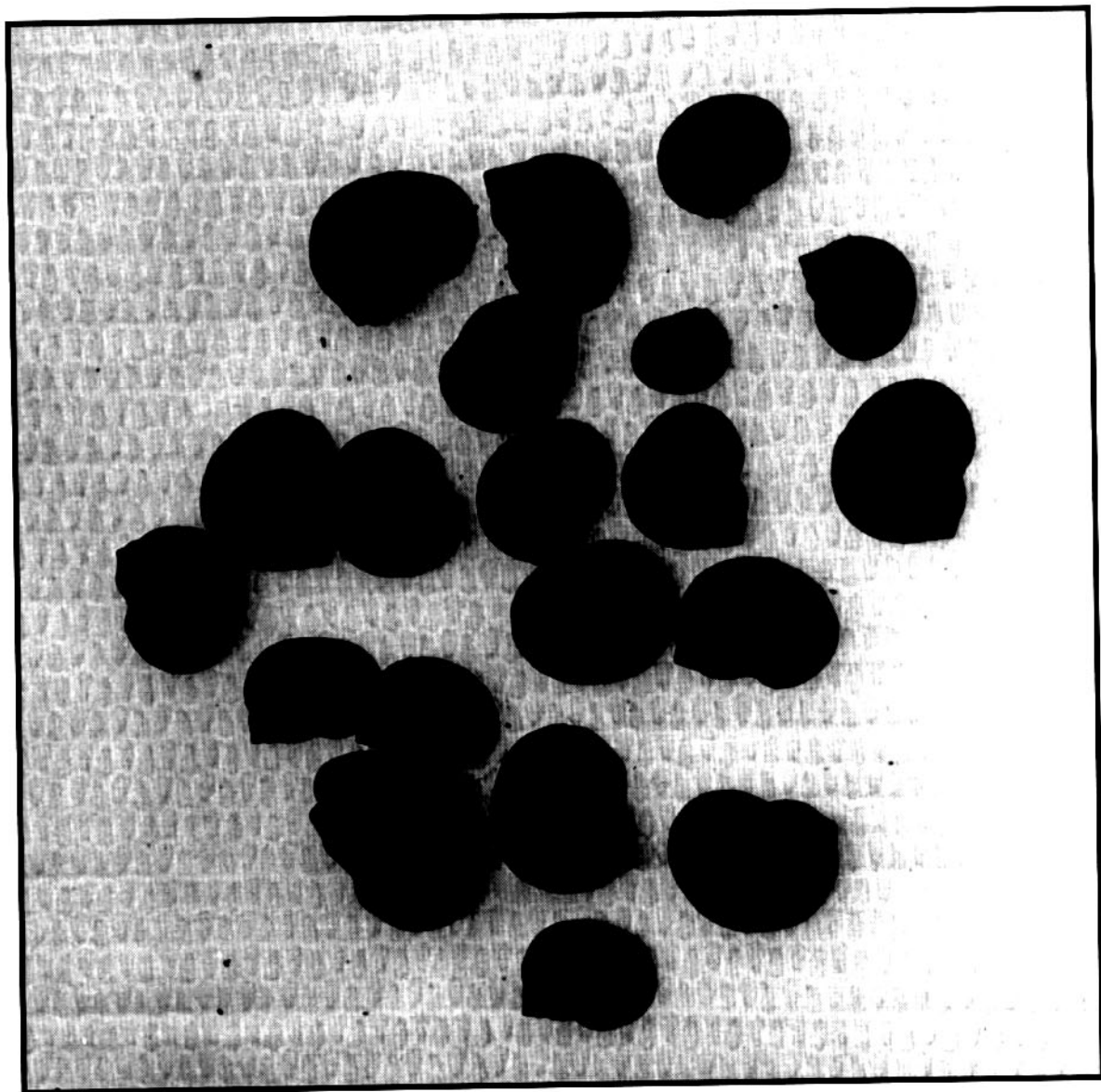


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Volume 17, No. 3

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## In This Issue

### Spatial Patterns in a Population of Olivella semistriata (Gray, 1839) in a Pacific Beach of Nicaragua

A. Mijail Pérez & A. López, S.J. 124

Two Land Snails from Italy Beatrice M. Winner 130

### Abnormal Molluscs II: Philippine Islands

James L. Barnett & Manuel O. Montilla 133

Lure of the Liguus, Continued Henry T. Close 143

### A Taxonomic Discussion and Update of Shell-Bearing Marine Molluscs reported from the Northwest Atlantic Ocean North of Cape Cod (excluding Greenland), and Canadian Arctic Archipelago

