2 holotype; Emerson, 1985, figs. 11-14), but differs in the number of axial and spiral ridges, the dentition of the outer lip and the unique sculpture of the parietal shield (Fig. 5).

Acknowledgments

We are grateful to Taizo Ninomiya for depositing the holotype of this new taxon in the type collection of mollusks of the American Museum of Natural History. Richard L. Goldberg of Fresh Meadows, New York, William Liltved of San Francisco, California, and Peggy Williams of Sarasota, Florida kindly provided information on living *Morum* observed or photographed in the field and laboratory. Their generous cooperation is much appreciated. Alan G. Beu of the New Zealand Geological Survey, and Sally Diana Kaicher of St. Petersburg, Florida, generously provided the photographs for figures 8, 9 and 5, respectively.

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A NEW DEEP-WATER SPECIES OF *LEPIDOPLEURUS* (POLYPLACOPHORA) FROM THE VENEZUELA BASIN.

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ABSTRACT

A new species of Lepidopleurus *from the depths of the Venezuela Basin, Caribbean Sea, is described and compared with* L. scrippsianus *Ferreira, 1980, from the Eastern Pacific.*

From October to December 1981, the Naval Ocean Research and Development Activity (NORDA), NSTL Station, MS, conducted intense physical and biological investigations of deep-sea sediments in the Venezuela Basin from aboard USNS Bartlett (cruise 1301-82). Among the benthic macrofauna were 6 specimens of chitons: 3 specimens, ca. 13, 11, and 9 mm long

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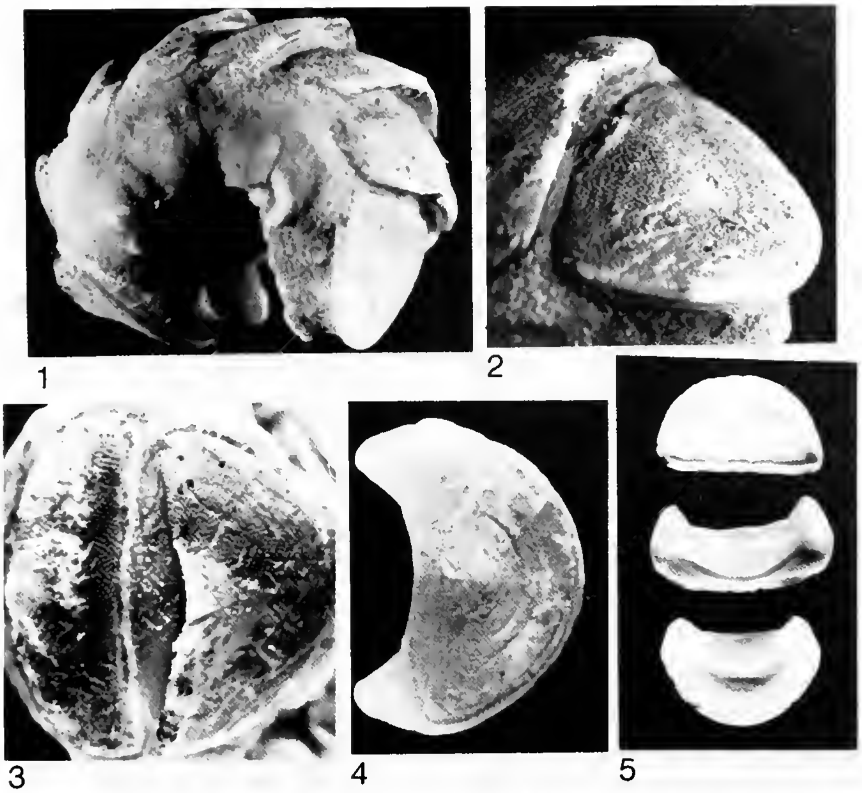
[1] Published posthumously. Died 1986.



FIGS. 1-5, *Lepidopleurus bartletti* Ferreira, *spec. nov.:* Holotype (USNM 859000), side view. **2**, view of posterior valve. **3**, first and second valve. **4**, paratype, posterior valve. **5**, paratype, under view, valves i, iv and viii.

(sta. 40: 15°08′N, 69°12′W, depth 3867 to 4009 m, 28 Oct. 1981); 1 specimen, ca. 15 mm long (sta. 63: 13°45′N, 67°45′W, depth 5046 m, 8 Nov. 1981); 1 specimen, ca. 10 mm long (sta. 65: 13°45′N, 67°45′W, depth 5046 m, 9 Nov. 1981); and 1 specimen, 1.3 mm long (sta. 88: 13°30′N, 64°45′W, depth 3516 to 3550 m, 25-26 Nov. 1981). All chitons were found on pieces of wood brought up in trawls. Study of this material, generously made available through Michael D. Richardson and Paula M. Mikkelsen, revealed a new species here allocated to the genus *Lepidopleurus* Risso, 1826.

Order **Neoloricata** Berhenhayn, 1955
Family **Lepidopleuridae** Pilsbry, 1892
Genus ***Lepidopleurus*** Risso, 1826

Lepidopleurus bartletti Ferreira, spec. nov.

Figures 1-6

Diagnosis: Small (up to 15 mm long) white chitons. Valves somewhat rugose; posterior edges moderately angled; surface covered with microgranular cuticle over sculptureless, chalky tegmentum. End valves remarkably flat; mucro slightly anterior; lateral areas not prominent, with some concentric growth rugae continuing into central areas. Gills posterior. Girdle thick; upper surface carpeted with small spiculoid elements with occasional, thin, straight, long spicules interspersed; undersurface reduced to fine cuticle devoid of scales or spicules. Radula median teeth wider in back than in front, with tricuspid major lateral teeth and rakelike spatulate teeth.

Type material: Holotype (USNM 859000) and paratypes (CAS 059845; IRCZM 061:085; LACM 2123).

Other material: Specimen 1.3 × 0.9 mm, from sta. 88, tentatively identified as *L. bartletti* (CAS 059846) but not given paratypic status in view of its small size and ill-defined, juvenile characters.

Type locality: Venezuela Basin, Caribbean Sea, 13°45′N, 67°45′W, at depth of 5046 m. (Station 63, roughly 150 mi. N.E. of Bonaire, Netherlands Antilles).

Description: Holotype (from USNV *Bartlett* sta. 63), preserved in alcohol, curled, ca. 15 mm long, 10 mm wide (figs. 1-3). Valves subcarinate, moderately beaked, with angled posterior edges. Shell surface covered with microgranular cuticle, easily scraped off to show chalky white, sculptureless tegmentum beneath. Anterior valve remarkably flat. Lateral areas of intermediate valves not prominent except for greater valve thickness and concentric growth rugae often continuing unto sculptureless central areas. Posterior valve extremely flat; mucro slightly anterior, poorly defined. Gills posterior, about 20 plumes per side, extending 40% of length of foot. Girdle creamy white, thick, with conspicuous straight, thin, glassy spicules interspersed on background of much smaller, thinner, closely packed spiculoid elements.

Paratypes (from USNV *Bartlett* sta. 40 and sta. 63.) very similar to holotype. Paratype from sta. 40, 13 mm long, disarticulated: Cuticle easily removable from valves uncovering chalky, sculptureless tegmental surface beneath (fig. 4). Articulamentum white with no insertion teeth or slits (fig. 5). Valve i, 5.2 mm wide, 3.2 mm long, 1.2 mm high at posterior edge. Valve v, 6.0 mm wide, 2.0 mm long in midline. Valve viii, 5.1 mm wide, 3.7 mm long, 1.0 mm high at anterior edge, slightly convex in premucro area, slightly concave in postmucro area. Sutural laminae short, triangular; sinus very wide; on valve viii, relative width of sinus (width of sutural sinus/width of sutural lamina) is 1.8. Girdle dorsal surface densely carpeted with blunt-ended, cigar-shaped, spiculoid elements up to 100 × 25 μm (up to 120 × 35 μm at sutures), often longitudinally striated (fig. 6-A), interspersed straight, vaguely striated, glassy spicules up to 300 × 28 μm (fig. 6-B), interspersed; undersurface reduced to fine cuticle without scales, spicules or other elements; girdle bridges empty. Radula 6 mm long, comprising 55 rows of mature teeth; median teeth (fig. 6-A) 80 μm long, 30 μm wide at anterior blade, enlarging posteriorly to 60 μm; first lateral teeth about 80 μm long, with socketlike concavity at anterior end; major lateral teeth with tricuspid head (fig. 6-B) about 70 μm wide, 100 μm long at middle cusp; spatulate teeth 150 μm wide with fasciculate, rakelike appearance (fig. 6-C); outer marginal teeth 90 μm long, 120 μm wide (width/length, 0.75).

Distribution: Lepidopleurus bartletti is known only from the general area of the type locality in the central lower Caribbean at great depths.

Remarks: In addition to *L. bartletti*, only two other living species of *Lepidopleurus* are known: *L. cajetanus* (Poli, 1791), a common intertidal to sublitoral European species, and *L. scrippsianus* Ferreira, 1980, collected at over 2500 m in

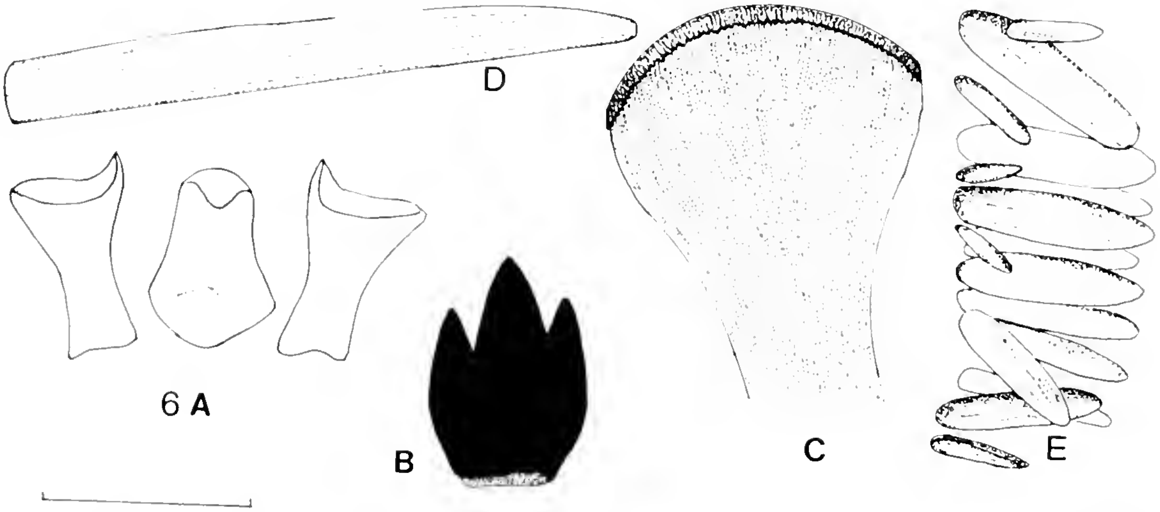


FIG. 6. *Lepidopleurus bartletti* Ferreira, spec. nov.: Paratype (CAS 059845), radular - (A) median and first lateral teeth; (B) head of major lateral tooth; (C) head of spatulate tooth; (D) interspersed spicule; (E) background spiculoid elements. Scale bar 100 μm.

the eastern Pacific, SW of Cabo San Lucas, Baja California, Mexico. A fossil species, *L. morozakiensis* Itoigawa, Nishimoto and Tomida, 1977, is known from the Miocene Morozaki group of central Japan.

Lepidopleurus bartletti is quite similar to *L. scrippsianus* from which it differs in 1) more delicate, less rugose valves, 2) posterior edge of valves forming much wider angle, 3) lateral areas much less accentuated, 4) extremely flat end valves, 5) anterior mucro, and 6) valve covering cuticle [not seen in specimens of *L. scrippsianus*], giving *bartelli*'s valves a microgranular appearance which contrasts with the sculptureless, chalky tegmental surface beneath. Notable features common to *L. bartletti* and *L. scrippsianus* are 1) girdle elements, 2) girdle undersurface reduced to cuticle without spicules or scales, and 3) radula with unusually shaped median teeth and rake-like spatulate teeth.

The species is named *bartletti* in honor of the USNS *Bartlett* for her central role in this study of the Venezuela Basin.

Acknowledgments

I express my appreciation to Paula M. Mikkelsen, Indian River Coastal Zone Museum, Harbor Branch Foundation, Inc., Fort Pierce, Florida, who entrusted these specimens to my care and study. William G. Lyons of Florida's Department of Natural Resources very kindly made many improvements to the manuscript.

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A NEW SPECIES OF *LYRIA* (GASTROPODA: VOLUTIDAE) FROM THE ARABIAN SEA

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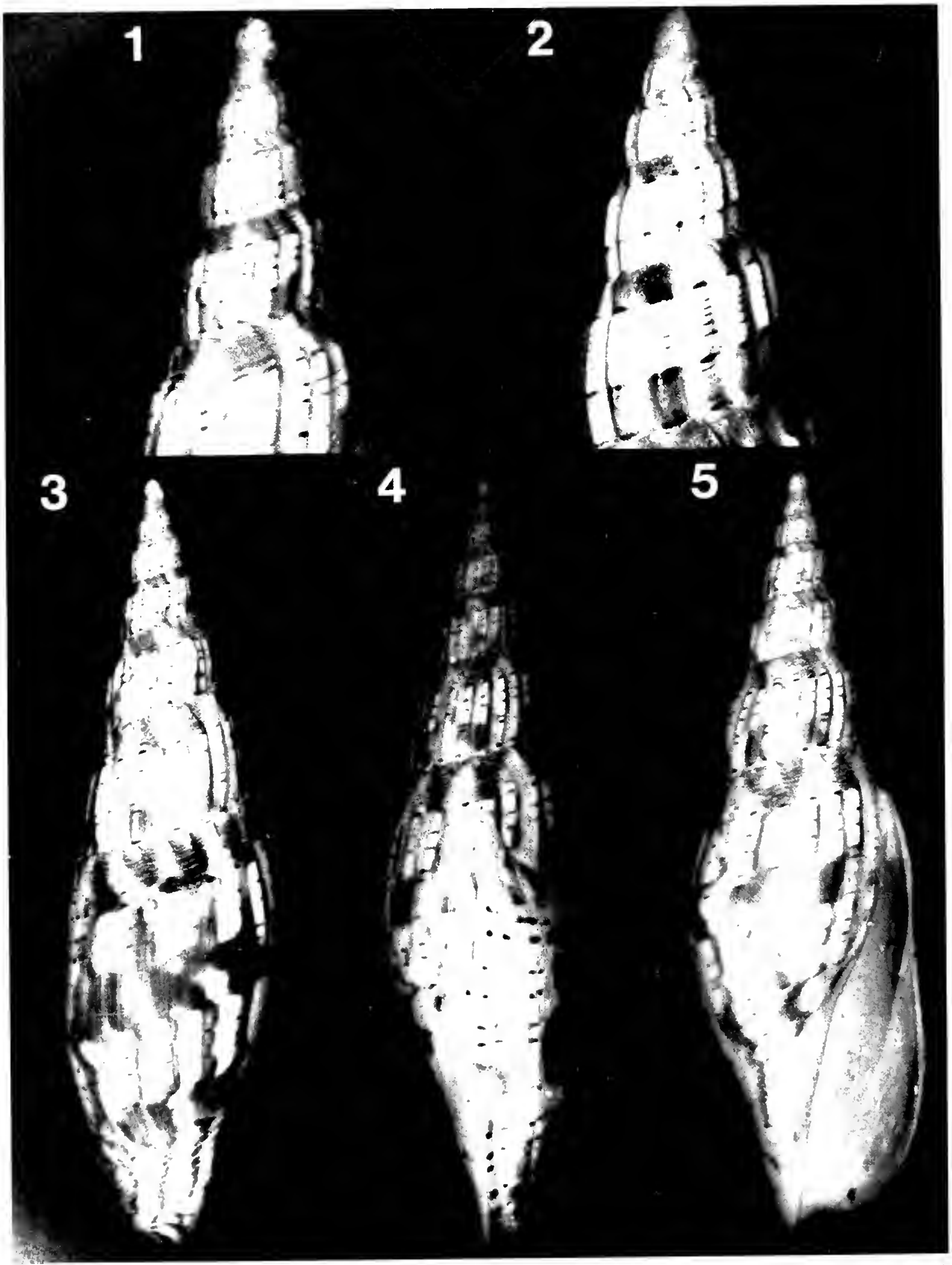
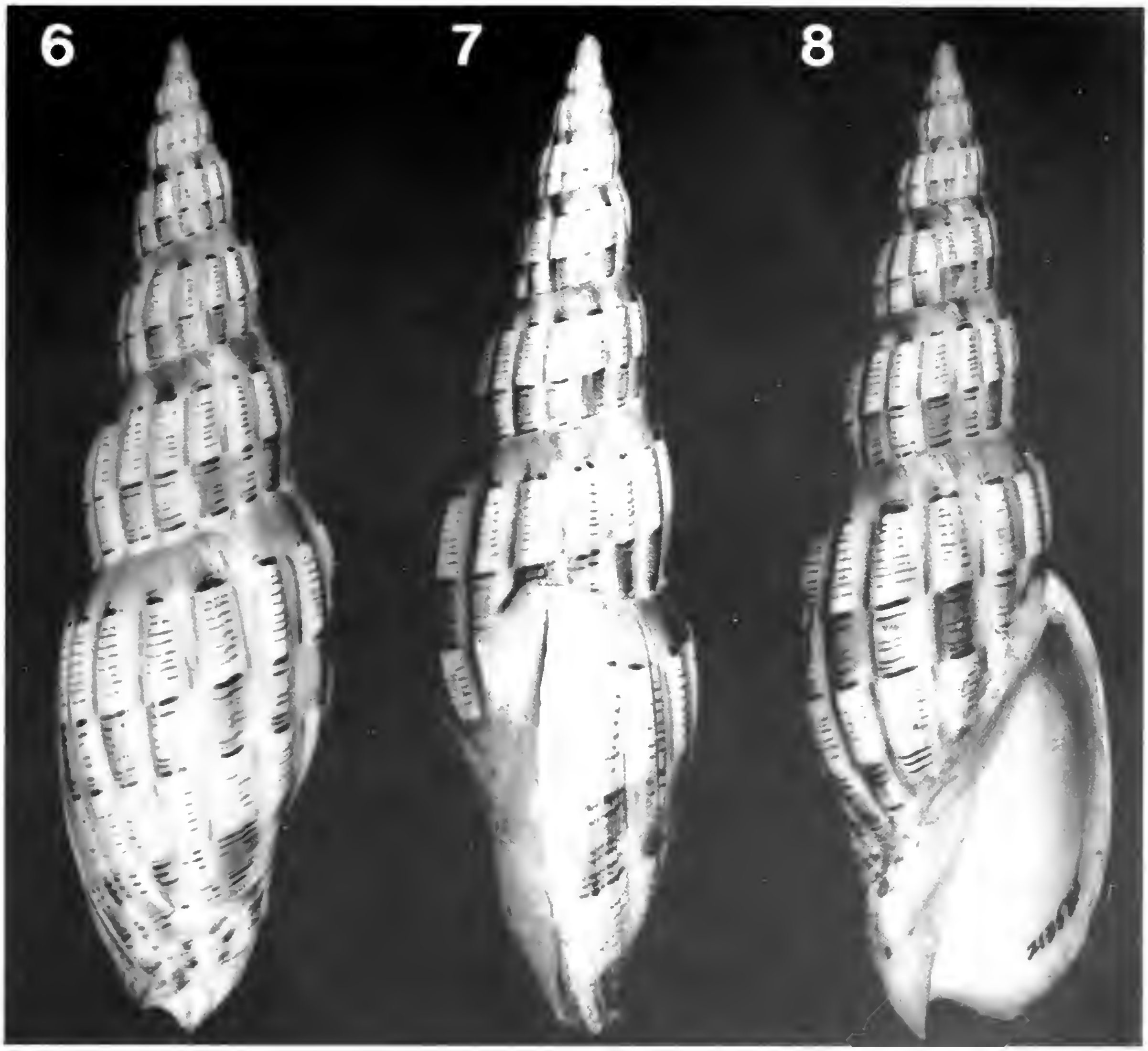
ABSTRACT

Lyria leslieboschae, *new species, is described from off Masirah Island, Sultanate of Oman, Arabian Sea. Known only from a few beach specimens, this new taxon is distinguished by discrete differences in shell morphology from the superficially similar species,* Lyria lyraeformis *(Swainson, 1821), which occurs off the coast of Kenya, East Africa.*

Donald and Eloise Bosch resided for nearly thirty years in Oman, where she was a teacher and he was a practicing physician. During this time, they became knowledgable shell collectors and eventually co-authored an illustrated guide, "Seashells of Oman", which was published in 1983. Among specimens they recently submitted to us for study were four examples of a new



FIGURES 1-5. Holotype of *Lyria leslieboschae* new species, AMNH no. 221655. **3-5,** dorsal, apertural and oblique views, ×1.1. **1-2,** of early whorls, ×2.



FIGS. 2, 6-8. *Lyria lyraeformis* (Swainson, 1821), trawled off the coast of Kenya, AMNH 213583. **6-8**, dorsal, apertural, and oblique views, ×1. **2**, detail of early whorls, ×2.

species of *Lyria* found for the first time in January, 1985, at Masirah Island. We are extremely pleased to name this exquisite volute in honor of their daughter-in-law, Mrs. Leslie Bosch, who actively participated, together with her husband, David, on ten annual collecting expeditions of the Bosch family to this locality.

Lyria leslieboschae *new species*

Figs. 1, 3-5

Diagnosis: In outline and general appearance the shell resembles *Lyria lyraeformis* (Swainson, 1821, pl. 54, 2 figs.; Weaver and duPont, 1970, pl. 5 A, B; Abbott and Dance, 1982, p. 213, 1 fig.; and Okutani, 1983, pl. 31, fig. 8; here illustrated, figs. 2, 6-8), but differs in possessing a blunt, bulbous nucleus, which lacks a calcarella (cf. figs. 1, 2), an anal canal that is narrow, open and flares posteriorly to the region just below the subsutural spiral band (cf. figs. 4, 7), as well as by axial sculpture that is less strongly developed on the body whorl, and a distinctive color pattern that is more diffused.

Description of holotype, figures 1, 3-5: Shell large for genus, attaining 130 mm in height, elongate-fusiform, spire high, attenuated. Nucleus of 2½ smooth whorls, without a calcarella. Teleoconch of 7½ rounded whorls, indented at the suture; axial sculpture weakly developed on body whorl, numbering 21 on penultimate whorl, more evenly defined on the early whorls than on the penultimate and body whorls. Spiral sculpture best expressed on the wide, spirally indented subsutural bands, each with 6 spiral lirae acutely raised at the points of alignment with the axial ribs. Aperture narrow, gaping anteriorly, with a short wide siphonal canal, terminating posteriorly in a long, narrow, open anal canal, near the base of the spiral band below the suture. Columella with three anterior plaits; parietal region without plaits. Exterior surface above the siphonal canal with 7 spiral ridges.

Base color a cream-tan, overlaid with interrupted bands of reddish brown formed in the subsutural areas and on the medial and basal regions of the body whorl. Reddish brown spiral lines on the axial ribs. Reddish brown irregular axial lines on the nucleus. Interior of aperture and columella glossy, colored a tannish cream, with a bluish tint. The coloration of live-taken specimens can be expected to be more vividly expressed than in this well-preserved beach specimen, which had several large colonies of bryozoa encrusting the interior of the aperture at the time of collection.

Nothing is known of the radula or soft parts.

Measurements: Holotype, AMNH no. 221655, 129.3 mm in height, 38.4 mm in width. Paratypes, AMNH no. 221656, Paratype A, 85.5 mm in height, 31.3 mm in width, Paratype B, 87.9 mm in height, 31.9 mm in width, Paratype C, 91.8 mm in height, 29.4 mm in width. (The paratypes lack complete spires).

Type locality: About 8 km south of the village of Haql, on the southeastern coast of Masirah Island, Oman.

Distribution: Known only from the type locality.