Ross Mayhew & Flone Cole 159

An Adaptive Bivalve Brian C. K. Dy 170

### Update on Octopus giganteus Verrill, Part 1: More forgotten fragments of its 19th century history

Gary S. Mangiacopra, Michael P. R. Raynal,  
Dr. Dwight G. Smith and Dr. David F. Avery 171

The Cowry n.s.	132	1995 Shows, etc.	131	Program Available	130
First International	132	In Review	128	Your Ideas Please	129
		Poets' Corner	128	Our Covers	178

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Articles from this magazine may be reprinted in other publications provided full credit is given the author and Of Sea and Shore Magazine and two (2) copies of the complete publication in which the reprint appears are mailed to the Editor at the above address.

## From the Editor's Desk

Looks like I didn't leave myself much room for an editorial, so I'll just wish you all well. Hope you enjoy this issue and will think about contributing an article for the next one. Off to the Philippines and Thailand, as you read this - maybe you'll come along next time!

Tom Rice, Editor

## DISPLAY AD INDEX

Capensis Seashells	122	Guido T. Poppe	179
Charles Cardin	141	Rocks & Gems	142
Phillip W. Clover	127	Edward T. Schelling	141
Dryasac	122	Schooner Specimen Shells	127
Mathilde Duffy	141	The Sea	131
Epinet	142	Sea Gifts	131
Femorale	122	Shell World, Inc.	127
Thomas Honker	127	Specimen Shell Sales	127
La Conchiglia	126	Jorge Vasquez	141
La Jolla Cave & Shell Shop	122	World Shells	141
Perth Shell Distributors	122	Worldwide Specimen Shells	122

# Spatial Patterns in a Population of *Olivella semistriata* (Gray, 1839) (Gastropoda: Prosobranchia: Olividae) in a Pacific Beach of Nicaragua

A. Mijail Pérez & A. López, S.J.\*

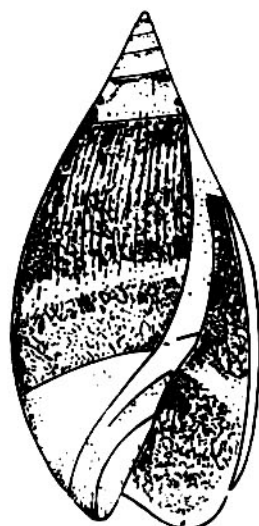


Fig. 1

**Abstract:** Spatial patterns were studied in a population of *Olivella semistriata* in a sandy beach of the northern Pacific coast of Nicaragua. The methods employed, Block Quadrat Variance (BQV) and Two-Terms Local Quadrat Variance (TTLQV), show that there is a clear clumped pattern present. The possible causes are biological (e.g. gregarious habit) and ecological (differential beating of the waves).

**Keywords:** *Olivella semistriata*, Olividae, Spatial patterns, sandy beach, Nicaragua.

According to Emmel (1975) spatial patterns are an important characteristic of plant and animal populations. Connell (1963), stated that this is one of the most fundamental properties of any group of living organisms.

The study species, *Olivella semistriata* (Gray, 1839) (Fig. 1), offers an excellent organism for studying this property, due to its great abundance and continuous distribution along the range. It ranges from the Gulf of California to the northern shore of Perú (Keen, 1971) where it inhabits the infralittoral (Sabelli, 1979) and the mesolittoral (personal observation).

Here we investigate the spatial pattern of a population of *O. semistriata* in a sandy beach of the Pacific coast of Nicaragua, Central America.

Jiquilillo beach is located in the Department of Chinandega, on the north Pacific coast of Nicaragua (12° 45' N, 87° 31' W) (Fig. 2). The study was conducted in the morning of November 20, 1993.

Three basic patterns are recognized by ecologists: random, clumped and uniform. We tested the null hypothesis that the spatial pattern was random, the

alternative led us towards the other two (clumped or uniform).

The sampling consisted in making 121 contiguous quadrats along a line transect parallel to the edge of the tide line. All sampling was made during the same tide, in order not to have to move the transect backwards or forward due to the changing tide. The number of individuals present was counted in each quadrat.

To determine the pattern, we employed the Block Quadrat Variance (BQV) method developed by Greig-Smith (1952a) and Goodall (1954a), in which we computed the variance of the number of individuals at different block sizes obtained by combining  $N$  quadrats to some power of 2 (e.g.  $2 = 256$ ). The work equation for block size 1 is:

$$\text{Var}(x) = (2/N) \left( \left[ \frac{1}{2} (X_1 - X_2)^2 \right] + \left[ \frac{1}{2} (X_3 - X_4)^2 \right] + \dots \left[ \frac{1}{2} (X_{N-1} - X_N)^2 \right] \right) \quad \text{where:}$$

$N$ : number of quadrats sampled  
 $X_i$ : counts of individuals per quadrats

Considering the limitations of the previous method, restricted to work with some power of two, we also employed the Two-Term Local Quadrat Variance method developed by Hill (1973a) as an alternative to the BQV method. This method is basically the same, but with another blocking "scheme". The work equation for TTLQV method at block size 1 is:

$$\text{Var}(x) = \frac{1}{(N-1)} \left( \left[ \frac{1}{2} (X_1 - X_2)^2 \right] \left[ \frac{1}{2} (X_2 - X_3)^2 \right] + \dots \left[ \frac{1}{2} (X_{N-1} - X_N)^2 \right] \right)$$

The variables mean the same as in BQV.

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Fig. 2

With the variances obtained at different block sizes an XY plot is made, which is afterwards compared to theoretical plots showing the more or less typical behaviour of the three basic patterns (Fig. 3).

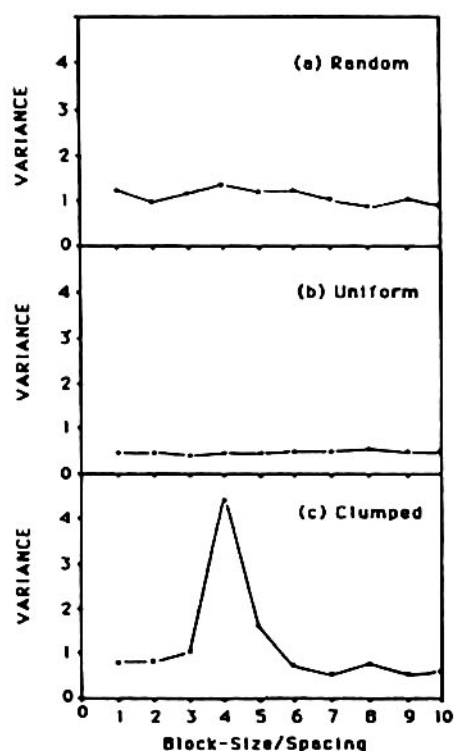


Fig. 3

The XY plot obtained (Fig. 4) shows a behaviour that fits well with the clumped pattern. However, considering the decrease of the variance at block sizes 8 and 16, and the few points to analyze, due to the intrinsic limitations of the method, it is not easily seen.