Remarks: The only known specimens were washed ashore by the heavy surf on the Indian Ocean side of the island. On this exposed beach, Dr. Bosch (*in litteris,* May 9, 1986) also reported finding dead specimens of *Festilyria festiva* (Lamarck, 1811) and *Conus lischkeanus* cf. *tropicensis* Coomans and Filmer, 1985, species which are known to occur in moderately deep offshore waters. The present species apparently lives at moderate depths and will require SCUBA diving and/or dredging operations to collect living specimens.

Acknowledgments

We thank Dr. and Mrs. Bosch for their kindness in calling to our attention this most elegant addition to the Volutidae and for depositing the typological specimens in the type collection of mollusks of the American Museum of Natural History. We also thank Stephanie Crooms for word-processing the manuscript and Stephen Butler for the photography.

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BOOK REVIEW

Hong Kong Seashells by John D. Orr. 1985. Urban Council, Hong Kong. 122 pp., 94 color photos. Paperback.

The author presents 60 beautiful, close-up photographs of living specimens of cowries, olives, cones, *Strombus* conchs and helmet shells, as well as the shells of 84 other common, shallow water bivalves and gastropods of the Hong Kong area. Hints on collecting, classifying and studying mollusks are included. The spectacular photographs of living specimens make up for the few included species, lack of authors and dates, and occasional typographical errors. *Cymatium clandestinum* on page 102 is really a worn *Cantharus (Pollia)* probably *undosa* (Linnaeus, 1758).—*R. T. Abbott.*

LITHARCA LITHODOMUS AND ADAPTIVE RADIATION IN ARCACEAN PELECYPODS

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ABSTRACT

Litharca lithodomus *is a rock-boring arcid (subfamily Litharcinae Frizzell, 1946) that has a geographic range from Nicaragua to Peru. It is not known as a fossil, and this species may be less than one million years old.* Litharca lithodomus *is most likely a mechanical rock-borer. The possible ancestral species is* Barbatia (Cucullaearca) reeveana, *which is commonly found throughout the present range of* Litharca lithodomus. Barbatia (Cucullaearca) reeveana *nestles in crevices in rocks and its shape is frequently distorted. The change of habit from nestling to rock-boring is not great, and this change is seen in some other species in different families of pelecypods.*

The earliest arcaceans, which appeared during the Middle Devonian, were epibyssate. Shallow-burrowing species of arcaceans probably did not occur before the Triassic, and nestling species probably appeared no later than the Paleocene. Fresh-water and rock-boring arcaceans seem to be confined to the Recent.

Many large families or superfamilies of suspension-feeding pelecypods exhibit more adaptive radiation than all of the Protobranchia, which are deposit feeders. One of these large superfamilies, the Arcacea, is diverse and widely distributed in the seas today, ranging from the tropics to the cold water of the Antarctic, as well as to abyssal and hadal regions.

The earliest true arcaceans appear suddenly in the Middle Devonian (Givetian Stage) about 380 million years ago. Most paleontologists have said that the Cyrtodontidae represent the ancestral stock that gave rise to the arcaceans, based on the similarity of the hinge teeth and ligament in some members. A few have doubted that the cyrtodonts were the ancestors of the arcaceans (Nicol, 1984). Perhaps a more likely group to have given rise to the arcaceans was the Ambonychiidae. Some ambonychiids have ligaments and hinge teeth similar to the arcaceans and many were byssally attached whereas the Cyrtodontidae were burrowers according to Stanley (1972). Furthermore, while the Ambonychiidae were common in the Middle Devonian, the Cyrtodontidae were nearly extinct by that time. It is also easier to derive the byssally attached arcacean *Parallelodon* from a byssally attached ambonychiid rather than a burrowing cyrtodontid.

It is generally agreed that the first arcaceans were byssally attached to the substrate, and *Parallelodon* has a rectangular valve outline that resembles *Arca, sensu stricto*. Some of the Paleozoic arcaceans were probably endobyssate, and this life habit occurred in some species of *Parallelodon*. However, arcaceans are not common and diverse throughout the Paleozoic, and the great adaptive radiation of this superfamily began in the Jurassic and continued throughout the Cretaceous (Nicol, 1984).

The first burrowing arcacean may have been *Macrodontella*, which occurs in the Triassic (text fig. 1). These early burrowing arcaceans did not appear until at least 150,000,000 years after the first arcaceans appeared. Other burrowing arcaceans occur amongst the cucullaeids in the Jurassic and Cretaceous, and the glycymeridids and *Trigonarca* during the Cretaceous. Some of the Cretaceous limopsids were probably burrowers but some were endobyssate (Oliver, 1981). Epibyssate, endobyssate, and burrowing arcaceans continue to the Recent with burrowing species probably outnumbering the epibyssate and endobyssate forms.

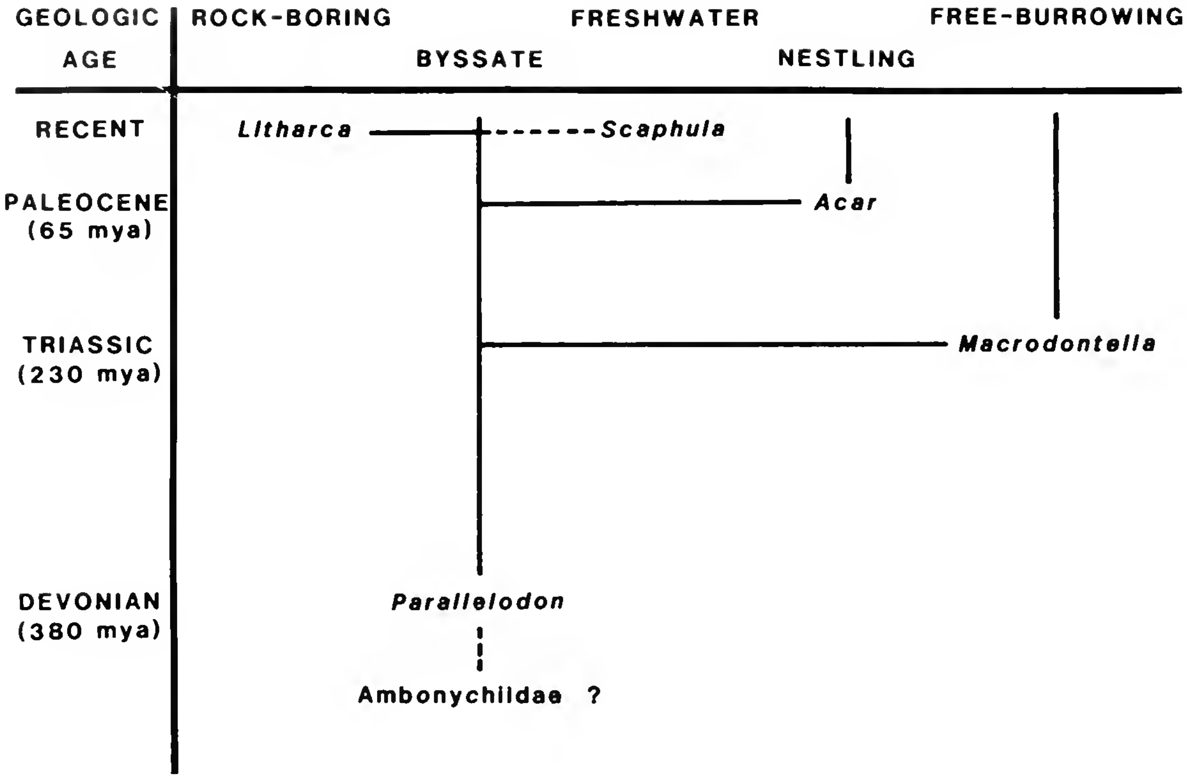

FIG. 1. Diagram showing adaptive radiation in the Arcacea.

Some species of *Acar* are true nestlers, and this genus appeared in the Paleocene, about 65,000,000 years ago. *Scaphula* is an arcacean that has invaded brackish and fresh water during the Recent.

The most unusual adaptation of the arcaceans occurs in *Litharca lithodomus* (Sowerby, 1833), a rock-borer (plate 1). The genus is monotypic and is known only from the Recent. Keen (1971) stated that the range of the species extends from Nicaragua to Peru, and it appears to be most common along the coast of Ecuador. Olsson (1961) claimed that *Litharca* is so common in some areas of Ecuador that fishermen use it for food and bait. *Litharca lithodomus* is a relatively large arcid, and Frizzell (1946) had one specimen that was 91.1 mm in length. Olsson (1961) stated that the adult shell reaches a length of nearly 100 mm.

The shell of *Litharca* is unusually thick for a rock-borer, and only some species of rock-boring tridacnids have slightly thicker shells. In other words, rock-boring pelecypods commonly have very thin shells as seen in the mytilids, pholads, petricolids, and myids. A thin shell may have an advantage in that it can be more easily and frequently moved within the borehole. Furthermore, a thick shell, as in *Mercenaria*, is not needed for protection from carnivorous gastropods and crustaceans. Shells of mechanical rock-boring pelecypods commonly consist of aragonite, but the nacreous structure found in unionids and Pteriidae is absent. Nacreous shells are friable and would not be suitable for mechanical rock boring.

One of the most unusual features of *Litharca lithodomus* is the greatly elongated anterior end (Plate 1). The ligament is wholly prosodetic and lacks a posterior limb (i.e., the ligament lacks chevrons). This lack of a posterior limb of the ligament is also seen in the Cretaceous glycymeridid *Postligata* (Nicol and Jones, 1984). Frizzell (1946) stated that the beaks are slightly opisthogyrate, but Olsson (1961) said that they are probably prosogyrate. The beaks are most likely opisthogyrate because of the prosodetic ligament and the extreme elongation of the anterior end of the shell. Prosodetic ligaments and opisthogyrate beaks are quite common in glycymeridids. A byssus is present in adult

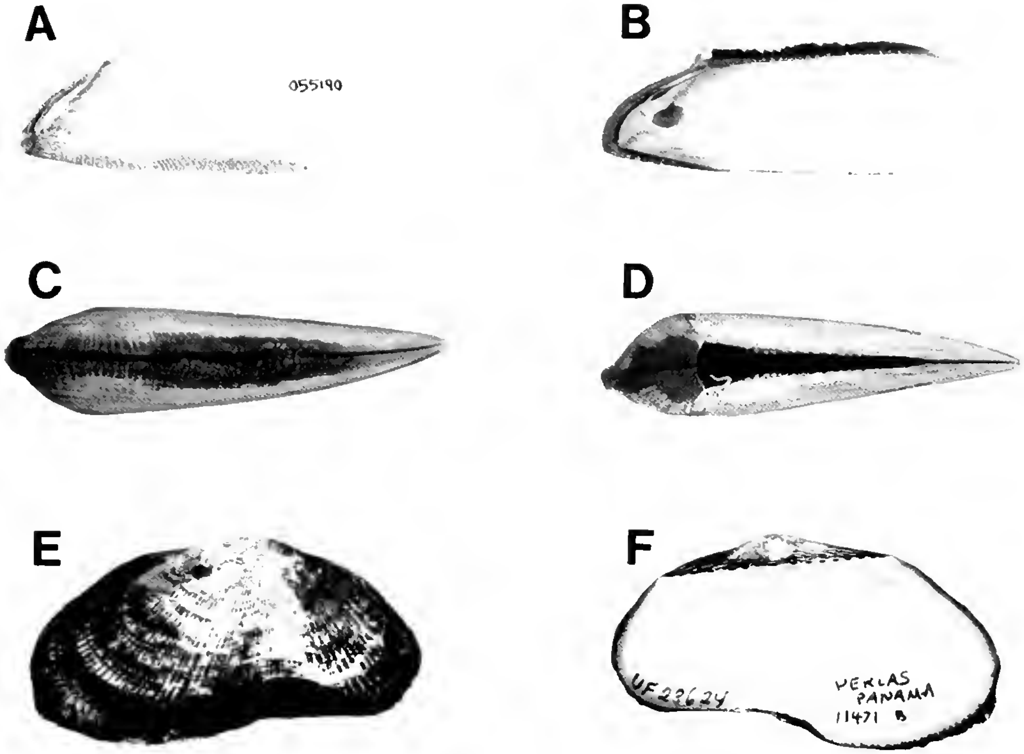

PLATE 1. **A-D.** *Litharca lithodomus* (Sowerby). Manta, Ecuador. **A,** Exterior, right valve. **B,** Interior, left valve. **C,** Ventral view, both valves showing small byssal gape (shell length 86.5 mm). **D,** Dorsal view, both valves showing truncated posterior to the left. **A-D,** California Academy Sciences #055190. **E-F,** *Barbatia (Cucullaearca) reeveana* (Orbigny). Perlas, Panama. **E,** Left valve, exterior. **F,** Left valve, interior (shell length 79.7 mm). **E-F.** Florida State Museum #23624.

Litharca lithodomus, but the byssal gape is narrow and elongate, and the byssus is flexible so that the animal is able to move downward in its borehole (Olsson, 1961). As is shown in Frizzell's figure 5 (1946), the valves are wedge-shaped with the most convex portion near the posterior end. The anterior end is narrow. This is an unusual shape for a rock-borer.

Thomas (1974, 1976) has assumed that the boring is accomplished by chemical means in *Litharca*, but this may not be so. Both Frizzell (1946) and Olsson (1961) have observed that *Litharca* bores into massive sandstones in Ecuador. Are these sandstones calcareous or cemented with calcium carbonate? Field and laboratory observations on these sandstones would be essential to come to a final conclusion as to the mode of boring. Just because *Litharca* has a weak ligament and a pitted shell exterior does not necessarily rule out the possibility that it may bore mechanically. Furthermore, of the remaining rock-boring species of pelecypods, only some species of mytilids bore by chemical means whereas other species of rock-boring mytilids are mechanical borers (Yonge, 1951). Perhaps, as Thomas implies (1976), both mechanical and chemical means of boring may be employed by *Litharca*.

The fact that at least one arcid species has developed a rock-boring habit is apparently not as incongruous as it would at first seem. The two most unusual features found in *Litharca lithodomus* that are generally not seen in other rock-boring species are the posterior displacement of the beaks and the hatchet-shaped convexity of the valves with the most convex region near the posterior end. Most rock-borers are cylindrical in shape, and the beaks are either near the center of the valves or near the anterior end. The byssus is not unique because rock-boring mytilids and tridacnids have this organ developed in the mature rock-boring stage (Yonge, 1951). Compared to some other rock-boring pelecypods, *Litharca* is relatively unspecialized.

Rock-boring pelecypods are most diverse in the tropical marine regions. They do not occur in the abyssal and hadal regions of the oceans nor in fresh water. There are at least eight families that have been purported to have one or more rock-boring species and they are: Arcidae, Mytilidae, Tridacnidae, Petricolidae, Hiatellidae, Myidae, Gastrochaenidae, and Pholadidae. The Mytilidae and Pholadidae comprise most of the rock-boring species, but there are probably no more than 100 living species of rock-boring pelecypods. Rock-boring species of pelecypods are of average to large size. The largest rock-borers are three species of *Tridacna*, but they are the smallest-sized species in the family and none attains a maximum size of more than about 400 mm. Furthermore, the species that bores the deepest into the rock is *Tridacna (Chametrachea) crocea* Lamarck, and it is the smallest of the three species, attaining a maximum size of only 150 mm (Rosewater, 1965). It also appears that species of pelecypods that attain a size of less than 20 mm are not rock borers, and this may be caused by a lack of boring capabilities in small-sized species.

It was assumed by Olsson (1961) and Thomas (1978) that the ancestor of *Litharca* was a species of *Arca*. An hypothesis ascribed by Dechaseaux (1969, p. N765) to Douvillé is as follows: "The ancestor was a species living where its earliest representatives are found and having some of its distinctive characters." If one uses this logical principle, then a likely ancestor to *Litharca lithodomus* could be *Barbatia (Cucullacarca) reeveana* (Orbigny, 1856) (plate 1). According to Keen (1971), this is a common species found throughout the present range of *Litharca lithodomus*. The ribbing and periostracum of *Barbatia (Cucullaearca) reeveana* resemble *Litharca*. The size and convexity of the valves in the two species are similar. There would have to be a reduction of the byssal gape because it is much larger in *Barbatia (Cucullaearca) reeveana* than it is in *Litharca*. The beaks of *Barbatia (Cucullaearca) reeveana* are commonly subcentral (not near the anterior end as in *Arca*), and it would require not a great modification to have the beaks thrust toward the posterior as in *Litharca lithodomus*. *Barbatia (Cucullaearca) reeveana* has a habit of attaching between rocks (Keen, 1971) so that a shift to a rock boring habit as in *Litharca lithodomus* would be a likely change in adaptation. This is also borne out by Yonge's observation (1958) that some rock-boring species have evolved from a byssate nestling species.

Whether *Litharca lithodomus* will be a short-lived experiment within the Arcidae or will continue to evolve and produce more rock-boring arcids is impossible to assess. As Frizzell pointed out (1946), the lack of a fossil record of *Litharca lithodomus* may be caused by the small number of rock-boring habitats in the fossil record and the relatively thin shells of this species inhibiting preservation. However, the morphologic changes for the origin of *Litharca lithodomus* must have been rapid, and it is quite possible that the appearance of this species was less than one million years ago.

Frizzell (1946) erected a separate subfamily, the Litharcinae, for *Litharca lithodomus*, and Vokes (1980) has followed Frizzell in this classification. We agree with Frizzell and Vokes because taxonomy should show the differences as well as the likenesses between species, and *Litharca lithodomus* is so unique in morphology and habit that it merits being placed in a separate subfamily within the Arcidae.

Acknowledgment

We are indebted to Dr. Peter U. Rodda of the California Academy of Sciences for granting us a loan of specimens of *Litharca lithodomus* for study.

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THE RADULA OF *ACRORBIS PETRICOLA* (PULMONATA: PLANORBIDAE)

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ABSTRACT

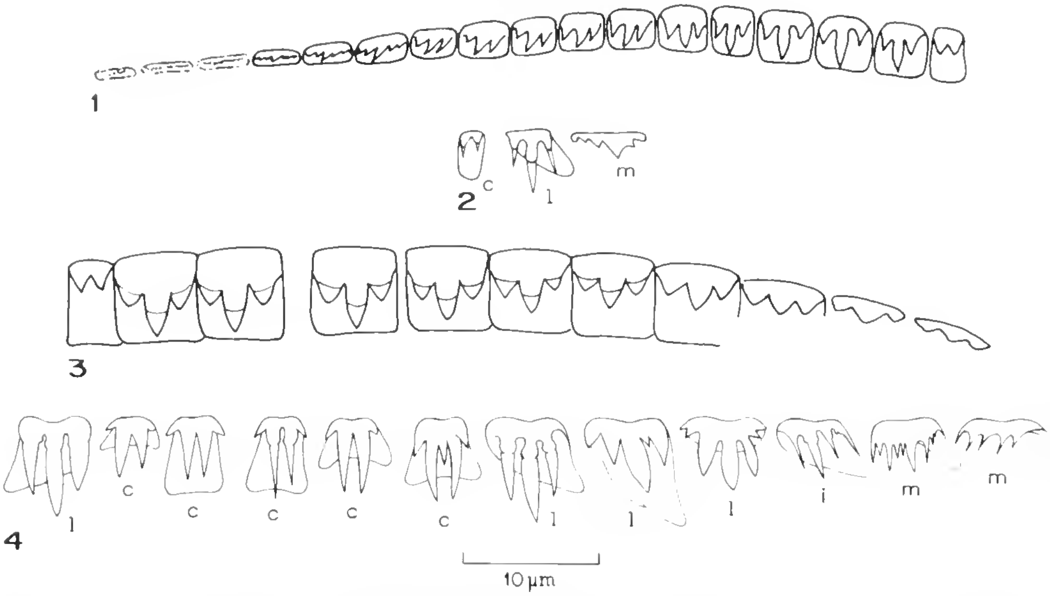
Observation of the radular teeth of Acrorbis petricola *Odhner, 1937, and* A. odhneri *Scott, 1960 with the scanning electron microscope showed no difference between the two nominal species, which also are indistinguishable in shell and anatomic characteristics.* A. odhneri, *therefore, is a junior synonym of* A. petricola. *The radular teeth of* Acrorbis *are similar to those of* Gyraulus, *but taxonomically important differences in qualitative characters of the genital system show that the two genera are less closely related than suggested by their radular characteristics.*

Acrorbis petricola is an atypical planorbid snail described by Odhner (1937) from specimens from Nova Teutônia (27°16′S, 52°20′W), a village in the Brazilian state of Santa Catarina, sent to the Swedish Ricksmuseum by the natural history collector, Herr Fritz Plaumann. Decisive characteristics for the erection of the new genus *Acrorbis* were the *Helix*-like shape of the shell, and especially the squarish radular teeth with short hooks (see Fig. 1).

Pilsbry (1938) pointed to the relationship between *Acrorbis* and *Drepanotrema* (misprinted *Drepanostoma*) by the similarity of the penial complex and the presence of a flagellum on the penial sheath, but distinguished the two genera by the teeth characteristics as shown by Odhner (1937).

Baker (1945:123) commented on the alleged differences in the radular teeth: "The radula [of *Acrorbis*] appears very different from that of *Drepanotrema* because of the apparent absence of interstitial cusps between the larger cusps. These might have been present but overlooked because of the small size of the radula teeth. The general shape of the mesocone in Odhner's figure 4 is suggestive of the same cusp in *Drepanotrema*, but the ectocone and entocone are much shorter." . . . "*Acrorbis*, therefore, appears to be another one of the peculiar groups of South American Planorbidae, related to *Drepanotrema*, but distinct by both shell and anatomy."

Examining specimens from Nova Teutônia, Hubendick (1955) observed that "though not very detailed, Odhner's description and figure of the radula in *Acrorbis* is not incorrect". His drawings of a central, a lateral and a marginal teeth, reproduced in Fig. 2, may be compared



FIGS. 1-4. **1**, Radular teeth of *Acrorbis petricola* reproduced from papers by Odhner, 1937; **2**, Hubendick, 1955; **3**, Scott, 1960, under the name *Acrorbis odhneri;* **4**, Paraense and Deslandes, 1959. (c, central; i, intermediate; l, lateral; m, marginal. Scale bar refers to Fig. 4).

with Odhner's (Fig. 1).

A redescription of *A. petricola*, based on specimens collected at my request by Herr Plaumann at the same breeding-place from which the sample studied by Odhner had been taken, was published by Paraense and Deslandes (1959). The teeth were represented as shown in Fig. 4. Accessory cusps can be seen on either side of the main cusps in the central teeth, and also between the two main cusps in the fifth figured central tooth. Spaces wider than usual appear between the bases of the cusps in several teeth; such spaces, as later realized, were really occupied by small cusps which could not be clearly discerned owing to their minuteness added to light diffraction effect. After discussing the anatomic affinities between *Acrorbis* and *Drepanotrema*, Paraense and Deslandes (1959) concluded that the shape of the shell was the only character that might warrant separation of the two genera. Stating, however, that a revision of the genus *Drepanotrema* would show so wide interspecific variation in shell configuration that any generic diagnosis based only on the shell characters of the type species would be meaningless, they treated *A. petricola* as a member of *Drepanotrema*. Subsequently, Paraense (1975) adopted the genus *Acrorbis* on account of its *Helix*-shaped shell not sculptured with longitudinal rows of minute dots (punctation), and of its very long spiral radula projecting far beyond the buccal mass.

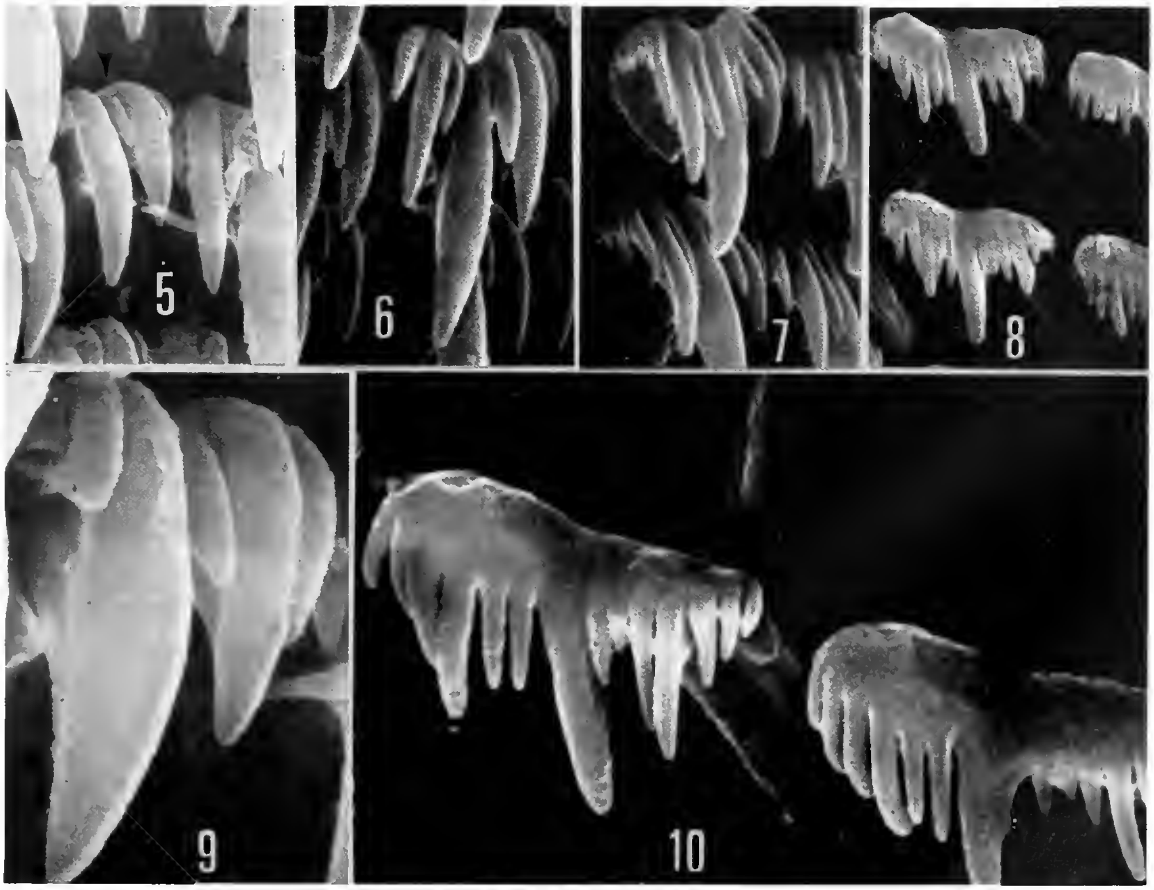
Under the name *Acrorbis odhneri*, Scott (1960) described a snail from Argentina anatomically identical with *A. petricola*, but differing in shell characteristics: larger size (largest specimen 4.25 mm in diameter, as against 2 mm in Odhner's specimens), rapid whorl growth, proportionally wider aperture, umbilicus partially covered by the basal reflection of the lip, and absence of spiral lines on the shell surface. Scott (1960) states that Odhner so precisely represented half a teeth row that she could recognize in it the radula of her own specimens (Fig. 3). (Translated): "There are no interstitial teeth between the cusps of the laterals, and the marginals are markedly short showing no oblique reflection". Considering the lack of a long oblique reflection in the marginals sufficient to separate *Acrorbis* from the Planorbidae, Scott (1960) created the family Acrorbidae to include *A. petricola* and *A. odhneri*.

On 17 May 1973 I collected 23 specimens of *A. odhneri* at its type-locality, Salto Encantado (27°03′S, 54°50′W), Departamento Libertador General San Martín, Province of Misiones, Argentina. One may easily reach Salto Encantado by Road 14 (Ruta 14) as far as km 212, where it intersects Ruta 220 (about 14 km east of Aristóbulo del Valle, Departamento Cainguas), and then northward by the last-mentioned road for about 3 km.

Salto Encantado is a waterfall which drops vertically and sprays the adjacent cliff, favoring a thick growth of moss where the snail is found. Such peculiar habitat is similar to that of *A. petricola*, which lives among moss on rocky banks of streams kept wet by trickling water from the surrounding ground and above the stream level.

The collected specimens were indistinguishable, in shell and anatomy, from *A. petricola* from Nova Teutônia, as described by Paraense and Deslandes (1959). The largest shell was 3.2 mm in diameter. As in the specimens from Nova Teutônia in our collection, the umbilicus was to a variable extent covered by the basal reflection of the lip and the shell surface was more or less perceptibly sculptured with thin spiral lines. Other differences mentioned by Scott (1960) as diagnostic of *A. petricola* (shell size, rate of whorl increase, proportion of apertural diameter) can be ascribed to intraspecific or interpopulational variation.

As to the radula, no significant difference was observed between the two forms, so that only teeth of a specimen from Salto Encantado are shown in Figs. 5-10. As observed with the scanning electron microscope, the central tooth (Figs. 5, 9) has two dagger-like cusps, of which the left one is longer than the right; there is one (sometimes two) minor spine-shaped cusp high on either lateral side of the major cusps, and another one between the latter. The laterals (Fig. 6) have three dagger-like major cusps, of which the mesocone is much longer, and show one smaller spine-shaped cusp high on the lateral side of the ectocone and entocone and



FIGS. 5-10. Scanning electron micrographs of radular teeth of *Acrorbis petricola* from Salto Encantado, Misiones province, Argentina. **5**, central (arrow), a little slanted to the right; **6**, laterals; **7**, intermediates; **8**, marginals; **9**, central, a little slanted to the right; **10**, marginals. Figs. **5-8**, ×29,000; **9**, ×25,000; **10**, ×20,000.

between the major cusps. Small cusps between and outside the three major cusps are added from the intermediates (Fig. 3) to the extreme marginals (Figs. 4, 6), while the ectocone, the entocone and particularly the mesocone remain easily distinguishable. Both major and minor cusps grow smaller toward the edges of the radular ribbon. The marginals have short wide reflections high up on the base of attachment. The extreme marginals usually show 13-14 cusps, including the three main ones.

The radular teeth of *Acrorbis* are similar to those of *Gyraulus*, recently studied by Meier-Brook (1983) and Burch and Jeong (1984), but the absence in *Acrorbis* of taxonomically important characters such as a penial stylet and a separate prostatic duct, and the presence of flagella on the penial sheath, show that the two genera are less closely related than suggested by their radular characteristics.

The observations described above point to the identity of *A. petricola* and *A. odhneri*, lending no support to the removal of the genus from the family Planorbidae.

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NATICA (GLYPHEPITHEMA) TEDBAYERI, A REPLACEMENT NAME

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In a recent issue of *The Nautilus* (Rehder, 1986: *Nautilus*, **100**(1):38) I proposed the name *Natica (Glyphepithema) bayeri* for *Glyphepithema floridana* Rehder, 1943, not *Natica floridana* Dall, 1892.

Now Alan R. Kabat at the Museum of Comparative Zoology has kindly called my attention to the fact that the taxon *Natica bayeri* is preoccupied by *Natica (Naticina) bayeri* Koperberg, 1931 (Jaarboek von het Mijnwezen in Nederlandsch Oost-Indie, 59: 139, pl. 3, fig. 48) from the Pliocene of Timor, Indonesia.

I propose now to name the species found, from southeastern Florida to Brasil, *Natica (Glyphepithema) tedbayeri* Rehder.

BOOK REVIEWS

Seashells of Western Australia by Fred E. Wells and Clayton W. Bryce. 1986. Western Australian Museum, Perth. 207 pp., 74 colored pls. Paperback. $17.95 Australian (approx. U.S. $12.50).

This is an excellent, well-illustrated guide to the more common and readily found species of marine mollusks of Western Australia. The western third of Australia is particularly rich in molluscan species because of the meeting of the tropical Indo-Pacific province in the north with the colder temperate waters of South Australia and Tasmania. Of the approximate 2000 species from this region, this accurate guide beautifully illustrates 671 species, including many photographs of living specimens of opisthobranchs and cephalopods. Each family is defined and, when available, useful bibliographic references are included. Scientific name, author and date, size, geographical distribution, relative abundance within Western Australia, and an excellent photograph are given for each of these common and conspicuous species. A short introduction on protecting mollusks, cleaning and maintaining a collection of shells, together with a glossary and index round out this fine little book. –*R. T. Abbott.*

The Littorinid Molluscs of Mangrove Forests in the Indo-Pacific Region. by David G. Reid. 24 April 1986. 228 pp., 98 figs., 1 color plate. Publ. no. 978, British Museum (Natural History). Cloth, $35.00 (Approximately U.S. $52.00).

This is one of the most complete and competently executed monographs of a well-known group of common mangrove-dwelling gastropods. The taxonomy of this otherwise perplexing genus, *Littoraria,* has been well worked out. Despite the recognition of 27 Indo-Pacific species and subspecies in a group heretofore usually treated as three or four good species, the author has proposed only two Indo-Pacific new species, one new subspecies and one new subgenus, *(Palustorina).* His detailed presentation of anatomical, egg-capsule, radular and distributional characteristics will probably lead to a universal acceptance of his views. Very fortunately a large number of earlier names solely based on shell characters were available for these new biologically recognized species. Excellent drawings of penes, pallial oviducts, sperm nurse cells, and distributional maps accompany each of the 27 Indo-Pacific taxa. Worldwide, 37 taxa are recognized in five subgenera of the genus *Littoraria* Griffith and Pidgeon, 1834. The first 70 pages of this work have an excellent discussion of morphological characters, reproduction, habitats and biogeography. –*R. T. Abbott.*

It's Easy to Say Crepidula! by Jean M. Cate and Selma Raskin. 1986. 155 pp. Pretty Penny Press. P.O. Box 3890, Santa Monica, CA 90403. Paperback, $19.95, plus $1.50 postage.

This is a useful phoenetic guide to the pronunciation of the scientific names of about 3,000 common molluscan taxa. The authors usually give two pronunciations, one evidently used in American Latin classrooms, the other used customarily among most American malacologists. Readers may take their choice. However, the customary pronunciation of the *-ae* ending, used in species named for a woman, is not given. The name *myrakeenae,* for instance, is usually pronounced: MY' ruh KEEN' ee, but the authors give only MY' ruh KEEN' ay and MY' ru KEEN' eye. They are correct in suggesting that names for males, ending in *-i,* may be pronounced "eye", as in *laurenti:* law RENT' eye. There is also an eleven-page glossary of malacological terms. –*R. T. Abbott.*

Seashell Treasures of the Caribbean by Lesley Sutty. Edited by R. Tucker Abbott. E. P. Dutton, New York. 1986. 128 pp., 139 color plates. $19.95. (with autographed, numbered bookplate $21.95 from American Malacologists, P.O. Box 1192, Burlington, MA 01803).

The author, an accomplished naturalist, diver and photographer, has chosen 100 species of Caribbean mollusks "to illustrate and comment upon so that the reader may share my enthusiasm and joys in discovering the shells of these beautiful tropical islands." She has attempted to inspire others to study mollusks by relating her experiences in seeking these elusive and fascinating animals in the Lesser Antilles. Her lively and engaging narrative, coupled with her stunning photographs, are certain to provide any shell lover with many hours of pleasurable reading, and should stimulate interest in seeking and observing marine shells.

A preface by the editor and the author's introduction begin this volume, followed by chapters entitled, "What is a Rare Shell?", "Strange and Beautiful Shapes", "Treasures of Sea and Reef", and "Science in Shells." Rare shells discussed and illustrated include *Cypraea surinamensis*, *Pterynotus phyllopterus* and *Conus granulatus*, to name just a few. Unusual mollusks, such as *Umbraculum umbraculum*, *Glossodoris clenchi* and *Xenophora conchyliophora* become familiar through the author's animated writing style. The bulk of the species are treated in the "Treasures" chapter where we meet the rediscovery of *Hexaplex straussi* and such desirable species as *Lyria archeri*, *Conus cedonulli* and *Chlamys multisquamata*. An abbreviated history of Caribbean malacology, followed by a brief bibliography, index and glossary of terms, completes the text.

There is a great deal of merit in this beautifully illustrated book, and it is important again to stress that the author has fully achieved her aim of sharing with others her collecting activities. This book is not intended to be an identification guide. Despite meticulous editing, last minute publisher's errors do creep in, such as the transposition of the captions for plates 22 and 23, and the indiscriminate use of parentheses around every author and date. Nonetheless, it is hoped that this well-produced and lavishly illustrated work will be enjoyed and appreciated by nature lovers and conchologists, and will serve to introduce living mollusks to many new enthusiasts – *Walter E. Sage.*

North Atlantic Nudibranchs (Mollusca) Seen By Henning Lemche by Hanne Just and Malcolm Edmunds. 1985. 170 pp., 69 pls. in color. Paperback. Supplement 2 of *Ophelia*, International Journal of Marine Biology, Denmark. 500 kroner (approx. U.S. $60.00)

The excellent 69 color plates depicting the late Dr. Henning Lemche's personal paintings of 76 of the known 217 species of opisthobranchs of the North Atlantic will prove useful to students of nudibranchs. The descriptions of the species and the information on feeding and reproduction, together with up-dated taxonomic notes by the author-editors add considerable usefulness to the book. A geographical checklist of the 217 species by Elizabeth Platts is very helpful.

Most of Lemche's illustrated species are in the genera *Doto*, *Onchidoris*, *Flabellina*, *Eubranchus*, *Cuthona* and *Aeolidiella*. 26 of the 76 species are given no trivial names and await further taxonomic consideration. Perhaps someday this unfinished book will be carried to conclusion by one or both of the authors. –*R. T. Abbott.*

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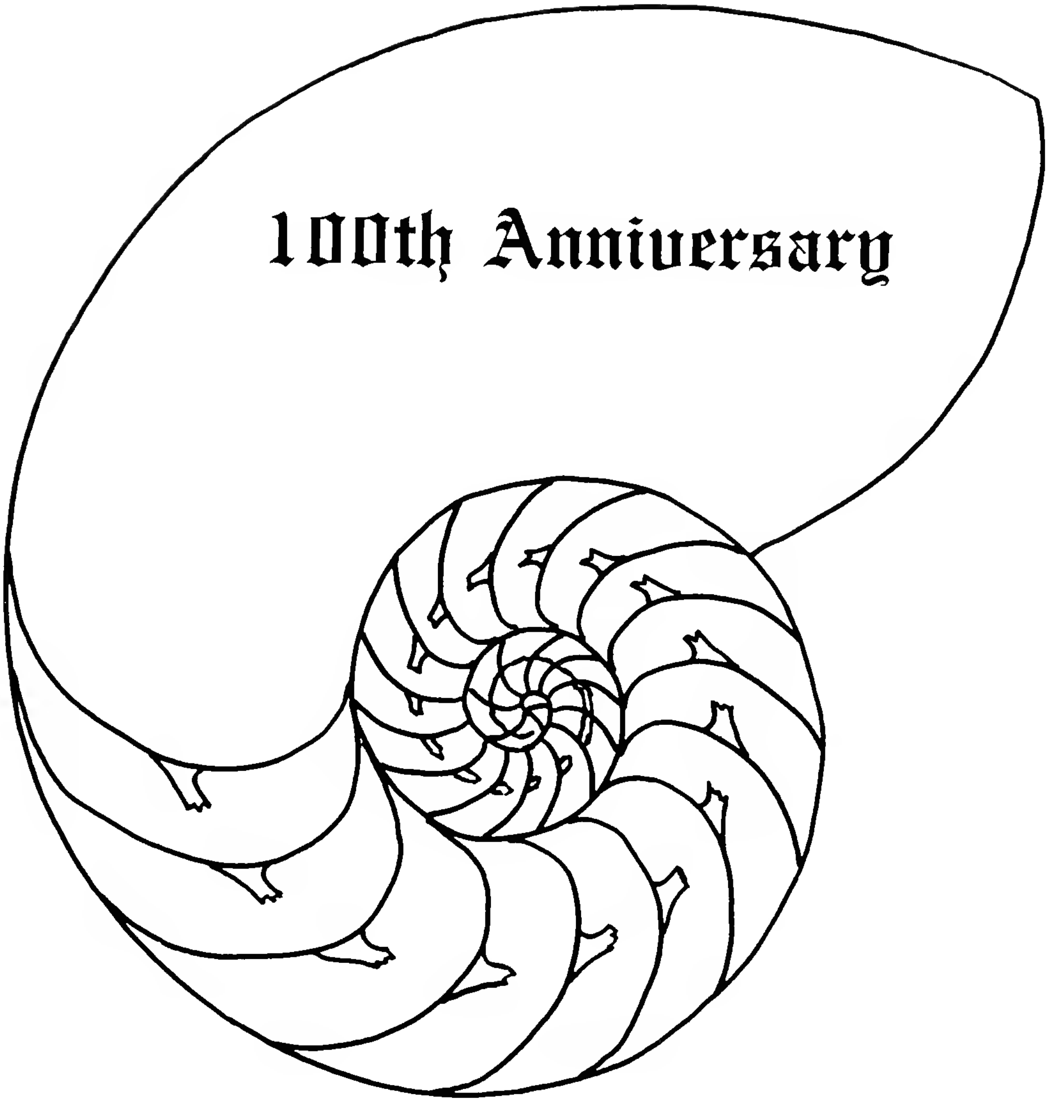

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"THINGS TRULY EXCELLENT. . .": HENRY VAN DER SCHALIE, 1907-1986

Louise Russert-Kraemer and **Elmer G. Berry**

HENRY VAN DER SCHALIE (1907-1986)

Henry van der Schalie, extraordinary scholar, teacher and friend to so many of us, died Tuesday afternoon, 15 April, 1986, in his home near the Raisin River in Manchester, Michigan, with his beloved wife and colleague, Annette Rudolphi van der Schalie, at his side. Born in 1907 in Amsterdam, the Netherlands, Professor van der Schalie completed high school in Paterson, New Jersey, and then earned an A.B. degree from Calvin College in Minnesota in 1929, an M.S. degree from the University of Michigan in 1931, and a Ph.D. from the University of Michigan in 1934. At the University of Michigan, he served from 1929 to 1934 as Museum Assistant, from 1934 to 1944 as Assistant Curator of Mollusks, and as Curator of Mollusks from 1944 to 1977. He also held an appointment as Instructor of Zoology at the University of Michigan from 1934 to 1937, and served as Exchange Professor at the University of Puerto Rico from 1940 to 1944. Returning to the University of Michigan, he became Assistant Professor of Zoology in 1944, Associate Professor in 1950, and Professor of Zoology in 1957, a position he held until his retirement in 1977.

Highly respected as an outstanding international authority on mollusks, Professor van der Schalie served on numerous committees and as consultant to government agencies in Egypt, Sudan and Japan. He served as a consultant to the World Health Organization, as well. His work for these organizations centered on the mollusk hosts of human pathogens, such as *Schistosoma*. A well-known authority not only on disease-bearing snails around the world, but on land and freshwater mollusks of Puerto Rico, on the value of mussel distribution in tracing stream confluence, on the biology of land and freshwater mollusks, on medical malacology, on paleoecology, and other subjects as well, Professor van der Schalie published well over 110 manuscripts on his research. More complete details on his professional activities can be found in *American Malacologists* and its sequel, the *Register of American Malacologists* (1986).

In the Bulletin of the American Malacological Union for 1980, Professor van der Schalie provided an illuminating review of "Fifty years of Malacology at the University of Michigan (1929-1975)." Herein he summarized the outstanding features of the "Goodrich Period (1929-1944)", the "van der Schalie Period (1944-1977)" and the "Highlights of the Mollusk Collections" during those years at the Mollusk Division of the Museum of Zoology at the University of Michigan.

At a festschrift organized by his students, for Professor van der Schalie in Ann Arbor in April, 1978, on the occasion of his retirement in 1977, many tributes were presented to "Van" by dozens of his students, colleagues and friends. Of particular poignance was the careful comment offered by one of Van's oldest friends and colleagues, Professor Elmer G. Berry. Several paragraphs from Dr. Berry's unpublished reminiscence on that occasion, follow:

"Henry van der Schalie was born in Amsterdam, January 8, 1907. His father died when Henry was but an infant and his mother, in 1909, emigrated from Holland to Paterson, New Jersey, with Henry and his two older brothers. Circumstances necessitated Mrs. van der Schalie to find employment to provide for herself and the three boys, John, Herman and Henry. She was very gifted in knitting, crocheting and sewing in general and found employment in a cotton factory where, among other items, skirts were manufactured. Most likely, all three boys worked in this plant after school and during the summer months. Henry was assigned to the packing department, particularly the wrapping and tying of cartons of shirts for shipment. Anyone who has observed Henry wrapping and tying a carton can vouch for his adroitness from the experience gained when he was a mere lad.

"Somewhere around 1925 Henry left Paterson for Grand Rapids, Michigan, where he enrolled as a student in Calvin College. Although he majored in Zoology he also completed the premedical requirements because of his indecision regarding his future profession. The head of the Department at Calvin College was Dr. van Heisman, a recognized parasitologist. Henry had been influenced by (Dr. Heisman) and began to concentrate in the field of parasitology. His splendid scholastic record during his undergraduate years merited commendable recommendations from his professors. Although four universities offered him assistantships, he chose the University of Michigan and began his work under Dr. George R. LaRue, an outstanding parasitologist and Chairman of the Department of Zoology.

(After coming to Ann Arbor, Henry accepted an assistantship in the Division of Mollusks in the new Museum of Zoology. With some reluctance, Dr. Berry reports, Dr. La Rue allowed Henry to transfer.)

"Calvin Goodrich was the Curator of Mollusks at that time. He had formerly been the editor of a newspaper in Ohio, but had taken an interest in collecting shells as a hobby. He was acquainted with Dr. Bryant Walker, a highly successful practicing lawyer in Detroit. Walker had made an outstanding reputation as a malacologist and had been appointed Honorary Curator of Mollusks at the Museum of Zoology. Goodrich's association with Dr. Walker brought him in contact with A. G. Ruthven, Director of the University Museums (later President of the University of Michigan) and with F. M. Gaige, Director of the Museum of Zoology. It is reported that Goodrich asked Ruthven if he could have a small corner in the new Museums to "play with his shell collection." He was given a room, but the relationship between him and the fine Curator of Mollusks was not the best, which subsequently resulted in the resignation of Miss Mina Winslow. With this termination, Mr. Goodrich was appointed Curator.

"Goodrich was a highly sensitive individual and unquestionably realized that being appointed Curator of Mollusks at the University of Michigan was a unique position with a (status) equal to that of Harvard or the Philadelphia Academy of Natural Sciences. He was not academically trained as a scientist (and that) caused him to develop an inferiority complex. He had a flair for writing, especially historical or narrative experiences such as a collecting trip, and was a much better editor of his newspaper than a curator of mollusks.

Elmer Berry continues: "Mr. Goodrich replied to my application for an assistantship (at the Museum in 1933) with a frank statement that the Museum's budget had already been trimmed. He advised me that the only job likely to be open would consist of feeding animals and cleaning their quarters. With the severe cut of appropriations, even this job might be eliminated because of lack of funds. (In) his letter written to me on February 2, 1933, he wrote, 'We have been rather fortunate in the students who have worked in this division – H.B. Baker, whose work you are familiar with; W. J. Clench who is now clearing up his long studies of the Physidae; Henry van der Schalie promising to be an authority on the Unionidae; and Alan Archer, who already knows land shells very well and has undertaken to straighten out the Viviparidae of North America. It would be a pleasure to add your name to this small, but excellent, company, and my hope is that it can be brought about.'