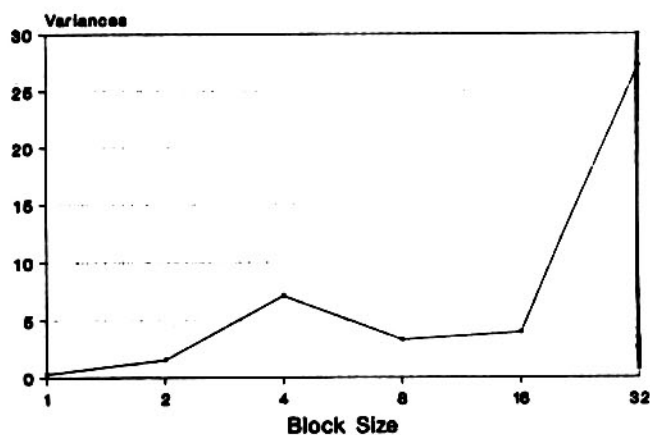


Fig. 4

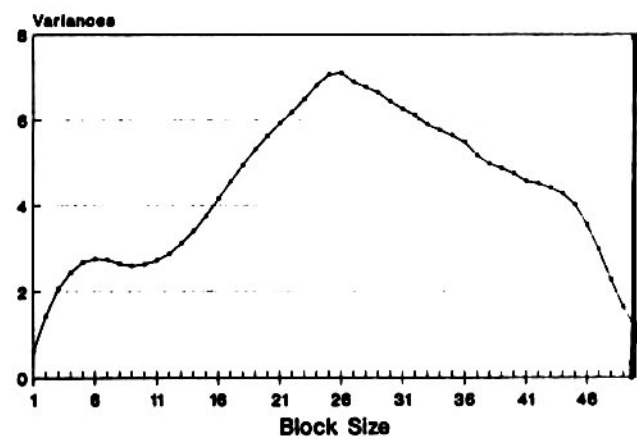


Fig. 5

In the XY plot obtained with the TTLQV method (Fig. 5) a much clearer interpretation of the underlying patterns can be had. The nature of the method gives the possibility of having several more block sizes to consider, therefore the scatterplot is very much wider and easier to visualize. Hence, a clear clumped spatial pattern is observed.

Ocular inspection of areas of the beach additional to those sampled, confirm our calculations and lead us to conclude there is a clumped spatial pattern present in the population studied.

From the theory we know that random patterns in a population of organisms imply environmental homogeneity and/or non-selective behavioural patterns. On the other hand, non random pattern (clumped and uniform) imply that some constraints on the population exist. Clumping suggests that individuals congregate in the more favorable parts of the habitat; this may be due to gregarious behaviour, environmental heterogeneity, reproductive mode and so on.

Although detecting a pattern and explaining its possible causes are separate problems (Ludwig & Reynolds, 1988) we here briefly discuss some of the possible reasons.

As far as we could examine, the nature of the sand along the beach is homogenous, which partially eliminates the possibility of environmental heterogeneity and points towards a gregarious behaviour, reproductive mode, both or some other intrinsic reason.

It should be kept in mind, however, that nature is multifunctional and many interacting processes (biotic and abiotic) may contribute to the existence of patterns (Quinn & Durham, 1983). Therefore, another possible factor to be considered is the beating of the waves, which may be slight but measurably different at diverse points of the shore. This last factor, together with the ones mentioned above, might be the cause of the pattern observed.

One interesting thing to point out is that these animals, since they are infra- and mesolittorals, move in the direction of the waves, outward at high tide and inward when low. However, they seem to conserve their underlying spatial pattern despite their constant moving.

*Olivella semistriata* is the principal food item of the different *Agaronia* spp. that prey on them at low tide (Lopez, 1978) such as *A. griseoalba* (Martens, 1897) and *A. nica* (Lopez et al, 1988). The incursion of these predators into the *Olivella* colonies may well be a factor affecting distribution patterns.

However, a lot of work remains to be done to clarify the ecology and the taxonomy of this interesting species, which also shows a great deal of colour polymorphism.

#### ACKNOWLEDGMENTS

We are grateful to Isabel Siria Castillo, from the Nicaraguan Institute of Terrestrial Studies (INETER) of Managua, Nicaragua, for the drawings presented in this paper.

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Designed in beauty  
loveliness and grace

Beware ..... deadly  
Pretty snail

Deceptive Textile Cone  
The deadly Cloth of Gold

## The Jellyfish

The Jellyfish  
has no mind of its own  
lives by the way of the wave.

Devilfish \_ \_ \_ the Manta Ray  
as gentle as can be ... so graceful  
ballerina of the sea.

Plant-like animal --- the Sea Anemone  
with lethal tentacles -- yet beautiful  
like a flower nodding to greet you.

**The three poems above are by**

**Josephine Young**

## IN REVIEW

### AUSTRALIAN MARINE SHELLS (2 volumes)

[Prosobranch Gastropods]

Barry Wilson (Vol. 1: 1993, Vol. 2: 1994)

Odyssey Publishing, Australia

Years ago, when I was first involved in collecting and studying shells, the only book available on the shells of Australia was Joyce Allen's "Australian Shells" (1959). In the intervening years there have appeared several books on the subject of the shells of that large island continent, but until 1992's publication of "Bivalves of Australia" (Volume 1) by Lamprell and Whitehead and now the two volume set covering the prosobranch gastropods, there was nothing really comprehensive that included color photographs and extensive coverage of the families, habitats and living animals that produce these magnificent collector's items - sea shells.

With the publication of Myra Keen's "Seashells of Tropical West America", we collectors had a shell "bible" for that area of the world's oceans, now with the appearance of "Australian Marine Shells" we have a similar "bible" for at least a great number of the shells that area of interest. These large volumes (each measures 8½ by 12 inches - volume one has 408 pages, volume two 370 pages) are loaded with information, gorgeous color photographs (100 full-page color plates) of both the molluscan shell and the living animal and hundreds of excellent line drawings (600 hundred) for those species not included in the color plates. Arranged systematically, each species entry (following sections on superfamily, family, subfamily, genus and subgenus) includes detailed description of the shell and animal, size, range and rarity of the species as well as a list of synonyms.

Volume one includes families from the limpets through the eulimids, including the popular cowries, as well as introductory text, information on nomenclature, collecting and preserving shells, etc. Volume two continues the coverage from the murex shells to terebras, and includes both the cones and the volutes.

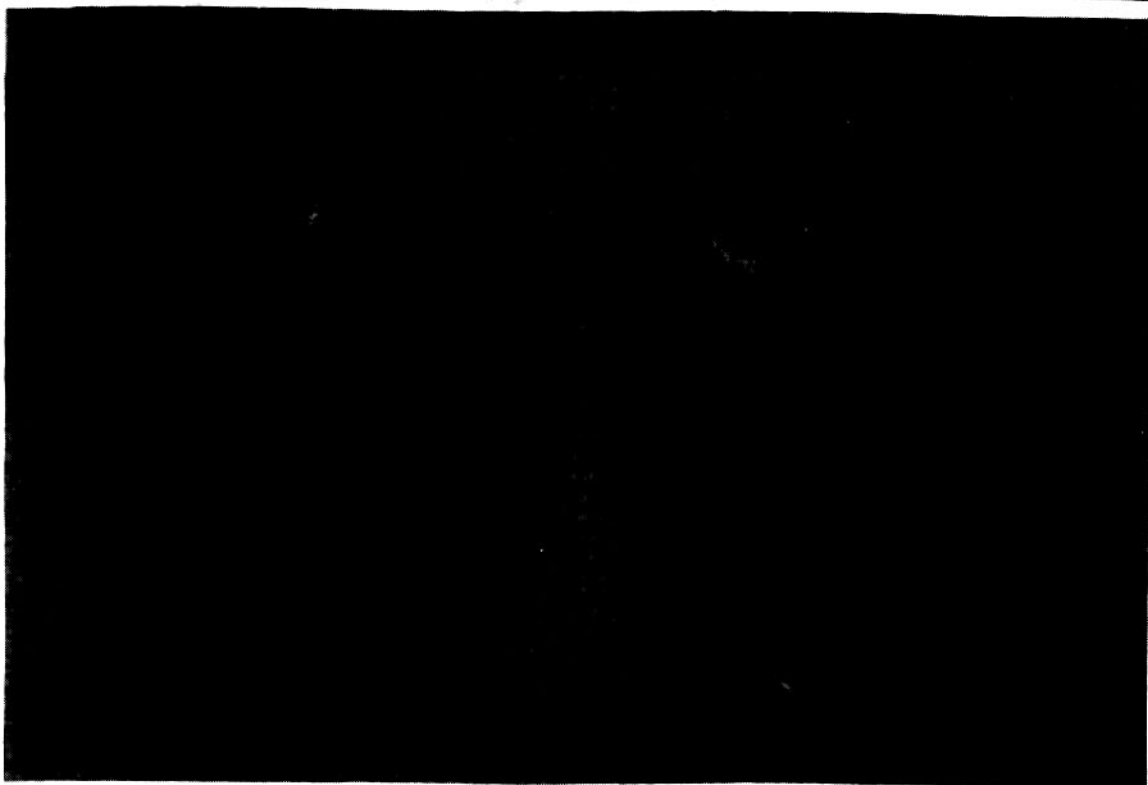
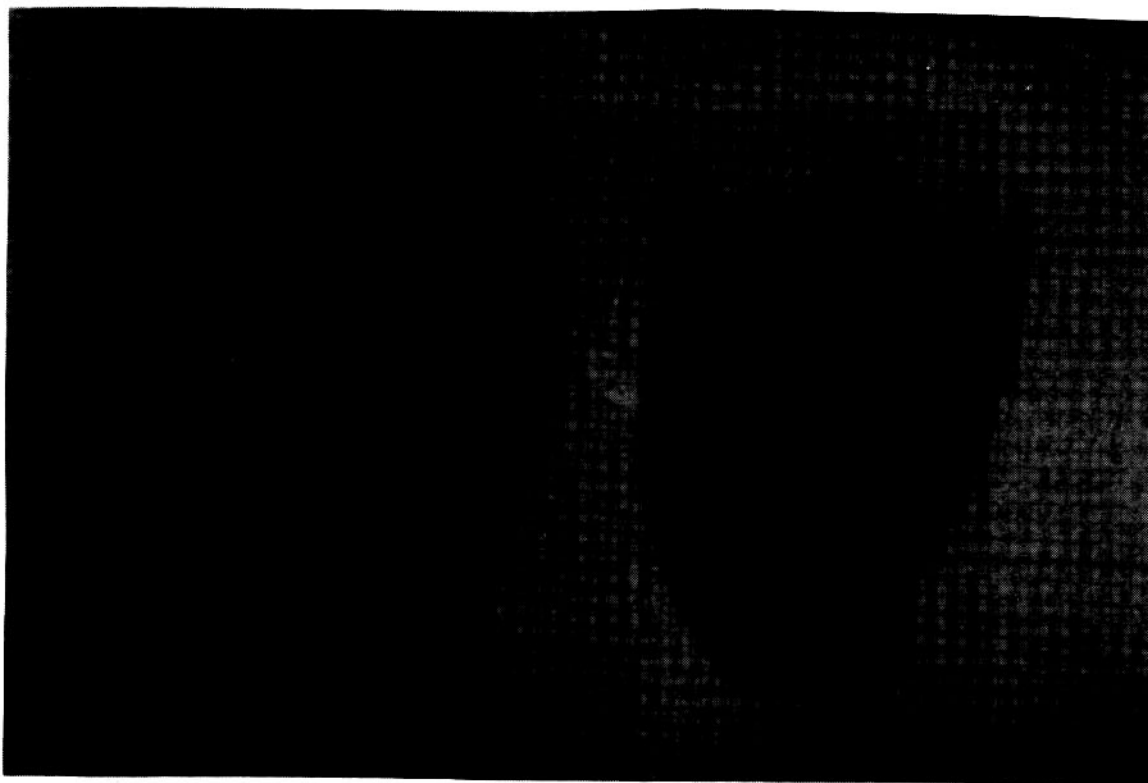
Unless one specializes in only a single family, I don't know why anyone would only want a single volume of the set. For myself, I know both volumes will get heavy use and be constantly referred to in my studies. And I will heartily recommend the set to anyone interested in the shells of Australia - or in shells in general.

Great job Barry!