"I shall always remember my introduction to Ann Arbor and the Museum of Zoology. It was terribly hot and humid, (July, 1933) but I was impressed with the beautiful rotunda of the Museum's building and the graceful marble stairs leading to the second floor. That morning I met Henry van der Schalie. He was very friendly and about the first thing he asked was where I was staying. When I told him, the Allenel Hotel, he replied, 'You can't afford to stay there very long!' Henry had been raised to be thrifty as well as energetic. Each month a portion of his small salary went to his mother and the remainder paid for clothing, tuition, books, room and board. He learned quickly that my salary of $60 per month would necessitate stringent budgeting because the cost of living in Ann Arbor, even in 1933, was very high. He invited me to have lunch with him, providing I could get along on a peanut butter and jelly sandwich, which I was happy to accept. In order to cut expenses Henry and three other zoologists were sharing a two-room apartment just a half-block east of the Museum Building on North University Street. I don't know what persuasive powers Henry exerted on his three roommates, but by two o'clock on my first day in Ann Arbor, I was invited to become the fifth member of this fraternity. Henry's Dutch ancestry and home-training instilled in him a delight in getting things clean. Each of us had certain duties to perform in the apartment and Henry was assigned to cleaning the kitchen and, on alternate Saturdays, the bathroom. On reciprocal Saturdays the bathroom was to be cleaned by Nap Curtis who lived in the west wing of the 2nd floor. When Henry finished his assignment, the bathroom sparkled with cleanliness. Nap, in contrast, considered it unnecessary to spend much time in cleaning. As soon as Henry discovered (Nap's) perfunctory job, a furor developed and eventually provoked a breach of friendship between the two.

"Henry received his Ph.D. in 1934 and at the beginning of the new fiscal year he was appointed Assistant Curator of Mollusks. The American Malacological Union meetings were scheduled to be held at Stanford University during the summer. Goodrich, who was one of the founders of the Union, gave his endorsement (for Henry to attend, and present a paper on his dissertation). I was invited to drive west with him in his Model A Ford. It was Henry's first trip west so we made plans to see as much as we could in the limited time. We included Yellowstone, the Tetons, Great Salt Lake and planned to do some collecting in the western canyons, Pyramid Lake—a relic lake in Nevada, Lake Tahoe, as well as some side trips in California. We had a delightful trip and met many malacologists for the first time, the Junius Hendersons, the Oldroyds, and saw a few old friends, Stillman Berry, Allyn Smith, Leo Hertlein and others. Best of all Henry and I got to know each other very well and found each other's company very compatible.

"Late in 1935 Henry became an active member of Phi Sigma. He enjoyed the meetings and found the members very congenial. Particularly, he was attracted to a botanist by the name of Annette Rudolphi. Both of them enjoyed ice skating and taking walks through the arboretum. By the spring of 1936 it was obvious to me that this attraction had developed into a serious romance. Walking to the Museum and back again, or while preparing dinner or washing dishes, the major conversation was about his girl friend. By midsummer Henry informed me that I had better find another place to live because they were going to be married and would occupy the apartment we were sharing. The date was set for October 3rd and I was honored in being chosen as his best man at their wedding.

"Goodrich retired in 1944 and Henry was appointed Curator of Mollusks. He inherited a division rich in historical importance, perhaps the finest collection of land and freshwater mollusks in the country, and a top notch library. Unfortunately the yearly budget had been reduced to poverty level. Henry didn't remain discouraged for very long, however, and his frugality, coupled with his exploring abilities that might provide increments to purchase microscopes, microtomes, establishing aquarium rooms, etc., not only restored the budget to its original status, but surpassed it many times. The new addition to the Museums Building was constructed and this allowed the Mollusk Division to expand in scientific areas unique in malacology.

The Division's high status subsequently attracted splendid investigators to receive their advanced training in malacology at the University of Michigan under Henry's direction.

"I well recall two phrases Henry frequently used, particularly when it involved a person with whom he disagreed. He would say, "Well let me tell you, I've got news for him!" This remark would be followed with what he was going to do, and he wasn't fooling! The magnificent achievements accomplished by the Mollusk Division were due to Henry's tremendous effort and unbelievable drive. When deeply disappointed by a granting agency's reply to a grant request which Henry had painstakingly made, and which had looked promising, that stated, 'We regret to inform you. . .' Henry, having given vent to his feelings, would end the discussion with a grin and a shrug of his shoulders, saying, 'Oh well, we're having fun!' "

He *meant* it! An inspiring teacher and fierce advocate for rigorous study and understanding of mollusks, Henry van der Schalie expected a lot from us. He expected us to be rational, careful, committed, *and* to derive joy from our dedication, as he did from his. As one of his last students, I have treasured the great legacy of his intellect and his spirit. I never knew "Van" to be half-hearted about anything. He was emphatic, enthusiastic about whatever he was doing, whether it was digging into a new research project, encouraging a student, pursuing his beloved mollusks in their improbable habitats, or sharing his parenting energies with his incomparable wife and colleague, Annette. He regularly doted on all the accomplishments of his children, each of whom he and Annette always regarded with boundless, affectionate concern and pride.

Van had a strong environmental ethic long before the raised consciousness of the present era. He evinced articulate, righteous indignation whenever he perceived that human error, indifference or greed had resulted in the destruction of a precious habitat, or failed to fund research, or allowed neglect of irreplaceable museum collections. I remember his recounting to me his participation in a panel discussion, along with other biologists and lawyers, on the University of Michigan campus, in the 1970's, on aspects of environmental law. Van related to me his consternation with the attitude evinced by his colleagues, who had caved in to sophistry and had adopted a resigned, expedient demeanor in the discussion. Van expostulated, "My God! When I think of what (natural resources) we have *squandered!*" Van insisted, rightly I think, that better laws to protect the environment could not be made in a society where knowledgeable experts didn't *care*. He believed passionately in the coupling of the fine old values of knowledge and responsibility. Van's capacity for moral outrage was good for us all. It continues to inspire and sustain us as we pursue urgent, sometimes unpopular, environmental causes of our own.

In recent years, a visit to Manchester, Michigan, to see Van and Annette for good mollusk talk, in their palatial spread along the Raisin River, was a revitalizing joy. One ambled with them about their acres, past the huge, burgeoning vegetable gardens Van and Annette and their son, Arnold, were cultivating in delighted competition with each other. One followed them through the verdant, leafy marshland next to the river, where Van would pridefully point out the most recent wonders of Annette's botanical expertise, and then to the Raisin River itself, where, thanks to van der Schalie effort, a number of species of *Lampsilis* still maintain reproducing populations.

On such jaunts I always got a lump in my throat. I knew again that this wonderful man, Henry van der Schalie, lived a life of indefatigable personal integrity. His career spanned almost five decades of vital research at the University of Michigan and around the world. More, to the end, he cared deeply about mollusks as mollusks, about human beings as human beings. In a glowing, over-arching way Van cared about the lovely planet that we share. Such jaunts invariably left me with the poignant reminder that I shall always think of Van as a grand model. I shall always think of Van with admiration and love.

CANTHARUS MULTANGULUS NEW SUBSPECIES *GRANDANUS* FROM NORTHWEST FLORIDA (BUCCINIDAE)

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During the last few years, members of the Gulf Coast Shell Club in Panama City, northwest Florida, have been very active in surveying the marine mollusks of their area. In fact, they have published several checklists and in 1983 issued their illustrated *Seashells of Bay County and the Gulf Coast*. In 1982, Robert Granda, and later other members, collected and sent me an unusual form of *Cantharus* which I now take pleasure in naming after its original discoverer.

Family Buccinidae Rafinesque, 1815
Genus *Cantharus* Röding, 1798
Cantharus multangulus (Philippi, 1848)
new subspecies ***grandanus***

Description—Shell small, up to 28 mm in length, fusiform, light-weight, finely but coarsely sculptured, and with 6 or 7 whorls. Nuclear whorls 1½, smooth, rounded, rapidly descending, translucent tan to clear. First 4 or 5 postnuclear whorls slightly shouldered, with 10 or 11 strong, rounded, axial ribs crossed by about 9 or 10 very small, irregularly-sized, square-topped, spiral threads. On the penultimate and last whorl, which is smoothly rounded, the axial ribs are obsolete. Body whorl and short siphonal canal with about 30 to 40 fine spiral threads of uneven size. Columella with two weak, oblique plicae at the base. Outer lip simple and minutely jagged. Inside of last whorl glossy tan and with about a dozen, smooth spiral threads. Color of outer shell tannish brown, reddish or whitish yellow with numerous fine flecks, occasional narrow spiral bands and sparse axial flames of chocolate-brown. Operculum chitinous, translucent tan, elongate-oval and filling most of the aperture. Soft parts and radulae not examined.

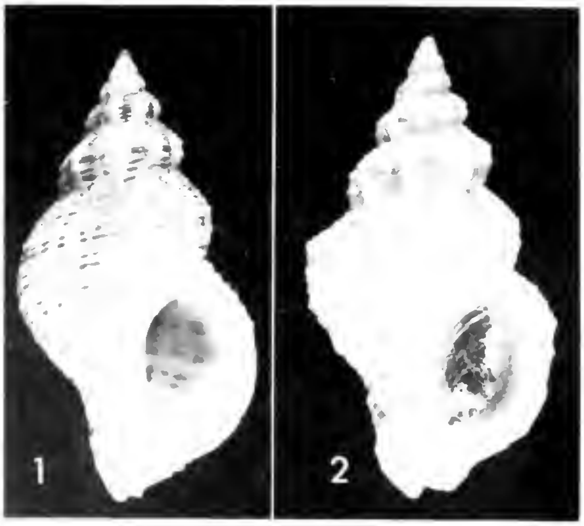

FIG. 1. *Cantharus multangulus* subspecies *grandanus* Abbott, holotype, UNNM no. 859096, 28.7 × 14.4 mm. FIG. 2, *Cantharus multangulus multangulus* (Philippi, 1848) from off Shell Island, Panama City, N.W. Florida, 29.1 × 15.6 mm. Both collected by Robert Granda, 1982.

Type locality—2 to 4 feet of water, on sand and weed bottom, Islet, ¼ mi east of Black Isle, Saint Joseph Bay, off Port St. Joe, Gulf County, northwest Florida. Robert Granda, collector, March 13, 1982.

Types—The holotype is deposited in U. S. National Museum as no. 859096. Paratypes from the type locality have been deposited in the Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, N.Y., the Museum of Comparative Zoology at Harvard, and the Florida State Museum, University of Gainesville, Florida.

Records—This moderately rare subspecies has been collected in several places in St. Joe Bay. Linda Brunner has also collected this subspecies in St. Andrews Bay in nearby Bay County.

Measurements (mm.)—

	length	width
Holotype	28.7	14.4
Paratype	26.8	13.1
Paratype	26.7	14.0
Paratype	24.0	12.1
Paratype	21.1	11.0
Paratype	21.0	11.0

Remarks—The subspecies *grandanus* of the northeast Gulf of Mexico differs from the nominate *Cantharus multangulus* (Philippi,

1848) in having a lighter-weight shell, lacking the strong shoulder nodules on the last two whorls, in having more numerous spiral threads, and in being a little more elongate in proportions. The variations in colors and patterns are very similar. It is possible that these colonies in the "Panhandle" region of Florida represent an ecological, rather than a genetic, form.

Mr. Granda obtained two "clutches" of small, horny egg-capsules which he found on pieces of carapace from the horseshoe crab, *Limulus*. The urn-shaped capsules, about 5 × 8 mm, closely resembled those so well illustrated by D'Asaro in his account of the capsules of *Cantharus multangulus* from the same region (1986, p. 86, figs. A–D). Very similar capsules of the nominate species from Sanibel Island were illustrated by Perry and Schwengel, 1955, pl. 50, fig. 340.

Cantharus cancellarius (Conrad, 1846) from the same region differs in being more ovoid, having a shorter spire and in having much stronger and fewer spiral threads. The similar muricid, *Calotrophon ostrearum* (Conrad, 1846), has stronger shoulder nodes and a mauve to rosy-purple aperture. Fossil *C. multangulus* from the old St. Petersburg pits have fewer axial nodes per whorl. This group of species appears to be largely confined to southeast United States, the Bahamas, the north coast of Cuba and Yucatan, Mexico.

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ON THE TAXONOMICAL STATUS OF *TRITONIUM VIRIDULUM* FABRICIUS, 1780 (GASTROPODA: CANCELLARIIDAE)

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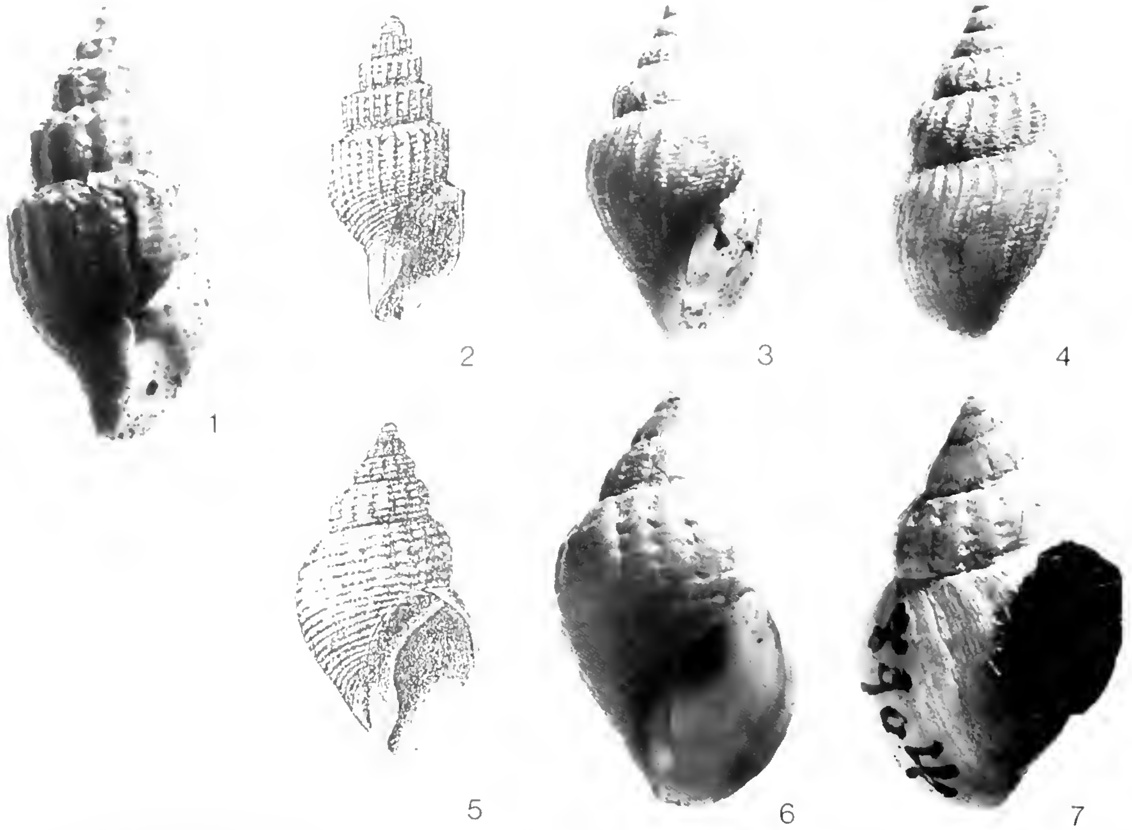
ABSTRACT

The taxonomic and nomenclatorial problems associated with the species Admete viridula *(Fabricius, 1780) are discussed. The fact that the type specimens of both* Admete viridula *and* A. crispa *Möller, 1842 are mising from the Zoological Museum in Copenhagen complicates the situation considerably as three species are involved,* Tritonium viridulum *Fabricius, 1780,* Defrancia viridula *Möller, 1842, and* D. exarata *Möller, 1842. Fabricius's name is to be regarded as a* nomen dubium *and that* Admete couthouyi *(Jay, 1839) should be used as the correct name for that species. Möller's* D. viridula *and* D. exarata *are both good species; but* D. viridula *should probably be named* Oenopota decussata *(Couthouy, 1839) and* D. exarata, Propebela exarata *(Möller, 1842).*

The original description of *Tritonium viridulum*, which was published by Fabricius in 1780 without an illustration, has commonly been regarded as the original description of *Admete viridula auctt.* The description fits the species fairly well, and the taxonomic situation would appear quite simple.

However, Dall (1886: 298) after having examined the holotype in the Zoological Museum in Copenhagen, claimed that the species belonged to the group *Bela auctt.* He also found that *Defrancia viridula* Möller, 1842 (Fig. 1)



FIGS. 1-7. **1.** *Propebela exarata* (Möller, 1842); one of the larger specimens from the syntype-collection of Möller (Zool. mus., Copenhagen). **2.** *Propebela exarata* (Möller) as drawn by G. O. Sars, 1878. **3** and **4.** A specimen of *Oenopota decusata* (Couthouy, 1839) = *Bela viridula*, from the collection of Möller (Zool. mus, Copenhagen). On the label is also written: "*B. viridula* (et var. inflata) = *B. decusata* Couthouy var. ventricosa". **5.** *Admete viridula* uctt. as drawn by G. O. Sars, 1878. **6** *and* **7.** Holotype of *Cancellaria buccinoides* Couthouy, 1838 (Reg. no. 279394 in Mus. Comp. Zool, Cambridge, Mass.). The species is *Admete couthouyi* Jay, 1839.

was founded on the same specimen, and concluded that it was identical with *Defrancia exarata* Möller, 1842 (Fig. 2). Dall writes that Mörch had discovered these facts before him and Posselt (1898: 168) confirms this by referring to a handwritten catalogue by Mörch. Concerning the nomenclatorial situation, Posselt claims that the correct name of *Admete viridula auctt. (Fig. 3)* should be *Admete couthouyi* Jay, 1839, because the older *Cancellaria buccinoides* (Fig. 4) of Couthouy, 1838 was described in another genus.

All three species involved in this problem show a great deal of variability, and Fabricius description fits both Möller's *Defrancia viridula* and *Admete viridula auctt.* as well. Concerning *Defrancia exarata*, Posselt (1898: 168) states that *Admete crispa* Möller 1842, which commonly is regarded as conspecific with *A. viridula auctt.*, resembles *D. exarata* with respect to sculpture.

This situation could have easily been cleared up if the type specimens in question, which were all from Greenland, had been available, but unfortunately the type specimens of both *Tritonium viridulum* and *Admete crispa* appear to have disappeared early in this century (Jörgen Knudsen, pers. commn.). Only one sample in the collection of the Zoological Museum in Copenhagen could possibly be Fabricius type, but this sample contains three specimens whereas the original description states that Fabricius had only one specimen available. In the Zoological Museum in Copenhagen there are type lots of both Möllers species *Defrancia exarata* (Fig. 2) and *D. viridula* (Fig. 1). The type lots of the last species contains seven syntypes and thereby shows that Möller did not base his description on Fabricius specimen.

None of Möllers type specimen fits very well with Fabricius description. However, Knipowitsch (1901) illustrates a specimen of *D. exarata* from Svalbard which rather closely resembles *Admete viridula auctt.* Considering this, and that the form called *Admete crispa* has a sculpture like that of *D. exarata*, we assume that some morphological overlap between the species is present. Although fitting the common forms of *Admete viridula auctt.* better than those of Möller's *Defrancia exarata*, Fabricius description covers the overlapping forms, with the exception that we never have observed *D. exarata* without prominent ribs on the last whorl as mentioned in the description. However, considering the large intraspecific variation within most species in this group it is no wonder that Dall (1886) reduced them to synonomy.

Möller's sample of *Defrancia viridula* fits Fabricius description fairly well except that the ribs, which are said to be straight ("costae longitudinales") in Fabricius description, are somewhat curved. As Möller's *Defrancia viridula*, which probably is conspecific with *Pleurotoma decussata* Couthouy, 1839, has a large intraspecific variation like all species in this group, Fabricius description fits both species fairly well, and one cannot apply it to one rather than the other.

Concerning Mörch's earlier opinions as first published by Dall (1886), there is a sample in the Zoological Museum, University of Bergen (no. 28208) which should be mentioned. This contains two dry specimens of Möller's *viridula* from Greenland which are identified to "*Bela viridula* M. Sars" by Mörch. Michael Sars never described any species with this name, but the sample could indicate that Mörch had Möller's species in mind when he claimed to have discovered that this and Fabricius species was founded on the same specimen. However, this is in contradiction to the presence of the seven syntypes of *Defrancia viridula* Möller in the Zoological Museum of Copenhagen.

Some additional information about the problems within the genus *Admete* may be found in Troschel's (1866–1893) work on gastropod radulae. Troschel investigated preserved material of both *Defrancia viridula* and the genus *Admete* in the Zoological Museum in Copenhagen with respect to radular teeth. He found the radulae in *D. viridula* were like those of other species within *Bela auctt.*, while in *Admete* he found two kinds of teeth. He also found two shell forms which he called *Admete viridula* (Fabricius) and *A. crispa* Möller according to figures in Middendorff's (1849) work on Russian mollusks. The shell forms corresponded with the radular forms, which may indicate that Troschel was correct in dividing the traditional *Admete viridula* into two species.

The nomenclatorial consequences of these taxonomic circumstances may now be summarized. Möller's *Defrancia exarata* presents no problems, and in our opinion it is best placed within *Propebela* Iredale, 1918. Fabricius *Tritionium viridulum* seems difficult to identify with any species, and in our opinion it should, since the holotype is lost, be regarded as a *nomen dubium*. One could use the existence of the sample identified by Mörch to attach the name to Möller's *viridula*, having also the facts presented by Dall in mind. However, since both Mörch and Dall seems to have considered that Fabricius original specimen belonged to *Propebela exarata* (Möller, 1842), this argument seems somewhat dubious. The fact that Möller founded his *Defrancia viridula* on a sample of seven syntypes still present in the Zoological Museum in Copenhagen also contradicts the view of Mörch and Dall. In our opinion, Möller's *Defrancia viridula* is best placed in *Oenopota* Mörch, 1852, probably as a synonym of *Oenopota decussata* (Couthouy, 1839).

Concerning *Admete viridula auctt.*, the oldest name for this species is *Cancellaria buccinoides* Couthouy, 1838. This name is, however, a primary homonym of *Cancellaria buccinoides* W. Wood, 1828 and has to be rejected as there are no strong reasons why it should be referred to the International Commission on Zoological Nomenclature for eventual preservation. The next available name is *Admete couthouyi* Jay, 1839, which meets all demands as a correct name for the species. The type of this is also Couthouy's type of *buccinoides* since Jay's name was proposed as a *nomen novum*. An eventual separation of Möllers *Admete crispa* from *A.*

couthouyi as proposed by Troschel (1866–1893) will not be discussed in detail, but as the type specimen of *A. crispa* is lost either a neotype should be selected or a new name should be proposed and Möller's name, *A. crispa*, regarded as a *nomen dubium*. As Möller never described the radula of his species the second possibility is probably the best.

Mr. Georg Crawford kindly corrected our English text.

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PISIDIUM HENSLOWANUM (SHEPPARD) IN THE CONNECTICUT RIVER, MASSACHUSETTS (BIVALVIA: PISIDIIDAE)

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ABSTRACT

The pisidiid clam Pisidium henslowanum *has been considered by several authors as an introduced species in North America despite its discovery in several parts of North America well away from industrial centers. The species has been recently found in the Connecticut River in Massachusetts which is the southeastern most record yet in North America. It is suggested that this species is native but locally distributed. The Connecticut River record seems also to represent the softest water in which the species has been reported in North America.*

Since its first discovery in North America by Sterki (1899), the pisidiid clam, *Pisidium henslowanum* (Sheppard, 1825), was known on the continent from only a small number of sites mostly clustered in the Great Lakes and St. Lawrence River drainages (Heard, 1961, 1962; Herrington, 1962). The species is well known in the palearctic region (Woodward, 1913; Zhadin, 1957; Ellis, 1978). Herrington (1962, 1965) and Heard (1962) determined that *P. henslowanum* was introduced into North America. Subsequent to Herrington's (1962) and La Rocque's (1967) reviews of the North American distribution of *P. henslowanum*, the species was reported from a number of localities in central and western Canada by Harris (1973), who also documented the occurrence of *P. henslowanum* in 7000 year old deposits. Harris (1973) used this information to question Herrington's (1962) and Heard's (1962) conclusions that the species was not native to North America. Harris (1973) also cited Herrington's (1962) listing of a much earlier fossil date (Pliocene-Pleistocene) for *P. supinum*, then considered by Herrington a synonym of *P. henslowanum*. However, subsequent study led Herrington (1965) to accept *P. supinum* as a distinct species, thus weakening Harris' (1973) argument. Nonetheless, Harris' (1973) data compelled a reassessment of the introduced status of *P. henslowanum*, yet subsequent studies (Burch, 1975; Clarke, 1981; Mackie, 1981) continued to follow Herrington (1962, 1965) and Heard (1962).

During the summer of 1985, *P. henslowanum* was collected in the Connecticut River at two locations in Hampden County, Massachusetts. The first collection was made in the Holyoke industrial canal complex (in direct communication with the river) in Holyoke and the second in the river in Longmeadow. The Holyoke collections were first made on 1 July and repeated on 27 October. Prior to each collection the canals had been drained for routine maintenance. A total of 98 specimens were collected, of which a series of shells have been deposited into the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ). The remaining alcohol preserved material has been placed into the Museum of Zoology, University of Massachusetts at Amherst. The Longmeadow collection was made on 16 September and comprised a single adult specimen. Previous to these collections the only New England records for *P. henslowanum* were Lake Champlain in Vermont (St. Lawrence River system) and Aroostook County, Maine (Johnson, 1915). Although the Vermont record is generally accepted in subsequent literature, the Maine record has not been repeated. The Maine record was listed by Lermond (1909) as well and was credited to Nylander as collector and Sterki (presumably) as the authority. A search of the pisidiid collections at the MCZ revealed no specimens of *P. henslowanum* from either locality.

The Connecticut River is clearly outside the Great Lakes and St. Lawrence River drainages and the populations in the Connecticut River could not have been established by recent migration. Additionally, the section of the Connecticut River in Massachusetts is well above the commercially navigable portion of the river and it seems unlikely that the population in the Holyoke canals has been artificially founded by "stowaways" from Europe. As argued by Harris (1973), this species may not be introduced in North America. It might, however, be native but very localized and thereby easily overlooked. The Holyoke canal collections were made in mud and silt sediments normally under 4.5 m of water. The single Longmeadow specimen was collected in .5 m of water. The species is common in the Holyoke canals, particularly along the base of the retaining walls, and is associated with the pisidiid species *Musculium securis* and *Sphaerium striatinum* and juveniles of the unionid mussels *Elliptio complanata* and *Anodonta implicata*. Chemical data for the canals (Anon., 1978, 1980) includes the following parameters (during July, August and September): pH = 7.0–7.7, total alkalinity = 25–35 mg/l (CaCO3), dissolved oxygen = 5.2–10.4 mg/l, nitrate = 0.0–0.5 mg/l, chloride = 7–35 mg/l. The chloride values in part represent runoff of residues of municipal operations. Chlorides in the Longmeadow portion of the river average about 10 mg/l (Anon., 1978). These values compare well with data given by Harris (1973) and Okland and Kuiper (1980) except for the alkalinity values. In Europe, Ellis (1978) has indicated that *P. henslowanum* prefers calcium rich waters and Harris (1973) concludes that the presence of dissolved salts are an important characteristic of this species' habitat. Overall, the water of the Connecticut River is relatively soft and has average levels of chloride salts (Wetzel, 1975). Thus *P. henslowanum* can apparently exist in somewhat soft water.

Specimens collected on 1 July were for the most part larviparous (11 of 13 specimens or 84% of the sample), and the 16 September specimen from Longmeadow was larviparous also. Of the 27 October sample, however, only 2% (2 of 85) were larviparous though many contained egg masses in the gills. These seasonal data compare well with Holopainen and Jonasson's (1983) findings for the presence of brooded larvae in Danish populations.

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PRELIMINARY OBSERVATIONS OF PREDATION ON OCEAN QUAHAUGS, *ARCTICA ISLANDICA*, BY ATLANTIC WOLFFISH, *ANARHICHAS LUPUS*

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ABSTRACT

Populations of the ocean quahaug, Arctica islandica, *may be susceptable to intensive grazing pressure by the Atlantic wolffish,* Anarhichas lupus. *In stomach analysis of four wolffish from an inshore Nova Scotia area, 85–99% of the wet weight contents were* Arctica islandica. *The number of quahaugs in the stomach contents ranged from 3–11. These individuals were 35–86 mm in shell length and were 4–60 years old.*

The ocean quahaug (or quahog), *Arctica islandica* (Linnaeus, 1767), is an underexploited commercial mollusk found in coastal waters of the south shore of Nova Scotia, Canada, and on the Scotian Shelf (Rowell and Chaisson, 1983). These bivalves are slow growing (Murawski *et* *al*, 1982) reaching a minimum market size of about 51 mm (2 inches) in 13 years, and long-lived (225 years, Ropes and Murawaski, 1983). Since they are commercially important in the northeast of the United States (Murawski *et al.*, 1982) and are of potential commercial importance in the south shore area of Nova Scotia it is important for the fishery biologist and manager to assess the impact of natural predation on stocks in relation to stock assessment and potential yields. Quantative data on the diet of the common Atlantic wolffish is sparce as are data on natural predation of ocean quahaugs. Early works (Verrill 1871, Gill 1911 and others) are primarily qualitative but indicate that shellfish play an important role in wolffish nutrition. Bowman et al. (1976) provide more quantitative data. They examined the stomach contents of 127 wolffish from offshore waters of western Nova Scotia. Approximately 42% of all stomachs were empty, but the remainder on average contained about 28% (by wet weight) bivalves. However, no further taxonomic breakdown was made. Although there is evidence of offshore predation of *Arctica islandica* by cod (*Gadus morhua*) (Arntz 1974, 1978) there is a lack of both qualitative and quantitative data relating to predator induced natural mortality of *Arctica islandica* in coastal waters. From our investigation in the coastal waters of Nova Scotia, Canada, qualitative and quantitative data make the common Atlantic wolffish, *Anarhichas lupus*, a prime suspect as an important predator of *Arctica islandica*.

During the first of a three year study begun in 1982 to study maturation of *Arctica islandica* at Port Mouton, Nova Scotia (64 51′N, 43 56′W) one of us (RBA) noted the arrival of wolffish to the study site in the spring and their departure in late summer. The time of this annual migration corresponded to wolffish bycatches in net and traps reported by local fishermen operating in other areas near our study site. The fishermen also noted that the wolffish guts were full of shell material. This information prompted us to catch wolffish at our study site to determine whether or not they were feeding on quahaugs and, if so, their impact on known quahaug stocks.

The study site, about 4000 m² of flat sandy bottom, had been surveyed 30 times with SCUBA prior to sampling for wolffish. The area was found to be generally void of any macro-epibenthos commonly eaten by wolffish, i.e. crabs, gastropods, and sea urchins (Bigelow and Schroeder, 1953). Wolffish inhabiting this area were collected by a diver who speared the fish and returned to the support craft where fresh weight (+/− 0.1 kg) overall length (+/− 0.5 cm) and sex were recorded. Whole intact stomachs were then removed and fixed in 10% formalin in seawater.

In the laboratory the total weight of the stomach contents (excluding liquids) was first determined. Subsequently, stomach contents were sorted and recognizable materials were pooled prior to weighing (+/− 0.1 g wet weight). The number and size of quahaugs eaten by wolffish was then determined. Recognizable umbo portions of valves were separated from stomach contents through careful examination of shell fragments. The number of paired umbones was considered representative of the number of quahaugs eaten. The original size of the live quahaugs eaten was determined by matching the fragmented umbo pieces with other valve fragments to assemble whole or partial valves. Size was attained by superimposing on the whole intact valves of a known size. Success in assembling the valves contributed to confidence in determining the numbers and sizes of the quahaugs consumed. From previous research on the biology of *Arctica islandica* by Rowell and Chaisson (1983), relationships were developed for animal size (overall length in cm) to age and whole fresh weight to equivalent meat weight. Estimates of the total fresh weight as well as equivalent meat weight consumed by each fish was then determined from the number and size composition of quahaugs in gut contents.

The general, solitary, non-schooling nature of wolffish (Bigelow and Schroeder, 1953) is supported by our findings that few wolffish were caught at our study site. We encountered wolffish in only four of twelve SCUBA surveys over three months of study (June 1983; May, July 1984). In addition, we noted that once a wolffish was removed another occupied the former residence position by our return. This may indicate that wolffish occupy and possibly defend large territories which may exceed the 4000 m² area of our study site.

Only five wolffish were caught for stomach content analysis (Table 1). The largest individual measured 101.6 cm in overall length and weighed 12.0 kg, the smallest was 72.6 cm and 4.4 kg wet weight. Four fish contained easily identifiable quahaug shells (*Arctica islandica*), comprising 85–99% of the total gut content wet weight (Table 1). The remaining foods (1–15%) were trace amounts of periwinkles (*Littorina* sp.) sea urchins (*Stronglyocentrotus droebachiensis*) and unidentifiable crustacean exoskeleton. The fifth fish was packed, to a point where the stomach was distended, with finely crushed tests of the sanddollar *Echinarchinus parma*.

After assembling shell fragments for qualitative analysis, we found from 3–11 quahaugs in the gut contents of a single fish (Table 1). The size of ingested quahaugs ranged from 35–86 mm in shell length, representing quahaugs approximately 4–60 years old. Qualitative estimates of total fresh weights of quahaugs ingested per fish ranged from 255.5–737.7 g; meat weights were from 81.1–155.3 g, respectively. Meat weights expressed as a percentage of total fish weight (Table 1) indicated that only 0.7–2.2% of fish live weight is a food ration in the form of quahaug meat.

It is realized that the sample size is small, but the fact that ocean quahaugs comprised over 85% (by wet weight) of the diet of these wolffish is of interest. This is supported by the insignificant amounts of macro-invertebrate fauna in the stomaches of fish with quahaugs. In contrast, the sanddollar (*E. parma*) constituted 100% of the diet of one fish. This finding supported our reconnaissance of the study site which revealed a general lack of macro-epibenthos. These results further suggest a possible selection preference for quahaugs by wolffish, although other items of marginal food value are also eaten. The slow growth of *Arctica islandica* (Murawaski et al. 1982) makes it available to wolffish for 50–60 years after the clam settles on the bottom. This is a long period of potential exposure to predation by wolffish, but the duration of the life span infers low natural mortality. This in part reflects low levels of wolffish abundance, their ability to locate and capture prey as well as the clams ability to avoid

TABLE 1. Summary of stomach content analysis for five Wolffish, *Anarchicas lupus*, at Port Mouton, Nova Scotia, Canada.

	D. Mo. Yr.	Fish length (cm)	Total weight (kg)	Sex	Stomach Content (Wet. wt.) (g)	Quahaug Shell (Wet. wt.) (g)	Percent of stomach Contents (%)	Number of Quahaugs in Stomach	Quahaug Size, range (mm)	Quahaug Age,range (y)	Quahuag wet wt. (g)	Quahaug meat wet wt. (g)	Quahaug Meat wt. as % of Fish wt. %
1	02 06 83	81.3	5.0	female	97.8	83.3	85	9	47-80	10-48	513.9	110.3	2.2
2	16 06 83	N/A	N/A	N/A	204.9	174.9	85	6	47-86	10-60	735.7	155.3	N/A
3	17 05 84	76.2	4.4	male	91.1	90.4	99	11	35-62	4-22	255.6	81.1	1.8
4	03 07 84	101.6	12.0	male	257.9	236.8	92	3	68-86	30-60	413.6	87.4	0.7
5	03 07 84	N/A	N/A	N/A	233.5	*	0	0	0	0	0	0	0

* - Stomach full of test fragments of the sand dollar E.parma

[1] - based on the size composition of quahaugs eaten and relationship established by Rowell and Chaisson (1983) on animal size versus wet weight and meat weight.

predation.

Under the assumption that a minimum daily ration of only 5% body fresh weight is required for maintenance (pers. comm. J. Castell, DFO, Halifax, N.S.) the consumption of quahaugs by wolffish in this study was considerably lower than this minimum value and ranged from 0.7 to 2.2% (Table 1). This is probably a reflection of low availability of ocean quahaugs in the study area. Rowell and Chaisson (1983) estimated that the mean density of ocean quahaugs in the immediate study area was 3.8 m^2. Over a much larger area of commercial potential in the same region (12 km^2) they estimated a mean density of 5.4 m^2. In the study area, the results indicated that wolffish probably prey on quahaugs equal to the number in one m^2, each day. Consequently, even in low abundance wolffish may exert considerable impact on the commercial densities of quahaugs. It's impact on quahaug beds in areas suitable for commercial exploitation may be higher but more research is needed to support such a hypothesis.

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FRESHWATER MOLLUSKS OF THE DOMINICAN REPUBLIC[1]

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ABSTRACT

A survey of the freshwater mollusks of the Dominican Republic revealed the presence of 27 species, 24 of them gastropods and 3 bivalves. There were 10 species of the family Planorbidae and of these 4 were species of Biomphalaria, *namely,* B. glabrata, *the intermediate host of* Schistosoma mansoni, B. havanensis, B. helophila, *and* B. straminea. *The role of the latter 3 species in transmission of schistosomiasis in the country is under investigation. Other families found were Lymnaeidae, Physidae, Ampullariidae and Thiaridae with 2 species each, and Ancylidae, Hydrobiidae and Pleuroceridae with 1 species each. There were 3 species of the Neritidae.*

There have been only a few reports on the freshwater mollusks of the Dominican Republic. Probably the first was by Crosse (1891), who listed the land and freshwater snails of the island of Santo Domingo (Hispaniola), but the nomenclature he used naturally does not agree with that used today. Other writers have reported the occurrence of the snail *Biomphalaria glabrata* (Say, 1818) in either a few or several habitats (Ponce Pinedo, 1947; Olivier et al., 1952; Etges and Maldonado, 1969; Schneider et al., 1985), and still others have listed a few freshwater mollusks associated with *B. glabrata* (Gomez, 1973; Vargas and Gomez, 1976; Schneider et al., 1985). The lymnaeid intermediate hosts of *Fasciola hepatica* were reported upon by some workers (Alvarez and Cordeiro, 1977; Gomez et al., 1986).

In this paper we include the results of surveys for the freshwater mollusks of the country carried out for the last five years by the Institute of Research in Bilharzia of the Autonomous University of Santo Domingo and by the junior author.

Materials and Methods

Hydrographic maps were consulted to locate freshwater bodies and detailed sectional regional maps were prepared to locate the various habitats. Identification of the specimens was based on information from the Pan American Health Organization (PAHO) Guide (1968), Malek (1985), and various literature on mollusks from the Great and Lesser Antilles.

Included in the information obtained for each body of water was the associated fauna and flora as well as the rainfall cycle and other physical and chemical factors influencing the mollusks; these data will be reported in a separate paper.

Results

Twenty-four species of freshwater gastropods were collected during this survey; these belonged to nine families (Table 1). Three species of bivalves were also found. Among the gastropod families there were 10 species of Planorbidae, of which *Biomphalaria helophila* (Orbigny, 1835) was the most common (31 habitats), *B. glabrata*, intermediate host of *Schistosoma mansoni* (26 habitats), followed by *B. havanensis* (Pfeiffer, 1839) (15 habitats), and *B. straminea* (Dunker, 1848) (1 habitat). *B. helophila* and *B. havanensis* are potential hosts for *S. mansoni*, and *B. straminea* is a known transmitter of this schistosome in South America.

Other families encountered were Lymnaeidae, Physidae, Ampullariidae and Thiaridae with 2

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[1] Contribution from the Instituto de Investigaciones en Bilharzia, U.A.S.D. Dominican Republic and the World Health Organization Collaborating Center for Applied Medical Malacology, Tulane University.

TABLE 1. Families and species of gastropods and their locations in the Dominican Republic.

Planorbidae
Biomphalaria glabrata
  Hato Mayor; Santo Domingo; La Vega; San Cristobal; Bayaguana; Haina; El Seibo; Sabana de la Mar; Guerra; San Jose de los Llanos; San Pedro de Macoris; San Fco de Macoris; Arenoso; Higuey; Miches; Nisibon; Constanza; Jarabacoa; Cotui; San Rafael del Yuma; La Romana; Ramon Santana; Santiago; Quisqueya; Nagua; El Valle.
B. havanensis
  Santo Domingo; Haina; Bani; Palenque; S. J. de la Maguana; Las Matas de Farfan; La Romana; Villa Vasquez; S. P. de Macoris; La Vega; Valverde; Puerto Plata; Esperanza; Navarrete; Villa Gonzalez.
B. helophila
  Santo Domingo; Haina; Valverde; Las Matas de Farfan; S. J. de Maguana; Barahona; Cabral; Las Marias; Neyba; Batey 4 and 5; Guerra; La Vega; Sabana Rey; Seibo; Hato Mayor; LA, Yabiquin River; LA. Yugery River; LA, Yonu River; Miches; Sta. Lucia Stream, Seibo; Lebron Stream, Seibo; Pana Pana River; S.F.M., Juda River; S.F.M. El Gran Estero; S.F.M. Arenoso; Bhona, Los Patos; Bhona, Quarantitre River; La Vega, Juma River; Ducantamiento River; Neyba; La Cabirma, Neyba.
B. straminea
  Los Llanos, SPM.
Helisoma trivolvis
  Valverde Mao (canals in rice fields).
H. foveale
  Santo Domingo, Distrito Nacional; concrete-lined fountains, Centro de los Heroes; concrete-lined fountains, Natural History Museum; Cabral Pond, Barahona.
Drepanotrema lucidum
  Haina; S. J. Maguana; Cabral; Villa Vazquez; La Vega; Puerto Plata; Mao; San Raf. del Yuma; Guerra; S.F.M., Casa de Altos; S.F.M., La Estancia; S.F.M, El Aguacate; S.F.M., Arenoso.
D. cimex
  Constanza; Haina; Cabon Pond, Haina; La Vega, El Ranchito; La Vega, La Cabulla; La Vega, Sabana Rey; Valverde, Guayacanes; Mao; Yerba de Guinea, Mao; Puerto Plata; Villa Vazquez; Las Lagunas, Santiago; Moca; Guerra, D.N.; S.F.M., Arenoso; D.N., Botanical Gardens.
D. anatinum
  D.N., Botanical Gardens; Haina; Km. 9 Aut, Duarte D.N.; Villa Mella; Mao; S.J. de la Maguana; Cabral; Villa Vazquez; Cabon Pond, Haina; Ranchito, L.V.; Tabagua; Puerto Plata; Dajabon; Moca; San R. del Yuma; Guerra; Nisao; S.F.M., casa de Alto; San Fco. de Macoris; S.F.M. Arenoso; S.F.M., El Gran Estero; Bonao; San Pedro de Macoris.
D. aeruginosum
  La Vega, El Ranchito.
Physidae
Physa cubensis
  Constanza; La Vega, Gima; La Vega, Sabana Rey; Guayacanes, Mao; Tabagua; Cerro Gordo, Mao; Los Pinos, Mao; Haina.
P. marmorata
  D.N., Botanical Gardens; Haina; Hda. La Estrella; Bani; Sabana Grande de Palenque; Guayacanes, Mao; Las Matas de Farfan; Neyba, Batey 4 and 5; Biran Stream, Barahona; Azua; Pedregal, Bani; Jarabacoa; Guayubin; Villa Vazquez; La Vega; Mao; Tabagua; Puerto Plata; Moca River; Juan Lopito, Moca; Hato Mayor; Martin Avila, LA; Anguilla River, El Seibo; Yonu River, LA; Miches; Santa Lucia Stream; El Seibo; Lebron Stream, Seibo; Guerra; Don Gregorio Pond, Nisao; Nisao; San Fco. Macoris, Casa de Alto; SFM, La Estancia; SFM, El Aguacate; SFM, Arenoso; Juma; Bonao.
Lymnaeidae
Fossaria cubensis
  D.N., Botanical Gardens; Constanza; Haina; KM. 9 Duarte Highway, D.N.; Sabana Grande de Palenque; Valverde; Santiago; San J. de la Maguana; Barahona; Las Matas de Farfan; Azua; Bani; Jarabacoa; La Vega; Esperanza, Mao; Villa Vazquez; Hato Mayor; Miches; Seibo; San Fco de Macoris; Bonao.
Pseudosuccinea columella
  Quita Sueno Pond, Haina; D.N., Botanical Gardens.
Ancylidae
Ferrissia irrorata
  Mao River, Mao; D.N., Botanical Gardens; Cabral; Seibo; San Cristobal; San Juan de la Maguana.
Thiaridae
Thiara granifera and *T. tuberculata*
  D.N., Botanical Gardens; La Vega; Santiago; San J. de La Maguana; Paraiso, Bhona; Cabral; Descubierta; Las Barias; Jimani; Neyba; Pedernales; Haina; Bani; Azua; Jarabacoa; Guayubin; Villa Vasquez; Sabana de la Mar; Miches; Nisibon; Seibo; Higuey; La Vega; San Pedro de Macoris; San Fco. de Macoris; Guerra; Hato Mayor; Moca; Dajabon; Ramon Santana; Puerto Plata; Nagua; Castillo; Mao; Samana; Sanchez; Bayaguana; Nigua.
Ampullariidae
Marisa cornuarietis
  D.N., Botanical Gardens; Guerra; Bayaguana; San Pedro de Macoris; La Vega; Jarabacoa; Nigua; Hato Mayor; Nisibon; Valverde; Nagua.
Ampullaria glauca
  Los Llanos; D.N., Botanical Gardens; Hato Mayor.
Hydrobiidae
Pyrgophorus parvulus
  D.N., Botanical Gardens.
Pleuroceridae
Goniobasis sp.
  Nigua; D.N., Botanical Gardens; Nisibon.
Neritidae
Neritina sp.; *N. punctulata; N. virginea*
  Puerto Plata; Haina; Santo Domingo; Nisibon.

species each, and Ancylidae, Hydrobiidae, and Pleuroceridae with 1 species each. Three species belonging to the Neritidae were encountered, and 3 species of bivalves: *Pisidium punctiforum*, *Eupera cubensis*, and *Anodonta* sp. The first 2 species are sphaeriids, family Sphaeriidae, and the third belongs to the family Unionidae.

More than one mollusk shared the habitat with at least one other mollusk. *Thiara* spp., however, did not occur together with *B. glabrata*, but *Marisa cornuarietis* (Linnaeus, 1758) did inhabit the same waterbody as *B. glabrata*. The flora and fauna in each habitat did not limit the distribution of mollusks. On the other hand, aquatic vegetation favored the occurrence of most of the species. However, *Thiara* spp. always favored habitats with little or no vegetation.

Discussion

Until 1972 *B. glabrata* occurred in a total of 11 habitats in the country (Vargas and Gomez, 1976), whereas we found it in 26 habitats in the present survey, indicating an apparent continuing dissemination. In addition to natural factors which favor spreading, the movement and introduction of ornamental plants in parks and other locations have apparently contributed to the dispersal of this medically important species. *B. havanensis* and *B. helophila* also show wide distribution, possibly because of their ability to adapt to habitats in the dry region of the country. *B. glabrata* has not yet invaded areas in the south. *B. havanensis* and *B. helophila* are potential hosts of *S. mansoni*, and specimens of *B. havanensis* from Haiti have been infected experimentally (Michelson, 1976). Specimens of *B. helophila* from Puerto Rico have also been infected experimentally (Richards, 1961, 1963).

While this paper was in preparation a study by Sodeman *et al.* (1985) was published in which they collected 6 specimens only of *B. straminea* in the river Iguamo. We have had the opportunity to collect close to 1000 specimens of *B. straminea* from Los Llanos, a different locality but in the same general area of San Pedro de Macoris. Our specimens showed the characteristic features of this species (PAHO, 1968; Malek, 1985), that is, those of the shell, of the penial complex, and corrugations on the vaginal surface, but these corrugations were not distinct in all specimens dissected. The previous known geographical range of *B. straminea* was Martinique, Costa Rica, and South America (Brazil, Venezuela, Guiana). We are at present testing the susceptibility of our Dominican specimens to infection with *S. mansoni*.

It seems that *Helisoma trivolvis* (Say, 1817) was introduced and became established in the northeast section of the country, and now occurs in large numbers. However, *Helisoma foveale* (Menke, 1830) is mainly encountered in small artificial habitats, such as small pools and fountains, indicating its possible introduction with tropical ornamental fish. *B. glabrata* now does not occur in the northeast, and competition may have occurred between *Helisoma trivolvis* and *B. glabrata*, as was demonstrated in the laboratory (Malek and Malek, 1978).