**Reviewed by Tom Rice**



## Your ideas please!

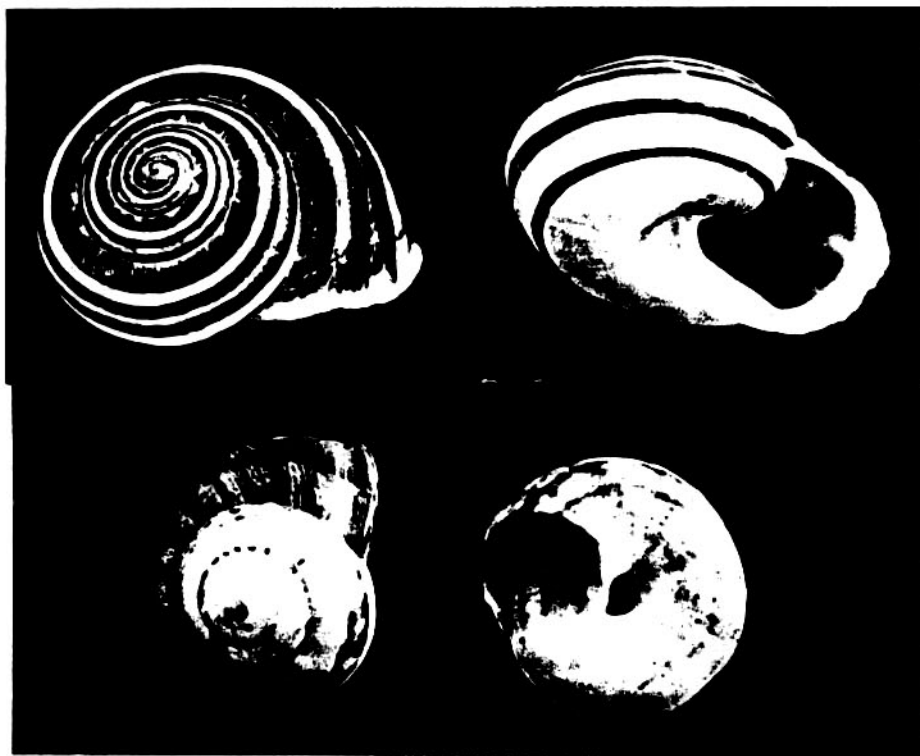


The above two specimens of *Voluta imperialis* are in the collection of Paul Kanner of Los Angeles. Paul obtained them as a gift from a friend. The only locality data is that they are from Siasi island, Sulu Sea, Philippines. Does anyone have an explanation for the

unusual spine-less specimen? Paul says that volutes are not a particular interest of his and he'd be open to a trade. The shells are gem condition and 215mm in length. Write Paul at 10609 Esther Ave.; Los Angeles, CA 90064.

## Two Land Snails from Italy

Beatrice M. Winner



In May of this year I went to Rome to visit my cousin. He then took me to the town where my father was born, Petilia Policastro, Prov. of Calabria. It was here at his country home while walking around the grounds, and in his orange orchard, that I found these two snails. The large one is *Eobania vermiculata* (Müller, 1774), [upper pair above] average length 3 cm.; the other is *Theba pisana* (Müller, 1774) [lower pair above] with an average length of 1.5 cm.

My cousins' maid, Elsie Lazzaro, and her family have quarters on his property. I happened to show her the snails and asked that if she found any would she let me have them. I was surprised when she showed me a pan full. She was going to have them for supper that night - they're a delicacy. Elsie has four children and she has them go into the fields and pick up snails. Quite often these snails can also be found on trees as well as the ground.

Here is how she cooks them:

First she washes the snails, then soaks them in salt water for a little while and finally throws them in boiling water for five minutes. She then removes the snail from its shell and sets the shell aside. In the meantime she prepares a fresh tomato sauce (with oil garlic, oregano, basil, little onions, salt and pepper) and after this sauce has cooked the snails are added and cooked for an additional five minutes.

Else saved me some to eat - and I did manage to get two down! Somehow, after collecting all these years, I find it difficult to eat snails of any kind.

I did bring some specimens home alive - and they are doing well and are eating lettuce.

### Program Available to Clubs

A recent issue of *Hawaiian Shell News* contained a short notice on a video that would be of interest to those struggling to find something interesting for the shell club's program. Produced by the U.S. Government and Virginia Tech it concerns native freshwater bivalves and the environmental crisis brought on by the "invasion" by

the infamous zebra mussels. The video comes with a script and costs only \$6. (To cover postage and handling.) By the way, the video does have sound. A special mussel poster is also available for \$1.75. Orders can be made - and the check made out to - Virginia Tech Extension Distribution Center, 112 Lansdowne Street, Blacksburg, VA 24061-0512.

## 1995 Shell Shows, Etc.

The following list is courtesy of Donald Dan, COA Award Chariman. To list your club's event contact him at 2620 Lou Ane Court; W. Friendship, MD 21794. Tel. (410) 442-1242 or 442-1942.