There were 4 species of the genus *Drepanotrema;* the first was *D. lucidum* (Pfeiffer, 1839) and we believe that it is not *D. hoffmani* F. C. Baker, 1940. This is because, first, our specimens were never more than 7.5 mm in diameter, and second, it seems that *D. hoffmani* was described by F. C. Baker based on large specimens of *D. lucidum*.

The lymnaeid *Fossaria cubensis* (Pfeiffer, 1939) has been known to occur on the island since the time of Crosse, and is a transmitter of the liver fluke, *Fasciola hepatica*. Another lymnaeid, *Pseudosuccinea columella* (Say, 1817), was recently reported to occur in the Dominican Republic (Gomez et al., 1986). This latter species is an experimental host for *F. hepatica* in Puerto Rico (Leon-Dancel, 1970), and is a natural host in Brazil (Ueta, 1980).

Thiara granifera (Lamarck, 1822) and *T. tuberculata* (Müller, 1774) have in recent years been introduced into the Dominican Republic as well as other Caribbean islands. Their populations share the same habitats and they can be confused morphologically, and thus are often reported in the Caribbean literature as one species, *T. granifera*. We have examined specimens from Puerto Rico, Guadeloupe, and Martinique and they all represent mixed populations but predominantly *T. tuberculata*. The junior author expressed these views in a short note (McCullough and Malek, 1984). In a recent publication (Starmuhlner, 1985), *Thiara tuberculata* was reported from Guadeloupe, Dominica and Martinique. Starmuhlner made an error in two of his figures; plate 8, Figures 6, 8 and 9 are *T. tuberculata*, but Figure 7 and especially Figure 10 are *T. granifera*. The two species can be differentiated as follows: in *T. granifera* the shell is characterized by distinct and raised axial ribs reticulating with spiral threads. Whorls of the spire are rather flat-sided; body whorl is wide and its height is more than half of total height of shell. In *T. tuberculata* the shell usually has low axial ribs and distinct and raised spiral cords especially on body whorl; sometimes whorls are nearly smooth with only incised spiral threads. Whorls are evenly rounded; body whorl is less in width than in *T. granifera* and its height is less than half of shell height; the shell is more slender than that of *T. granifera*, and is uniformly turreted. The position of the brood pouch is similar in both species, as well as the mantle edge bearing finger-shaped fringes in both. Alvarez and Mena Sanchez (1973) reported that *T. granifera* had been introduced into the eastern part of the Dominican Republic and at present it has spread to other parts of the country (Vargas et al., 1982). There may now be biological control of *B. glabrata* by competition with *T. tuberculata* and *T. granifera*. Some habitats previously occupied by *B. glabrata* now harbor only the two melaniid species. According to Ferguson (1978), *T. granifera* competes successfully with *B. glabrata* in Puerto Rico. In St. Lucia, four field trials demonstrated that *B. glabrata* was eliminated from marshes and streams 6–22 months after the introduction of *T. granifera* (Prentice, 1983).

Marisa cornuarietis, an operculate ampullariid, was introduced into the Dominican Republic by the personnel of the Health Department in charge of the control of schistosomiasis as a competitor of *B. glabrata*, because of the encouraging result in nearby Puerto Rico (see review by Ferguson, 1978). In our experience the two snails now occur together in some habitats in the Dominican Republic, and if *M. cornuarietis* did succeed in biological control in Puerto Rico this has taken place only in certain situations, for example, small ponds and reservoirs.

The bivalves of the Dominican Republic have not received much attention. *Anodonta* sp. (family Unionidae) was recently introduced into the country and is now present in the fish (*Tilapia* and carp) ponds of the Ministry of Agriculture in Nigua, close to the capital, Santo Domingo.

The main species of freshwater mollusks of the Dominican Republic are also present on certain other Antillean islands. In Haiti, which shares the island of Hispaniola with the Dominican Republic, Robart et al. (1976) reported 16 species; in Puerto Rico, van der Schalie (1948) reported 14 species; In Guadeloupe, Pointier (1974) listed 21 species, and in Martinique, Guyard and Pointier (1979) listed 19 species. In this paper we report 27 species to be present in the Dominican Republic, but some of these are of recent introduction.

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A PREHISTORIC ABORIGINAL FRESHWATER MUSSEL ASSEMBLAGE FROM THE DUCK RIVER IN MIDDLE TENNESSEE

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ABSTRACT

A total of 761 valves of freshwater mussels, representing a minimum of 28 species, was identified from a prehistoric aboriginal cave site located along the Duck River, Maury County, Tennessee. Two thirds of the mussels are Cumberlandian forms and, as a group and based on known habitat requirements, suggest that this stretch of the Duck River for some period between ca. 7,000 and 1,000 BP was more shallow than at present with numerous riffles and swift current. Recovery of numerous specimens of Pegias fabula *from aboriginal sites located along a ca. 150 km stretch of the Duck River reflects an extensive prehistoric population of this mussel in Middle Tennessee. This prehistoric assemblage is discussed in relation to Duck River mussel faunas reported over the last 60 years.*

Several small rockshelters situated in the Duck River bluffs were tested for aboriginal occupation during archaeological survey work in 1978 in the proposed Tennessee Valley Authority Columbia Reservoir area. One of these, Cheek Bend Cave (40MU261), is located approximately 13 km ESE of the city of Columbia, Maury County (Fig. 1), and testing (three 1 × 2 m excavation units) showed it to contain stratified deposits of bone and shell to a depth of approxi-

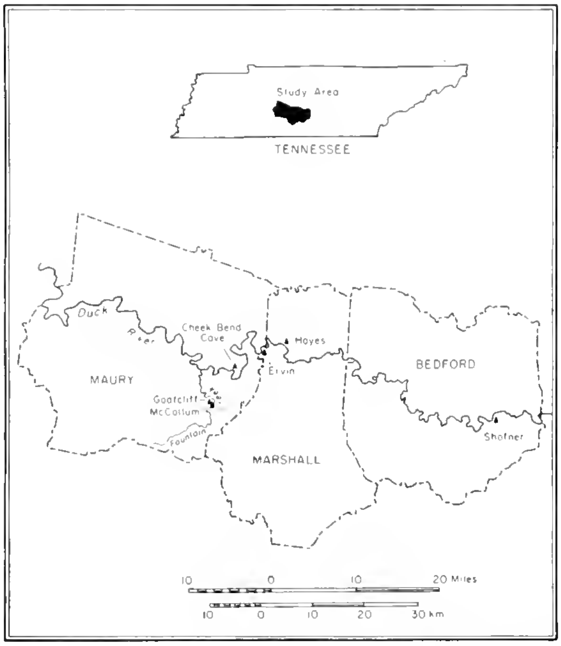

FIG. 1. The Duck River in Middle Tennessee with the location of Cheek Bend Cave and other aboriginal sites containing naiads discussed here.

mately 4.5 m. On the basis of the vertebrate species composition within and among strata, differing fill zones, and certain other stratigraphic features, the deposit reflects two distinct and well-defined major episodes of fill. The top 2 m represent the Holocene stage and contain remains of extant modern species. In contrast, the faunal assemblage in the bottom 2 m, although it includes some species that still inhabit the cave area, contains many such as the prairie chicken, 13-lined ground squirrel and pocket gopher that are now extirpated and reflect a prairie habitat (Parmalee and Klippel, 1981) and/or a boreal environment, species such as red-backed and yellow-cheeked voles, red squirrel, northern flying squirrel, and arctic and water shrews (Klippel and Parmalee, 1982).

Matrix from two additional one-meter-square columns was removed during 1982 and 1983. Only the vertebrate remains from the Pleistocene strata have undergone preliminary identification, but all freshwater mussel valves from the Holocene strata were removed and incorporated with the 1978–1979 specimens for this study. Although terrestrial gastropods occurred in all strata, aquatic gastropods, freshwater mussel shells and prehistoric human artifacts were encountered only in the Holocene strata. Mussels were commonly used as a food resource by prehistoric Indians in eastern North America (Parmalee and Klippel, 1974) and in all probability most if not all of the naiads present in this cave deposit were gathered by aboriginal groups occupying the site.

The majority of valves were well-preserved with some in the top two strata still retaining remnants of the periostracum, but also a large number of shells were broken with only portions of the hinge line remaining. Because of this latter condition, an additional 555 valve fragments could not be identified (Table 1). All species determinations were made using comparative reference specimens in the collections of the Section of Zooarchaeology, Department of Anthropology, University of Tennessee, Knoxville; all mollusk and vertebrate remains recovered from Cheek Bend Cave are housed in the Department of Anthropology.

The Duck River and Molluscan Studies

Interest by American malacologists in the varied and abundant freshwater molluscan fauna once present in most major river systems in eastern North America began well over a century ago. These beginning efforts centered around taxonomy, and emphasis was placed on describing and naming species new to science. By the 1850s the majority of "new" species had been described and the tendency then was to treat the total molluscan fauna of a specific region or river system. *List of Shells Collected in Central Tennessee* by Hinkley and Marsh (1885) is only one of many such references, but we cite it because it provides not only a list of species known from the Duck River (". . . the Duck River and adjacent country at Columbia, Maury Co.") at that time but also makes reference to the abundance of many species and the habitat in which they occurred. In addition, the following description by Hinkley and Marsh (1885:2) seems appropriate: "The Duck River, at Columbia, is a pretty and rather picturesque stream, the limestone bluffs along its banks having been sculptured by the action of rain and frost into various shapes, in places overhanging the water and forming quite a cavern underneath. The water is shallow, swift, and clear. . ." See Fig. 2.

After collecting the Duck River in 1921, 1922,

FIG. 2. View of the Duck River, Maury County, winter 1978–79, approximately 100 m upstream from Cheek Bend Cave.

and 1923, Ortmann (1924) published a comprehensive treatment of the naiad fauna that included 63 species and forms which he confirmed and 7 that "should be credited to the Duck River" based on previous published reports. More recent studies by Isom and Yokley (1965) and van der Schalie (1973) have pointed up the fact that the Duck River naiad assemblage has now been reduced by nearly one-fourth to about 45 species or forms. Completion of the Columbia dam and reservoir will bring about the extirpation of most species in the effected stretches of the river and will probably eliminate two species, now known to inhabit only this locale, from the entire river system. Ahlstedt (1981), in a recent survey of the molluscan fauna of the Duck River between the Normandy and Columbia dams, found a drastic decline in the numbers and abundance of species compared with earlier surveys in 1965 and 1973. The section of the Duck River above Columbia contains the last known populations in that river of such species as *Quadrula intermedia* and *Lemiox rimosus*. In 1982 TVA biologists transplanted ca. 4,000 individuals of *L. rimosus* into three other rivers (and at one location in the upper Duck River above the Normandy reservoir) in hopes of reestablishing this endangered species in known habitats where it once occurred. Success or failure of this ongoing program has not yet been fully evaluated (S.A. Ahlstedt, *pers. commun.*).

Cheek Bend Cave Mussel Assemblage

Although the shell was, for the most part, exceptionally well preserved, the disintegration of the periostracum in the majority of specimens and consequently loss of all color (including the nacre in most) and pattern made specific identification of valves representing certain groups (e.g. *Villosa*, *Epioblasma*) impossible or questionable at best. For example, Ortmann (1924: 52) commented that "The males of *D. [=Dysnomia=Epioblasma] florentina walkeri*, closely resemble those of the next species (*capsaeformis*), but they differ chiefly in color." Shells of species as distinct as *Lampsilis ovata* and *Actinonaias pectorosa*, when fresh, may be impossible to distinguish when only the dorsal portion of the valve (hinge line with lateral and pseudocardinal teeth) is preserved – as in archaeological or cave contexts.

Nevertheless, those specimens that could be identified provide an interesting record of the naiad species that inhabited the Duck River in Middle Tennessee in prehistoric times (on which there is no published data) and which, in turn, reflect river conditions at the time they were collected. Valves of *Epioblasma capsaeformis* (some of which may be *E. florentina*) comprised nearly 20% of the identified naiads recovered in the excavation units; at the time Ortmann collected the Duck River at Columbia/Leftwich/Lillard Mill/Willhoite it was "Rather abundant – New [previously unreported] for Duck River" (Ortmann 1924:53). Although still found in the Duck River above Columbia, it is uncommon and local in occurrence. We collected several dead mature specimens below Lillard Mill that were, unlike those from the cave, extremely large and thick-shelled. The spike, *Elliptio dilatata*, most of which were small, thin-shelled (for the species) and compressed – suggestive of a shallow small stream habitat – comprised about 12% of the cave naiad assemblage.

Ptychobranchus subtentum is another species that was apparently common in the Duck River near the cave site in prehistoric times; 107 valves (14%) were identified from the deposit. It was evidently uncommon at Columbia/Leftwich/Normandy when Ortmann (1924:40) made his 1921–1923 collections, reporting "Only a few specimens found." His further comment that it is "Most abundant in smaller streams above the range of *Ptychobranchus fasciolare*, and this seems to hold good also in Duck River" is of particular interest. This observation, coupled with the numerous valves of *P. subtentum* and other species (e.g. *Medionidus conradicus*) or forms from the cave that are indicative of a headwaters and/or small stream habitat, suggests that that section of the Duck River flowing in close proximity to Cheek Bend Cave during the mid-Holocene was smaller and more shallow than it is today.

Another species represented in the cave deposit (Stratum VII), namely *Pegias fabula*, is also indicative of a fast-flowing, shallow, small stream habitat. Archaeological surface collections were obtained from a Middle to Late Archaic (ca. 7,000-4,000 BP) shell midden at the Ervin Site (40MU147) during 1979. This prehistoric site, situated ca. 29 km upstream from Cheek Bend Cave in Maury County (Fig. 1), produced 15 specimens of *P. fabula* out of 1339 identified valves (Hofman, nd). During the 1982–1984 excavations at the Hays site (40ML139), ca 40 km upstream from Cheek Bend Cave in Marshall County, huge quantities of aquatic gastropods and freshwater mussel valves were removed from this Middle to Late Archaic (ca. 7,000-4,000 BP) shell midden. Included among the valves of the 32 species identified from this site thus far (Turner, nd) were 104 specimens of *P. fabula*. Even farther upstream, ca. 134 km above Cheek Bend Cave, Robison (nd) identified 43 valves of *P. fabula* (from a sample of 2,545 shells) from the Shofner site (40BD55), Bedford County, a Middle Woodland village dating ca. AD 600-500. Archaeological sites on tributaries of the Duck River have also produced *P. fabula;* one specimen was recovered from Woodland and one from Middle Archaic strata (266 valves identified) at the McCollum Rockshelter (40MU390) along Fountain Creek in Maury County. Two additional specimens (135 valves identified) were recovered from Goatcliff Rockshelter (40MU436) along the same Duck River tributary in what appears to be Woodland context (O'Hare, nd). Excavation of these rockshelters took place during 1980–1981 . A single specimen of *P. fabula* in the United States National Museum collections ("Duck River," USNM Lot No. 86229, catalogued Feb. 1888: Paul Greenhall, pers. comm., April 1986) appears to be the only documented historic record of this naiad for the Duck River (Clarke, 1981).

In a recent paper Starnes and Starnes (1980) report a viable population of *P. fabula* from the Little South Fork Cumberland River, Kentucky, a small fast-flowing stream ca. 20–25 m wide with an average water depth of about 20 cm at low river stages. Of additional interest is the fact that the associated mussel assemblage includes *P. subtentum, P. fasciolare, E. dilatata, M. conradicus, Villosa iris, Villosa taeniata, Villosa vanuxemensis* and *Lampsilis fasciola.* Although valves of *Alasmidonta viridis, Toxolasma cylindrellus* and *Lemiox rimosus* were not numerous in the Cheek Bend Cave deposit, the presence of these species is also indicative of a small stream habitat or stable stretches of shallow riffles in somewhat larger rivers like the Duck. Stansbery (1976) comments that "*Pegias fabula* appears to be a rare Cumberlandian species characteristic of stream conditions near, but not quite in, the uppermost headwaters."

The three-ridge, *Amblema plicata*, and purple warty-back, *Cyclonaias tuberculata*, are two of the more common species inhabiting the Duck River today. The 27 valves of *A. plicata* comprised only 3.5% of the total sample but were of interest in that they exhibited characteristics (small and compressed) of those inhabiting a headwaters or small stream habitat. Only two valves of the latter species were recovered in the cave. *Lexingtonia dolabelloides*, a species fairly well represented in the Cheek Bend Cave naiad assemblage (ca. 6% of the identified valves), still occurs in the Duck River, one of the few remaining rivers still supporting viable populations of this mussel. *Quadrula intermedia* is another species of interest in that it was present in the middle stretches of the Duck River in prehistoric times (2 valves from Cheek Bend Cave) and continued to survive until present (Ahlstedt, 1981) but at very low population levels. It was apparently never a common shell in the Duck River as evidenced by the paucity of specimens recovered at Cheek Bend Cave and at the Hayes site where only five shells of *Q. intermedia* were identified out of a sample of 3,870 valves (Turner,nd).

Anomalous Valves

During the identification process it was necessary to compare certain archaeological

Table 1 Freshwater mussels identified from Cheek Bend Cave, Maury County, Tennessee. Percent of each species within Strata and for Total Valves listed in parentheses ( ).

SPECIES	STRATA VIII	VII	VI	V	No. Prov.	Total Valves
Amblema plicata (Say, 1817) Three-Ridge	1 (8.23)	13 (4.19)	7 (12.28)	2 (.79)	4 (3.13)	27 (3.55)
Fusconaia barnesiana (Lea, 1838) Tennessee Pigtoe		5 (1.61)	2 (3.5)	4 (1.57)	2 (1.56)	13 (1.71)
Lexingtonia dolabelloides (Lea, 1840) Slabsided Pearlymussel		10 (3.23)	4 (7.02)	23 (9.06)	10 (7.81)	47 (6.18)
F. barnesiana and/or *L. dolabelloides*		2 (.65)		1 (.39)		3 (.39)
Quadrula Cylindrica (Say, 1817) Rabbitstoot			1 (1.75)			1 (.13)
Quadrula intermedia (Conrad, 1836) Cumberland Monkeyface				1 (.39)	1 (.78)	2 (.26)
Cyclonaias tuberculata (Rafinesque, 1820) Purple Wartyback		1 (.32)			1 (.78)	2 (.26)
Elliptio dilatata (Rafinesque, 1820) Spike	1 (8.33)	31 (10.00)	6 (10.53)	43 (16.93)	9 (7.03)	90 (11.83)
Hemistena lata (Rafinesque, 1820) Cracking Pearlymussel				1 (.39)	1 (.78)	2 (.26)
Pleurobema oviforme (Conrad, 1834) Tennessee Clubshell		2 (.65)	1 (1.75)	1 (.39)		4 (.53)
Alasmidonta viridis (Rafinesque, 1820) Slippershell		2 (.65)	1 (1.75)	1 (.39)	4 (3.13)	8 (1.05)
Pegias fabula (Lea, 1836) Little-winged Pearly Mussel		10 (3.23)			1 (.78)	11 (1.45)
Lasmigona costata (Rafinesque, 1820) Fluted Shell		4 (1.29)			2 (1.56)	6 (.79)
Strophitus undulatus (Say, 1817) Squawfoot		1 (.32)				1 (.13)
Actinonaias pectorosa (Conrad, 1834) Pheasantshell	1 (8.33)	2 (.65)		4 (1.57)	8 (6.25)	15 (1.97)
Toxolasma cylindrellus (Lea, 1868) Pale Lilliput			4 (7.02)	1 (.39)		5 (.66)
Toxolasma lividus (Rafinesque, 1831) Purple Lilliput				1 (.39)		1 (.13)
Epioblasma capsaeformis (Lea, 1834) and/or *E. florentina* (Lea, 1857) Oyster Mussel &/or Tan Riffleshell	1 (8.33)	85 (27.42)	6 (14.04)	40 (15.75)	16 (12.50)	150 (19.71)
Epioblasma brevidens (Lea, 1834) Cumberland Combshell				1 (.39)		1 (.13)
Lampsilis fasciola (Rafinesque, 1820) Wavy-rayed Lampmussel		3 (.97)		10 (3.94)	1 (.78)	14 (1.84)
Lampsilis ovata (Say, 1817) Pocketbook	1 (8.33)	17 (5.48)	2 (3.51)			20 (2.63)
Lemiox rimosus (Rafinesque, 1831) Birdwing Pearlymussel	1 (8.33)	5 (1.61)	1 (1.75)		6 (4.69)	13 (1.71)
Medionidus conradicus (Lea, 1834) Cumberland Moccasin	4 (33.33)	49 (15.81)	10 (17.54)	14 5.51)	23 (17.97)	100 (13.14)
Potamilus alatus (Say, 1817) Pink Heelsplitter		1 (.32)				1 (.13)
Villosa iris (Lea, 1830) Rainbow		4 (1.29)	2 (3.51)	3 (1.18)	2 1.56)	11 (1.45)
Villosa taeniata (Conrad, 1834) Painted Creekshell		17 (5.48)	1 (1.75)	35 (13.78)	20 (15.63)	73 (9.59)
Villosa vanuxemensis (Lea, 1838) Mountain Creekshell		4 (1.29)	2 (3.51)	1 (.39)	1 (.78)	8 (1.05)
Villosa spp. (*Epioblasma*?)	1 (8.33)	10 (3.12)	1 (1.75)	8 (3.15)	4 (3.13)	24 (3.15)
Ptychobranchus fasciolare (Rafinesque, 1820) Kidneyshell				1 (.39)		1 (.13)
Ptychobranchus subtentum (Say, 1825) Fluted Kidneyshell	1 (8.33)	32 (10.32)	4 (7.02)	58 (22.83)	12 (9.38)	107 (14.06)
Totals (Identified valves)	12 (99.97)	310 (99.90)	57 (99.99)	254 (99.96)	128 (100.01)	761 (100.00)
Totals (Unidentified valves)	17	142	88	205	103	555
Totals (All Valves)	29	452	145	459	231	1316

specimens, particularly incomplete valves and those of *Villosa* spp. and *Epioblasma* spp., with fresh material using a binocular scope. Under magnification, a variety of anomalous structures or conditions were noted that, in addition to making specific determinations difficult or impossible, pose some interesting questions. These anomalies consisted primarily of deep pits along, under and/or between the lateral and pseudocardinal teeth and the development of supernumerary "teeth" or projections between or adjacent to the pseudocardinal teeth (Fig. 3). Less than 3% of the valves exhibited one or more of these anomalies; the majority occurred in small, thin-shelled individuals. Possibly these conditions were the result of some trauma or perhaps parasites, but whatever the cause(s), such abnormalities have not been observed in other archaeological naiad material from prehistoric sites along the Duck River.

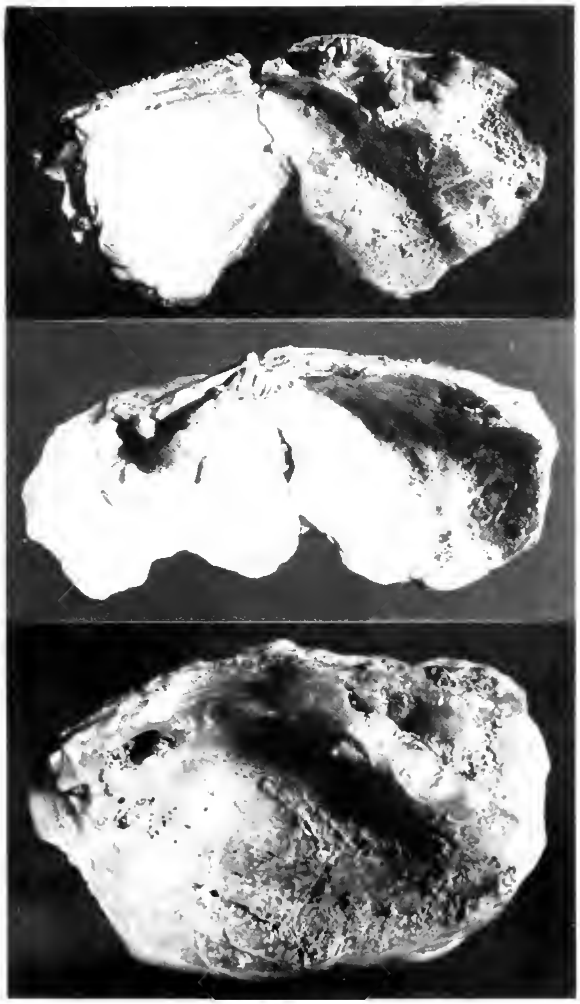

FIG. 3. Examples of anomalous naiad valves from Cheek Bend Cave that exhibit pitting and nacre deformities.

General Discussion

Ortmann (1924:19), in attempting to evaluate the zoogeographical affinities of the Duck River naiad assemblage, made the following significant observations: "Duck River being located between Cumberland River in Kentucky and Tennessee, and Tennessee River in northern Alabama, might be expected to contain a similar fauna to these two systems, a fauna which is known to contain peculiar elements, not found outside of this region in the Central basin (Mississippi and Ohio drainages), which might be called 'Cumberlandian' types (from the 'Cumberland subregion')." On the basis of his studies of the Duck River mussel species and those of other rivers of the southeastern region, he concluded (Ortmann 1924:61) that "It appears that the Cumberlandian fauna is the original fauna of Duck River, while the interior-basin-fauna is a later invasion of the river, coming up from the lower parts; yet important elements of the interior fauna have not yet reached Duck River. In the lower Duck, at Centreville, and probably farther down, the interior fauna alone is present, and this part does not belong to the Cumberland region. Duck River originally was more directly connected with the Cumberland and Tennessee, and, at that time, it was a rather small river." Approximately 65% of the species represented in the Cheek Bend naiad assemblage are Cumberlandian as defined by Ortmann, and they reflect a headwaters or small stream habitat. Several other species (e.g. *E. dilatata*, *A. plicata*) present in the cave with Mississippian or Interior Basin affinities exhibit small stream shell characters, that is, compressed, thin-shelled small valves. Therefore, the naiad assemblage recovered from the Cheek Bend Cave excavations and the occurrence of certain species such as *P. fabula* from this cave and other aboriginal sites in Maury, Marshall and Bedford counties suggest that the Duck River in Middle Tennessee was swift and shallow with riffles and a probable substrate of sand and small gravel for extended periods between 7,000 and 1,000 BP.

Acknowledgments

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THE FATE OF PELECYPOD FAMILIES, SUBFAMILIES, AND TRIBES DURING AND AFTER THE CRETACEOUS PERIOD

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ABSTRACT

Of the 114 surveyed supergeneric groups of pelecypods that occur in the Cretaceous, 38, or 33%, are extinct. In the Early Cretaceous one group became extinct every 9,300,000 years. During the Late, but not latest, Cretaceous, one group became extinct every 2,333,000 years. In the Maastrichtian Stage (latest Cretaceous), the extinction rate increased to one group every 470,000 years. Only seven groups became extinct during the Cenozoic: four during the Eocene and three during the Miocene. There was only one extinction of a supergeneric group every 9,500,000 years during the entire Cenozoic, which is comparable to the extinction rate during the Early Cretaceous. The rate of extinction of supergeneric groups of pelecypods increased rapidly in the Late Cretaceous and reached a climax at the end of that geologic period.

The number of families, subfamilies, tribes and groups of pelecypods that undoubtedly had one or more genera living during the Cretaceous Period, as reviewed in the Treatise on Invertebrate Paleontology (1969, 1971), is 124. In each of these supergeneric categories the genera and subgenera were tallied in each geologic Period and Epoch. In a few instances, more current data were used when it was available (Keen's, 1980, latest review of the Cardiidae), and a few of the geologic ranges of other supergeneric groups have been brought up to date. Ten of the 124 supergeneric groups were excluded because of insufficient geologic data, as, for example, the Solemyidae, Manzanellidae, Dimyidae, and Sportellidae.

The supergeneric groups that lived during the Cretaceous are, commonly, not ancient lineages. Only the Nuculanidae and Malletiidae can be traced back to the Ordovician, and they are as diverse today as they have ever been. Fifty three supergeneric groups (47%) appear in the Cretaceous. Some of these are short-lived groups but many others first appeared in the Cretaceous and are presently represented by many genera and species. By the end of the Cretaceous, most of the basic adaptive radiation of the pelecypods had occurred. Of the 114 supergeneric categories considered herein, 90% first appeared in the Mesozoic. Stanley's graph (1968, p. 215) depicts the great Mesozoic radiation.

The 114 supergeneric groups can be placed in seven categories based on the distribution of their genera and subgenera from the Cretaceous to the Recent.

1. Many supergeneric groups were relatively unaffected by the mass extinctions at the end of the Cretaceous and remained as diverse in the Cenozoic or increased in diversity during that Era. In this first category there are 46 supergeneric groups or 40% of the total of 114. Although some genera became extinct during the Cretaceous, they were quickly replaced by new genera arising in the Cenozoic. Almost 62% of these supergeneric groups began in the Cretaceous and 87% began after the Paleozoic. Those groups first appearing in the Cretaceous are commonly represented by one or two genera. In other words, they are comparatively young supergeneric groups. The protobranch families Nuculidae, Malletiidae, and Nuculanidae are exceptional in that they range well back into the Paleozoic and were not affected greatly by extinction at the end of the Mesozoic.

2. Some supergeneric groups were affected by Cretaceous extinction but later recovered and became most diverse in the Neogene. There are 15 supergeneric groups that have this distribution in diversity, which comprise about 13% of the total. In this category only six or 40% began in the Cretaceous but 93% began in the Mesozoic. In general, the families are longer ranging than those that were little affected by the Cretaceous extinctions. Some notable examples of supergeneric groups in this category of diversity are the Pitarinae, Tellininae, Cardiinae, Protocardiinae, and Mactrinae.

3. Some supergeneric groups were affected by Cretaceous extinction but continued on to the Recent with a reduction in diversity. In this category are included 15 supergeneric groups or approximately 13% of the total. These supergeneric groups are still longer ranging than those in the first two categories and only four, or 27%, began in the Cretaceous. However, 13, or 87%, had their inception in the Mesozoic. There are some notable groups that were adversely affected by the Cretaceous wave of extinction, including the Trigoniidae, which has survived to the present only in the Australian region. The Pholadomyidae is another group that is nearly extinct after its great diversity in the Mesozoic. Other relict groups at present are the Grammatodontidae, Cucullaeidae, Fimbriidae, and Arcticidae. All of these families were much more diverse and widespread during the Cretaceous.

Of the 114 supergeneric groups studied, 38, or 33% are extinct. They can be grouped into four categories.

4. A few supergeneric groups became extinct during the Early Cretaceous (before the Cenomanian). There were only five families or about 4.4% of the supergeneric groups that became extinct during this span of time. Eighty percent of this small group are confined to the Mesozoic, which includes the Neomiodontidae, a small family that lived in brackish and fresh water.

5. There are nine supergeneric groups of pelecypods that became extinct in the Late Cretaceous but before the Maastrichtian. This category constitutes 7.9% of the total number of supergeneric groups. Four of these are small and short-lived families and subfamilies that

were confined to the Cretaceous Period. One of these short-lived families, the Trigonioididae, lived in fresh and brackish water. I have placed the Mactromyidae in this category because *Bathycorbis* Iredale is most likely an aberrant venerid and Dockery (1982, p. 72) has proved that *Cordiula* Meyer was based on a young specimen of *Nemocardium*. The Mactromyidae is found primarily in the Jurassic and Cretaceous.

6. Seventeen supergeneric groups, about 15% of the total, became extinct at the end of the Cretaceous during the Maastrichtian Stage. Some of the supergeneric groups that became extinct at this time were large-sized, diverse, and common in strata of Cretaceous age. These include the rudist families Hippuritidae, Radiolitidae, Caprinidae, Monopleuridae, and Requiniidae. It also includes the Inoceramidae and Exogyrini. Seven of these seventeen groups (41%) were confined to the Cretaceous Period, and 14 (82%) were found only in the Mesozoic. The great extinction at the end of the Cretaceous did not greatly affect most of the older supergeneric groups.

7. Seven supergeneric groups (6.1%) survived the Cretaceous but became extinct in the Tertiary–four in the Eocene and three in the Miocene. Except for the Bakevelliidae and Eriphylinae, they consist of small groups (no more than four genera), and all but the Bakevelliidae and Eriphylinae originated in the Cretaceous Period. It is known that extinction rates increased near the end of the Eocene Epoch, as in the planktonic Foraminiferida, and for this reason it is not surprising that a few supergeneric groups of pelecypods disappeared at this time. Two of the three extinctions of supergeneric groups that occurred in the Miocene were the Gryphaeostreinae and the Flemingostreinae (Ostracea) and may have been caused by oncoming glaciation at the end of the Miocene (Nicol, 1984).

Fresh-water pelecypods were somewhat affected by the Cretaceous extinctions. Besides the two previously mentioned short-lived groups that became extinct in the Cretaceous, the Corbiculidae and Unioninae lost some genera and subgenera at the end of the Mesozoic.

TABLE 1. Extinction rates of families, subfamilies, and tribes of pelecypods during the Cretaceous and Cenozoic.

Stratigraphic time units and time in years	Number of extinctions	Extinction rate in years
1. Early Cretaceous (Berriasian-Albian) 46,500,000	5	9,300,000
2. Late but not latest Cretaceous (Cenomanian-Campanian) 21,000,000	9	2,333,000
3. Latest Cretaceous (Maastrichtian) 8,000,000	17	470,000
4. Late Cretaceous (Cenomanian-Maastrichtian) 29,000,000	26	1,115,000
5. Total Cretaceous 75,500,000	31	2,435,000
6. Paleocene-Eocene 30,000,000	4	7,500,000
7. Oligocene-Recent 36,500,000	3	12,170,000
8. Total Cenozoic 66,500,000	7	9,500,000
9. Total of Cretaceous and Cenozoic 142,000,000	38	3,740,000

In Table 1 I have summarized the rate of extinction of the supergeneric groups of pelecypods in years throughout the Cretaceous and Cenozoic. The actual time spans of the various stratigraphic units were taken from Palmer, 1983. The extinction rate was low in the Early Cretaceous, but beginning with the Cenomanian, which is the earliest Stage of the Late Cretaceous, the extinction rate increased and continued into the Campanian Stage. This latter rate is a fourfold increase over the Early Cretaceous rate of extinction. The Maastrichtian Stage at the end of the Cretaceous has the highest rate of extinction, being about five times faster than the previous figure in the rest of the Late Cretaceous, and it is about 20 times faster than the rate in the Early Cretaceous. Furthermore, the extinction rate in all of the Late Cretaceous was more than eight times more rapid than it was in the Early Cretaceous. These extinction rates do not appear to be an artifact of the geologic record. Cretaceous strata, particularly that of a shallow-water marine environment, are exceedingly widespread and have been thoroughly studied by invertebrate paleontologists. Evolution increased greatly in rate during the Late Cretaceous, a time span of 29,000,000 years. This rate of evolution increased and reached a climax in the latest Cretaceous Maastrichtian Stage, which spans only 8,000,000 years. For example, three of the supergeneric groups that arose in the Late Cretaceous also became extinct during that part of the Cretaceous Period. Apparently new species, genera, and families arose with increasing rapidity during the Late Cretaceous as evinced by the rudists (Jones and Nicol, in press, and Nicol, in press). The Inoceramidae also evolved rapidly during the Late Cretaceous. One may ask, did the widespread warm shallow seas that covered the continents during the Late Cretaceous cause evolutionary rates to increase greatly?

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FRESHWATER AND TERRESTRIAL SNAILS OF SAINT LUCIA, WEST INDIES[1]

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ABSTRACT

Surveys were made of the freshwater and terrestrial snails and slugs of Saint Lucia, one of the Windward Islands of the Lesser Antilles. Ten species of 7 families of freshwater snails, 9 species of 7 families of terrestrial snails, and 2 species of one family of slugs were encountered. The freshwater snail fauna inhabit all types of freshwater habitats available, i.e., rivers, brooks (ravines), stream embankments, flood plains and swamps adjacent to rivers, drainage ditches and ponds. Only one species of Biomphalaria, B. glabrata, *was found, although other species of this genus occur on some other neighboring islands, alone or together with* B. glabrata. *The majority of the land snail species were represented in the capital city, Castries, and the nearby hills and coastal lands. Certain species of land snails were associated with limestone deposits and others, although inhabiting the same areas, were also found in the igneous mountain highlands and in forests. A scarcity of land operculates was observed; only one species was found.*

There is some old information on the molluscan fauna of Saint Lucia. Bland (1861), E. A. Smith (1889, 1895) and E.A. Smith and Feilden (1891) listed land snails and a few freshwater snails of Saint Lucia and some neighboring islands. The author (1965), in an abstract form,

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[1] Contribution from the World Health Organization Collaborating Center for Applied Medical Malacology, Tulane University.

enumerated and discussed briefly the freshwater and land snails based on three trips to Saint Lucia for which reports to the Pan American Health Organization were prepared (Malek, 1962, 1963). The snails were later (Malek, 1980) illustrated to emphasize shell characteristics. Jordan (1985) in a brief appendix included only a short list of the freshwater and terrestrial snails on Saint Lucia, some of which were identified by the author.

The present report was prepared in view of the significance of the molluscan fauna in research on snail-transmitted diseases on the island, especially schistosomiasis and fascioliasis, and the reports in recent years on freshwater snails in other Antillean islands such as Guadeloupe (Pointier, 1974), Haiti (Robart et al., 1976), Martinique (Guyard and Pointier, 1979), Guadeloupe, Dominica and Martinique (Starmuhlner, 1985) and the Dominican Republic (Gomez et al., 1986).

The Island of Saint Lucia

Saint Lucia, one of the Windward Islands located between Martinique and Saint Vincent, is a small island 27 by 14 miles and is about 233 square miles in area. The middle part is mountainous; there is a longitudinal main ridge, almost median, with other mountains running down to the coast on either side. Between the offshoots of the main mountain ridge are broad, flat valleys which spread out toward the sea. Small rivers, measuring only 7 to 12 feet in width in most parts, and only a few feet in depth, run from the mountain heights through the valleys. Most rivers form separate drainage systems that are subject to frequent flooding.

Rainfall over most of the island averages 80 inches per year, but with only 40 inches on the southern and northern tips. The highest rainfall occurs from May through October, with peaks in August and September. Remnants of past volcanic activity are still noticeable in the sulphur area near Soufriere. The river beds have big rocks, seemingly of volcanic origin. Also in the geologic history certain areas were elevated, and during the Cretaceous period, deposition of limestone took place on several parts of the island, which support large numbers of the molluscan species.

Results

Ten species belonging to 7 families of freshwater snails, 9 species belonging to 7 families of terrestrial snails, and 2 species of one family of slugs were encountered in this survey (Table 1). Of the freshwater snails the Planorbidae was represented by 3 species, the Neritidae by 2 species and the Lymnaeidae, Physidae, An-

TABLE 1. Families and species of gastropods and their locations in Saint Lucia.

FRESHWATER

Planorbidae

Biomphalaria glabrata

Rivers: Castries, in the Entrepot area; Derniere, north of Dennery; Esperance, near Fond St. Jacques; Bance, near bridge south of school; Choc; Raveneau, at Delcer. Brooks (ravines): Ti Rocher; Trou Macis near Bance; above fall at Sulphur Springs. River and brook embankments: Ravine Poisson at Ravine Poisson; Augier River. Flood plains or swamps off rivers: Vieux Fort north of Joyeux; Canaries; Augier. Drainage ditches: Banana fields near Marquis and in Cul de Sac Valley. Ponds: At fall near Sulphur Springs; at Fond St. Jacques; at Derniere Fort. Concrete-lined channels: At Ferrand Estate.

Drepanotrema depressissimum

Pond at entrance of Union Agricultural Station; pond in Bonne Terre area; pond in Ville Boutille; pond near Monchy school; drainage ditch in Marquis Estate; Ti Rocher brook; swamp by road between Vieux Fort and Labourie.

Drepanotrema lucidum

Pond near Monchy school; pond in Bonne Terre area; pond in Ville Boutille.

Lymnaeidae

Fossaria cubensis

Ditches in banana fields, Cul de Sac Valley; along bank of river near Union Agricultural Station; Ferrand Estate.

Physidae

Physa cubensis

Derniere River; embankment along Poisson brook; Marquis River; Bagatelle River in the Marchand area; pond in Bonne Terre area; pond at Ville Boutille; pond in Monchy area; brook joining Vieux Fort River north of Joyeax.

Ancylidae

Gundlachia radiata

Pond near Sulphur Springs; Derniere River; Castries River in Marchand area; Choc River; ditches in banana fields, Marquis Estate.

Hydrobiidae

Pyrgophorus parvulus

Brook, near Fond St. Jacques; brook near Joyeux; brook in Cul de Sac Valley.

Ampullaridae

Ampullaria glauca

Derniere River; Marquis River; Bonne Terre pond; pond at entrance of Union Agricultural Station.

Neritidae

Neritina punctulata and *N. virginea*

Castries River; Marquis River; Choc River

TERRESTRIAL

Helicinidae

Helicina fasciata

Ferrand Estate, on banana plants and weeds along drainage ditches.

Succineidae

Omalonyx guadeloupensis

Banks of pond at entrance of Union Agricultural Station; Cul de Sac Valley; along ditches in banana fields.

Succinea approximans

Along Poisson brook; along Choc River; near Vieux Fort; at Union Agricultural Station.

Subulinidae

Subulina octona

Castries; Bois d'Orange; near Choc River; at Monchy; near Union Agricultural Station.

Streptaxidae

Gulella bicolor

Castries and vicinity.

Bulimulidae

Protoglyptus sanctaeluciae

Castries and vicinity.

Bulimulus guadalupensis

Castries and vicinity; several localities along the coast and foothills; on banana trees and shrubs in Ferrand Estate.

Urocoptidae

Brachypodella tatei

Several localities along coast and foothills

Camaenidae

Pleurodonte orbiculata

Castries; Choc River area; several localities between Castries and northern tip of island; Bois d'Orange; Cul de Sac Valley; Dennery.

Veronicellidae

Vaginulus occidentalis

Cul de Sac Valley on banana trees; Ferrand Estate on banana trees; hills overlooking Bois d'Orange; along Poisson Brook.

Veronicella floridana

Several localities in the northern half of island, sometimes with *V. occidentalis*

cylidae, Ampullaridae and Hydrobiidae by one species each. Of the terrestrial snails the Succineidae and Bulimulidae were represented by 2 species each, while the Helicinidae, Subulinidae, Streptaxidae, Urocoptidae and Camaenidae were represented by one species each. Two species of slugs found belonged to the family Veronicellidae.

The planorbid *Biomphalaria glabrata* (Say, 1818), intermediate host of *Schistosoma mansoni*, was found in 20 localities. Specimens, which are up to about 10 mm in diameter, never attain the large size of those found in Puerto Rico, the Dominican Republic or South America. Accordingly, F. C. Baker (1945) showed figures of *B. glabrata* from Saint Lucia and commented that they were immature. Examination of shell features and anatomical details of biomphalarids from various drainage systems indicated that *B. glabrata* is the only species of the genus *Biomphalaria* that exists on Saint Lucia. It is known that species such as *B. havanensis*, *B. helophila* and *B. straminea* occur on some of the Lesser and Greater Antilles, alone or in addition to *B. glabrata*. The snail was not found in fast-flowing waters, but frequents and breeds on flooded river and ravine (brook) embankments, in swampy areas close to rivers, in side pools and backwaters of rivers and ravines protected by rocks and vegetation, in drainage ditches of banana fields, and in concrete-lined channels. Sizable colonies were always found upstream rather than near the mouth of a river.

The planorbids *Drepanotrema depressissimum* (Moricand, 1839) and *D. lucidum* (Pfeiffer, 1839) live in ponds rich in aquatic vegetation. The lymnaeid *Fossaria cubensis* (Pfeiffer, 1839) is the snail host of *Fasciola hepatica* which is common on the island. Wet mud outside the water, with or without vegetation, represents the typical habitat of this lymnaeid, although it was also found in narrow drainage ditches in banana fields, in shallow water, and in narrow concrete-lined channels.

The Saint Lucian material of the hydrobiid *Pyrgophorus parvulus* (Guilding, 1828) exhibits variations common among individuals of this species. Some specimens have evenly rounded and smooth whorls, whereas other specimens have prominent spiral carinae situated a short distance between the sutures, and each carina carries a number of pronounced spines.

The land snails and slugs found during the survey seemed to be widely distributed, especially in the island's northern two-thirds where the tropical vegetation and coastal deposits of limestone exist. Species such as *Subulina octona* (Bruguière, 1789), *Pleurodonte orbiculata* (Férussac, 1821), *Bulimulus guadaloupensis* Bruguière, 1792 and *Protoglyptus sanctaeluciae* (E.A. Smith, 1889) occur in abundance in the most populated town, Castries. The several hills on which the town is located and the coastal strip harbor large colonies of these snails. Banana plantations in several parts of the island support large populations of helicinids, bulimulids, and veronicellid slugs.

Discussion

The distribution of the freshwater snails on Saint Lucia seems to be related to characteristics of the habitat, such as the stream gradient, water velocity, rainfall, and salinity. For example, *B. glabrata* was not found in parts of streams with steep gradients or in streams close to the sea. The nearest colony was found at about 400 yards from the coast. The bionomics of *B. glabrata* on Saint Lucia were investigated by Sturrock (1973, 1974). *Neritina* spp., however, seem to withstand higher salinity than the other freshwater snails. The drepanotrematids were found to be almost exclusively pond-inhabiting species, the exception being the occurrence of *Drepanotrema depressissimum* once in a drainage ditch and once in a slow-flowing brook.

The distribution of the land snails on this and other Antillean islands follows the usual correlation between the distribution of species and the geological formation of the area in which they occur. Species belonging to *Brachypodella*, *Gulella*, and *Subulina* are restricted to the limestone coastal land and adjacent hills. *Pleurodonte orbiculata* (Férussac, 1821), *Bulimulus guadaloupensis* (Bruguière, 1792), and *Protoglyptus sanctaeluciae* (E.A. Smith, 1889) also inhabit these areas, but they are additionally found in the igneous mountains in the highlands.

The main species of freshwater and terrestrial snails on Saint Lucia also occur on certain other Caribbean islands. The faunal relationship of Saint Lucia to other Caribbean islands and to the mainland in Central and South America deserves comment. Several theories have been postulated to explain the faunal and floral similarities among the islands of the West Indies on the one hand and among those of the islands and the fauna and flora of Central and South America on the other hand. Among the theories postulated is the past existence of land bridges (Ihering, 1931), or isthmian links (Schuchert, 1935) between the islands themselves and between the islands and the mainland of Central and South America. Snails have played an important part in helping to correlate the geological history and the zoogeography of the islands. Certain species, however, such as the cosmopolitan *Subulina* spp. and others are of little value in providing evidence of previous land connections. The land operculate snails offer evidence of zonal grouping within the West Indies. Surveys on Saint Lucia revealed the presence of only one land operculate, *Helicina fasciata* Lamarck, 1818–1822. Thompson (1967) described another operculate from Saint Lucia, *Lithacaspis xanthoglauca* (family Cyclophoridae). In general, however, there is a scarcity of land operculate snails on the Lesser Antillean islands and South America as compared to a preponderance of land operculates on the Greater Antilles islands.

Among the freshwater snails, the planorbids show relationships with the South American fauna. *Drepanotrema depressissimum* (Moricand, 1839) is typically South American. *B. glabrata* is found on some islands of both the Lesser and the Greater Antilles, and its range extends into South America. In the Antilles, *B. glabrata* occurs on Saint Lucia, Martinique, Guadeloupe, St. Kitts, Antigua, Dominica, Hispaniola, and Puerto Rico. *Ampullaria glauca* (Linnaeus, 1758) is also South American.

The melaniid *Thiara granifera* (Lamarck, 1822) was introduced by Prentice (1983) in field trials in marshes and streams for experiments on biological control of *B. glabreta*. Whether *T. granifera* still exists in these habitats or has spread to other habitats in Saint Lucia is not known. Jordan (1985) listed the sphaeriid bivalve *Pisidium punctiferum* (Guppy) as a member of the freshwater fauna of the island, but it was not encountered in my surveys. However, his list did not include the terrestrial operculate *Helicina fasciata* Lamarck, nor the slug *Veronicella floridana* (Leidy) which were both common in the material that I collected.

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ON THE REDISCOVERY OF *TERAMACHIA MIRABILIS* (CLENCH AND AGUAYO, 1941), AND ITS RELATIONSHIP TO OTHER CALLIOTECTINE VOLUTES

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ABSTRACT

A second known specimen of Teramachia mirabilis *(Clench and Aguayo, 1941) is here recorded from deep water (465.4 meters) on the Little Bahama Bank. Comparisons of this dead-collected, crabbed specimen are made with illustrations and descriptions of the holotype, which was live-taken in 521.3 meters off Matanzas, Cuba, in 1939. Largely on the similarity of shell characteristics, this New World species is retained in the genus* Teramachia, *as is* Calliotectum fischeri *Olsson, 1964, from the Pliocene of Ecuador. Examination of the typological specimens of* Calliotectum vernicosum *Dall, 1890, for which a lectotype is here designated, confirms the distinction between* Calliotectum *Dall, 1890 and* Teramachia *Kuroda, 1931.*

Zoogeographically, Teramachia *is confined mostly to the western Pacific and is known to date from the Neogene of Japan as well as Ecuador. Thus the widely* *separated modern distributional pattern of the genus* Teramachia *(six species in the western Pacific, one in the western Atlantic) suggests that* T. mirabilis *is a surviving element of a presently disjunct Pacific fauna.*

Howellia mirabilis Clench and Aguayo, (1941, pp. 177-178, pl. 14, fig. 2; Weaver and duPont, 1970, p. 178, pl. 76 A, B) was described on the basis of a single, live-collected specimen dredged at *Atlantis* Station No. 3483, off *Matanzas, Matanzas Province, Cuba* (23°12'N, 81°23'W), in 521.3 meters. The soft parts unfortunately were not recovered in a condition that could be preserved, and the shell was cleaned and dried during the trip. Regrettably, the holotype (catalog #135291) cannot be located in the collection of the Museum of Comparative Zoology and is presumed lost (*teste* D. Backus). This taxon was proposed as the type species for the monotypic genus *Howellia* by Clench and Aguayo (1941, p. 177). *Howellia* was placed provisionally by Clench and Aguayo (*op. cit.*) in the family Fasciolariidae, in the absence of knowledge of the radula and soft-part anatomy. Subsequently, Clench and Turner (1964, p. 177) assigned *Howellia* to the Volutidae, subfamily Calliotectinae, following the placement of Pilsbry and Olsson (1954, p. 19), based on shell characters. Clench and Turner (1964, p. 178), however, noted the resemblance in shell morphology of *Howellia mirabilis* to the western Pacific genus *Teramachia* Kuroda, 1931. Later Weaver and duPont (1970, p. 176) placed *Howellia*, 1941, in the synonymy of *Teramachia*, 1931, where it was retained by Emerson (1985, pp. 102, 103).

Recently Harry G. Lee of Jacksonville, Florida kindly called our attention to a crabbed specimen of *Teramachia mirabilis* in the collection of the Indian River Coastal Zone Museum (IRCZM) at Harbor Branch Oceanographic Institution, Inc., Fort Pierce, Florida. This specimen, apparently only the second known for this taxon, was found in a sediment sample collected on a Johnson-Sea-Link I submersible dive during R/V *Johnson* Cruise 159, on October 4, 1983. The bucket had been left on the bottom for 408 days to collect accumulating sediment near Black Rock, Little Bahama Bank (26°16.5'N, 77°38.5'W) in 465.4 meters, by C. M. Hoskin and J. K. Reed. The specimen presumably was carried into the 20-liter plastic bucket by the hermit crab occupying the shell.

Although long-dead and now discolored from the muddy sediment, this specimen, IRCZM #065:02138 (figs. 5, 6), compares favorably with the description and illustration of the holotype. The present specimen is larger (125 vs. 93 mm in height) and has weaker axial sculpture on the body whorl. In outline and in the development of axial sculpture on the body whorl *Teramachia mirabilis* most closely resembles the western Pacific *Teramachia johnsoni* (Bartsch, 1942, p. 12, pl. 2, fig. 3; holotype illustrated in color by Weaver and duPont, 1970, pl. 75G, H; cf. figs. 5, 6 with figs. 7, 8 herein). *Teramachia johnsoni*, however, has a tannish brown shell with a darker aperture, whereas the holotype of *Teramachia mirabilis* is whitish and tinged with a faint brownish red. The aperture is light brownish red within.

The discovery of the newly recognized specimen of *Teramachia mirabilis* extends the known provenance of this species northwestward from the vicinity of Cay Sal Bank, off northern Cuba, to the Little Bahama Bank. Specimens can be expected to occur at suitable depths elsewhere on these and other regional banks.

In the absence of anatomical data on the type species of *Howellia* it seems prudent to refer this New World species to the genus *Teramachia* on the basis of shell characters held in common with the western Pacific species of this group of calliotectine volutes (Weaver and duPont, 1970, p. 177, Emerson, 1985, p. 103). A more precise systematic assessment of *Howellia* must await knowledge of the soft parts and radular characters of *Teramachia mirabilis*.

Clench and Turner (1964, p. 178) briefly noted the close resemblance of the shell morphology of *Howellia mirabilis* to that of the Japanese species of *Teramachia*, and they stated, "Relationships of this sort from widely separated areas are unusual, but they do exist". Shortly thereafter, Olsson (1964, p. 129, pl. 23, fig. 4) described *Calliotectum fischeri* from late Pliocene rocks of the Esmeraldas formation of Ecuador. The holotype is based on a 52.8 mm


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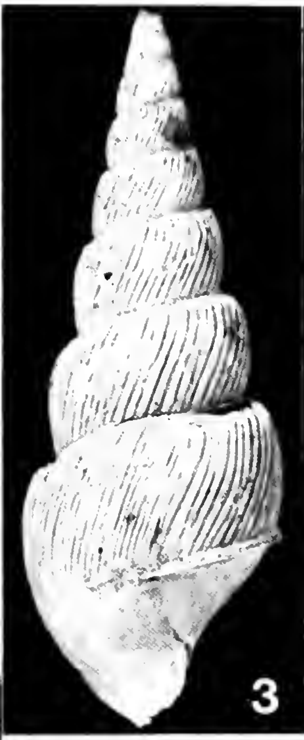
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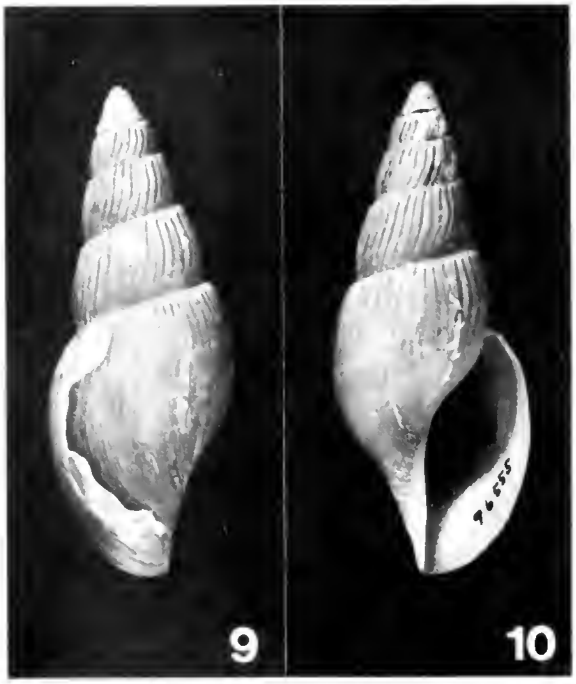
fragmental specimen, which was estimated to be "between six and eight inches in length" before the badly fractured specimen was extracted from the matrix. Olsson compared his specimen to *Prodallia dalli* Bartsch, 1942 from the Philippines and he referred *Teramachia* Kuroda, 1931 and *Prodallia* Bartsch, 1942 to the synonymy of *Calliotectum* Dall, 1890. We have examined the holotype and six fragmental specimens of Olsson's *"Calliotectum" fischeri* from near the type locality (Tulane Geol. Dept. localities 1397 [figs. 3, 4, herein] and 1402, and W. D. Pitt Coll. locality 9A-B3-915, all from the Esmeraldas formation). These specimens are from a deep-water facies and confirm the allocation of Olsson's taxon to the genus *Teramachia*. The only other known extinct species of *Teramachia* was described from the Mio-Pliocene [?Pliocene] Shimajiri formation of Okinawa, Japan as *T. shinzatoensis* (MacNeil, 1961, p. 96, pl. 9, fig. 1; Rehder, 1972, p. 9, figs. 5, 6). It was compared by the describer and Dr. Rehder with *T. johnsoni* (Bartsch, 1942).

The placement by Olsson (1964, p. 128) of his Pliocene Ecuadorian fossil *(Teramachia fischeri)* in the monotypic genus *Calliotectum* Dall (1890, p. 304) requires comment. Dall (1890, p. 305, pl. 5, fig. 8) considered the type species of *Calliotectum (C. vernicosum* Dall, 1890) to be pleurotomoid, but he noted the shell lacked an anal notch and a fasciole. Subsequently, Pilsbry and Olsson (1954, p. 19, fig. 16, rachidian tooth) proposed the volutid subfamily Calliotectinae with *Calliotectum* the type genus, on the basis of shell and radular characters, the radular ribbon being uniserial with a tricuspid rachidian tooth. Pilsbry and Olsson (1954, *op. cit.*) also referred *Teramachia* Kuroda, 1931, with *Prodallia* Bartsch, 1942 as junior synonym, to Calliotectinae. Weaver and duPont (1970, pp. 175, 176) added *Howellia* Clench and Aguayo, 1941 to the synonymy of *Teramachia*, 1931.

Dall (1890, p. 305) based *Calliotectum vernicosum* on five specimens dredged by the "Albatross", in 1888. Three of these were taken at station 2807, in 1485 meters from the type locality near the Galapagos Islands (00°24'00"S, 89°06'00"W). From this lot are Dall's figured specimen USNM #96555 (1890, pl. 5, fig. 8; Abbott and Dance, 1982, p. 224) here selected as lectotype (figs. 9, 10), and two paralectotypes: USNM #633904, and DMNH #10135 (Weaver and duPont, 1970, pl. 75, A, B) - both ex USNM #96555. The two remaining paralectotypes (USNM #97068) were dredged at station 2793, in 1355 meters off the coast of Ecuador (01°03'00"N, 18°15'00"W).

These typological specimens are very thin-shelled, with inflated whorls, the largest specimen being the lectotype with a height of 47.5 mm (spire incomplete) and with 6½ postnuclear whorls, and the smallest paralectotype being 24.8 mm in height (spire incomplete) with 5 postnuclear whorls. Although superficially resembling the shells of *Teramachia*, specimens of *Calliotectum* of the same stage of growth



FIGS. **9, 10.** *Calliotectum vernicosum* Dall, 1890, near the Galapagos Islands, in 1485 meters, lectotype USNM #96555; × 1.

FIGS. **1, 2.** *T. dalli claydoni* Poppe, 1986, off Port Hedland, northwestern Australia, in 450 meters, AMNH #221239. FIGS. **3, 4.** *Teramachia fischeri* (Olsson, 1964), Quebrada Camerones, Province of Esmeraldas, Ecuador, Tulane Geol. Dept. loc. 1397, Pliocene (early whorls and basal whorls missing). FIGS. **5, 6.** *T. mirabilis* (Clench and Aguayo, 1941), Little Bahama Bank, in 465 meters, IRCZM #065:02138. FIGS. **7, 8.** *T. johnsoni* (Bartsch, 1942), off Panglao, Bohol, Philippines, in 365 meters, AMNH #219986. FIGS. 1-8, approximately × 1.

have expanded, bulbous whorls and appear to represent a separate calliotectine lineage (cf. figs. 9, 10 with figs 1, 2 and figs. 3, 4). Therefore we reject Olsson's placement of *Teramachia* Kuroda, 1931 and *Prodallia* Bartsch, 1942 in the synonymy of *Calliotectum* Dall, 1890.

The widely disjunct modern distributional pattern of *Teramachia*, six species in the western Pacific and one in the western Atlantic (Emerson, 1985; Bouchet, 1986; Poppe, 1986), with extinct species in the Mio-Pliocene of Okinawa and the Pliocene of Ecuador, presents some problems in zoogeographic interpretation. The distribution of these deep-water mollusks is poorly known and the genus may be of wider occurrence than the available data suggest. Within the past few months, *Teramachia dalli claydoni* Poppe (1986) was described from the continental slope of northwestern Australia and an apparently new species of *Teramachia* inhabiting deep water off New Caledonia was reported (Bouchet, 1986). Additional species may eventually be found living in the eastern Pacific and elsewhere in the Atlantic Basin. The presence of *Teramachia mirabilis* living in the western Atlantic, however, may be an example of a Pacific faunal element which survived after being carried into the Caribbean region on the East-Pacific-Caribbean plate to its present position adjacent to Cuba (see Durham, 1985). According to Sykes *et al.* (1982), the Caribbean plate has moved east-northeast about 1,400 km since late Eocene time. Perhaps the precursors of *T. mirabilis* were carried into the western Atlantic on this plate. Durham (1985) cites additional examples of Pacific faunal elements that apparently moved with this plate into the Caribbean area.

Acknowledgments

In addition to Dr. Harry Lee, we thank Paula Mikkelsen, Indian River Coastal Zone Museum, Harbor Branch Oceanographic Institution, Inc., Fort Pierce, Florida, William D. Pitt, Sacramento, California, Drs. Emily and Harold Vokes, Tulane University, and Drs. Richard S. Houbrick and Thomas D. Waller, National Museum of Natural History, Smithsonian Institution, for the loan of specimens in their care. We also thank Drs. Joel Cracraft, Leslie F. Marcus, Malcolm McKenna, and Richard H. Tedford for an exchange of views on the biogeographical significance of Caribbean plate tectonics.

We are indebted to our colleagues in the Department of Invertebrates, American Museum of Natural History for their contributions to this study: Stephen M. Butler for the photography and Stephanie Crooms for word-processing the manuscript.

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REMINISCENCES

[About a hundred years ago The Nautilus *published many anecdotal accounts, but as the journal became more technical there was rarely an opportunity to add a personal touch. Because this 100th anniversary volume is dedicated to malacologists who have contributed in the past, we are including a few personal reminiscences by friends of William J. Clench and Joseph Rosewater. To the list of departed fellow-malacologists we regretably must add the name of that distinguished freshwater expert, Henry van der Schalie, whose touching obituary is included in this number of* The Nautilus. – R.T.A., editor].

To Joe Rosewater – from R. Tucker Abbott

[read at the 1985 memorial tribute at the Smithsonian Institution]

The corridors of malacology may be darkened today with the passing of our colleague and friend, Joe Rosewater, but we and generations to follow will find many bright rooms off to the side that are filled with Joe's warm kindness and illuminating scientific labors.

Calliostoma rosewateri – one of the most beautiful seashells of the Caribbean – was appropriately named after Joe by Drs. Clench and Turner twenty five years ago. Joe loved and understood the human qualities of his colleagues and a year later, in his famous biography of Calvin Goodrich, he quoted two letters written to his mentor, Bill Clench:

> "Thank you for naming the new species for me. In the days to come when the new generation rolls up its sleeves to undo the work of this one, as this one is undoing that of [taxonomic] workers who thought they had done a good, decent job, some one will note the name and speculate a bit about the guy it honors, and that will be in the nature of fame."

And Joe, with a sense of humor, went on to quote another prophetic letter:

> "Your students [meaning Clench's students] are of a high order. I was delighted with them, and would steal them away if I knew just how to go about it. After all, you've more students than you should have, considering the rarity of boys interested in mollusks. I wish you would tell them that I consider it far more of a pleasure to have met them and I have delighted in their friendliness and intelligence, whatever the police may think of them."

Just a month ago I received a letter from a now-retired, U. S. National Museum paleontologist living in Florida:

> "Joe really did a fine job of running the Division of Mollusks, and one could always write to him for help and expect a prompt reply. Joe was a careful and meticulous researcher as you well know."

Joseph Rosewater was born in Claremont, New Hampshire, on September 18, 1928. He was of the same New England breed of malacologists as the Binneys, Dall, Morse, C. B. Adams, A. E. Verrill and W. J. Clench. Following his early college days at the University of New Hampshire, Joe began his advanced training in malacology and museum curating at Harvard University. He was a favorite student of Clench's, and as Goodrich would say, was unknown to the police.

His magnificent service to the Smithsonian Institution began in 1960. Joe's twenty-five years of malacology was a fulfillment of James Smithson's bequest for the "increase and diffusion of knowledge among all men." He served as President of the American Malacological Union in 1968, and as President of the National Capitol Shell Club in 1964. His contributions to the leading malacological journals of America are well-known to his colleagues. His travels in search of mollusks to the Marshall Islands, Indonesia, Australia and Panama were the envy of all devoted shell collectors. No more gentle soul, with such a quiet sense of humor, nor with a more natural ability to help both professional or amateur malacologists could we all have asked for. Let us hope that his successors will match his sterling qualities. Let's light up the halls of the National Museum once again.

About Bill Clench – from Mary C. Kline

[Mary Kline, now of Honolulu, and her late husband, George, were for many years ardent shell collectors who contributed many thousands of specimens, photographs and much biological

information on mollusks for the journals, Johnsonia *and* Indo-Pacific Mollusca.]

Bill Clench was one of my favorite "extremists"–extremely kind, caring and loyal; an extremely good raconteur. By his enthusiasm for collecting shells and his insisting that the neophyte keep good field notes, he directed many beginners down the happy road to extremely rewarding and meaningful adventures.

Our friendship with Bill started about forty years ago when George and I first fell prey to the spell of the shell during a visit to Sanibel. On that first day of beach-walking George found a "different looking" shell. Local savants urged us to write to Dr. Clench at Harvard. The shell turned out to be an almost unheard of albino *Fasciolaria distans.*

And so began an encouraging flood of correspondence in response to our new shelling trips to the Florida Keys and Bahamas. Bill was in those days launching his new journal, *Johnsonia.* We had many live-collected specimens, plenty of notes and colored pictures of animals. "Drop everything, come to the MCZ [Museum of Comparative Zoology] for a weekend and bring the slides." We went, we talked, we spent a long time on the steps of the museum bing innoculatead with Bill's enthusiasm. At his home, his wife Julia, was a marvelous hostess who had great patience and was a perfect house mother to all and sundry who interested Bill.

Bill was many things but hardly the Ivory Tower type. For example: one day when we arrived at the museum lab he could hardly wait to show us his latest treasure. We knew that he and his associates had been working for a long time on a seemingly endless project–cleaning and rehabilitating the myriad drawers in the many huge specimen cabinets. As each drawer was finished a small blue star was affixed to the front, indicating that it had been completed. At last the goal had been reached and a party was given to celebrate. Bill was presented with a beautifully wrapped gift package. Inside was a suitably framed miniature of a real pair of Long-John bottoms with blue stars glued all over them! How this wonderful man loved those "Blue Starred Drawers!"

He begged us to become interested in land shells as well as freshwater mollusks for, he said, "the human population will grow and grow and habitats will become neighborhoods–freshwater shells will disappear for pollution is inevitable but the sea will always be with us." He lived to see the land fills where once there were reefs. Many fashionable resorts now have replaced sleepy lagoons over much of the tropical world.

What did I learn from Bill?–so many things–and here are just a few. 1. A shell without data is just a pretty bauble. 2. Learn the scientific names, beach names are generally local. 3. Be sure to learn the dangers of the areas in which you are shelling–and avoid them. 4. Join the A.M.U. and your local Shell Club. 5. In a foreign country deal with the proper authorities and remember, in your own way you represent America. 6. Ask the museum curator how you can help–leave the scientific side to him. 7. Keep accurate notes and charts–be a good observer. 8. Don't take all shells from one colony–leave the habitat as you found it. 9. And lastly, but far from least, keep your sense of humor.

Remembering Bill Clench–from Bunny Baker

[Mrs. Horace B. Baker, for many years the business manager of The Nautilus, *was raised in Boston, and has been an ardent sheller for over fifty years.]*

I first met Bill Clench in the fall of 1933 when I went to work at the Boston Children's Museum. The museum's exhibits were mostly on natural history topics, and though I was the financial secretary and only office worker, I thought I should know some natural history. My lifelong friend and childhood chum, who also worked in the museum, and I had collected shells along the Mass. coast, and so that seemed the logical place to start. I joined the Boston Malacological Club, and there met Bill who was to become a large part of my life.

In the fall of 1934 my chum, her mother, sister and I went to Miami for our vacation. Her family returned home by boat after a few days, and we two girls drove across the Tamiami Trail to Sanibel Island to collect shells. Bill had told us so much about it that we wanted to collect there. After a week we drove back to the east coast and met Bill and two of his students who had been on a collecting trip to Cuba. We all drove down to Homestead and into the Everglades where we camped out for five days and collected Liguus. Bill helped us identify the various color forms and taught us a lot about collecting and cataloguing our catch. It was a wonderful experience and of course we all got really acquainted with each other. We got hundreds of shells, and those added to my Sanibel collection and others from around the world gave me quite a cabinetfull. They are now in Harvard's Museum of Comparative Zoology.

Bill, his family and I saw much of each other; I became Secretary-Treasurer of the Boston Club and joined the A.M.U. It was at that meeting in Toronto in 1939 that I met my husband. Bill introduced us. In 1941 Bill drove his family and me to the meeting in Rockland, Maine. After a few days there I became engaged to H. B. Baker. We were married in December, 1941, and I moved to Philadelphia after a honeymoon on Sanibel.

In subsequent years we saw Bill often and kept in close touch. He had many friends and admirers. I am happy to have been one of them for over 50 years.

We will never forget you, Bill.

To Bill—Cecelia W. Abbott

[*Cecelia W. Abbott succeeded Mrs. Baker as Business Manager of* The Nautilus, *and she often accompanied Dr. Clench in his later life on his collecting trips to Kentucky, Georgia and Florida and more recent A.M.U. meetings.*]

So much of Bill Clench's life was devoted to helping new students and encouraging amateurs to study and collect shells that I thought it only appropriate that a special trophy be created for shell shows that would emphasize his keen interest and love of land and freshwater mollusks.

FIG. 1. Three proud winners of the William J. Clench Award in Jacksonville, Florida, all of whom created outstanding exhibits on non-marine mollusks. (from the left: Archie Jones, Zida Kibler and Alfredo Romeu). Photo by William Kibler.

The opportunity afforded itself when the Jacksonville Shell Club celebrated its 25th anniversary in 1984. I lent a splendid sketch of Bill and with the efforts and talents of club member, Allan B. Walker, a handsome plaque was designed. Bill's likeness, surmounted by two of his favorite shells—*Canthyria spinosa* (Lea) and *Triopsis albolabris* (Say) graced the William J. Clench Award "to the outstanding exhibit of land or freshwater mollusks that shows overall excellence and best furthers interest in nonmarine conchology."

The award has now been given three times, the first one, in 1984 to Archie Jones of Miami, Florida, an old friend of Bill's and an expert on *Liguus*. Other winners, to date, have been Zida and William Kibler, in 1985, of Shallotte, North Carolina, for their worldwide land shell exhibit, and Dr. and Mrs. Alfredo Romeu of Jacksonville, Florida, for their Land Shell of the World exhibit, 1986. Our hope has been realized that this trophy is inspiring others to produce outstanding, educational exhibits, and is reminding us all of the wonderful qualities of this kind and generous man after whom the Clench Award is named.

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MOLLUSK VOUCHER SPECIMENS

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