- Jan. 14-22. Oregon Shell Show; Portland, Oregon  
Maxine Hale; 347 N.E. 136th Avenue; Portland,  
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- Jan. 21-22. Astronaut Trail Shell Show; Melbourne,  
Florida. Jim & Bobbi Cordy; 385 Needle Blvd.;  
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- Jan. 27-28. Greater Miami Shell Show; North Miami,  
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- Feb. 3-5. Broward Shell Show; Pompano Beach, Florida  
John Chessler; 7401 S.W. 7th Street; Plantation,  
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- Feb. 4-5. VII émes Recontres Internationales du  
Coquillage; Paris, France. Gilbert Jaux; 3 rue  
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- Feb. 10-12. Ft. Myers Festival of Shells; Ft. Myers,  
Florida. Anna Marie Nyquist; 18372 Cutlass  
Drive; Ft. Myers Beach, FL 33931.  
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- Feb. 17-19. Sarasota Shell Show; Sarasota, Florida.  
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- Feb. 24-26. Naples Shell Show; Naples, Florida. Gary  
Schmelz; 5575 12th Ave. S.W.; Naples, FL  
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- Mar. 2-5. Sanibel Shell Show; Sanibel Island, Florida.  
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- Mar. 9-11. Marco Island Shell Club Show XII; Marco Id.,  
Florida. John Maerker; 365 Henderson Court;  
Marco Island, FL 33937. (813) 394-3438.
- Mar. 17-19. St. Petersburg Shell Show; Treasure Island,  
Florida. Bob & Betty Lipe; 440 75th Avenue; St.  
Petersburg Beach, FL 33706. (813) 360-0586.
- Mar. 17-19. Treasure Coast Shell Show; Stuart, Florida.  
Mrs. Cathy Fry; 1542 Jupiter Cove Dr. Apt. 502;  
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- Mar. 31- Apr. 2 [tentative]. Georgia Shell Show; Atlanta.  
John Cramer; 3537 Peppermint Court; Tucker,  
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- May 7. Pacific Shell Club Show; San Pedro, California.  
Frank Jewett; 1739 Vallecito Dr.; San Pedro, CA  
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- May 6-7. Fifth Belgium International Shell Show;  
Aarschot, Belgium. R. de Roover; Vorsterslaan  
7; 2180 Ekeren-Donk, Belgium. (3) 644-3429.
- June 8-12. American Malacological Union Annual  
Meeting; Hilo, Hawaii. Dr. Alison Kay; University  
of Hawaii; 2538 The Mall; Honolulu, HI 96822.  
(808) 956-8620.
- Jun. 17-18. XIV éme Salon International du Coquillage;  
Lutry, Switzerland. Dr. Ted W. Baer; CH-1602  
La Croix, Switzerland. (21) 393771 or 207371.

Jun. 23-29. Conchologists of America Annual Convention;  
San Diego, California. Don Pisor; 10383 El  
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Also we have been made aware of:

Jan. 2 - 7. International Conference on Computer  
Modelling of Seashells. Tweed Valley, N.S.W.,  
Australia. Prof. Chris Illert; Science-Art Research  
Centre; 2/3 Birch Crescent; East Corrimal, NSW  
2518, Australia. Tel/Fax 042 833009 (in  
Australia) or +61 42 833009 (outside Australia).  
See announcement on next page.

June 2-6. Western Society of Malacologists; 28th Annual  
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Continued from page 140

leadership role. While 150 nations signed the treaty, which calls for a reduction in greenhouse gas emissions, the treaty does not require precise reductions.

Thus, at present, scientists are divided on the possible causes and effects of global warming; global warming treaties are vague on what the various nations should do about reducing greenhouse gases, and the whole subject is bogged down by the lobbying of big business and industry, and by the fact that politics has become enmeshed in the entire situation. Politicians, like scientists, have taken sides, and a stalemate has resulted.

### CONCLUSIONS

Abnormal shells are appearing in the Philippines, and other tropical and sub-tropical regions, in large quantities, and almost all of the known genera of the various regions are included in this phenomenon. The causes of the abnormalities are unknown at the present time, but it appears that it may be a combination of causes.

American scientists, climatologists, marine biologists, oceanographers and others are working on the problems of coral bleaching, the world's changing weather and related topics, but very few are concerned with molluscs, whether normal or abnormal.

This being the case, it behooves anyone interested in molluscs, whether a mere collector, a writer, a shell dealer, or anyone else having access to shells from all areas of the world to pool their information through exchanges of correspondence, showing of abnormal shells at shell shows, writing about the abnormal shells of their particular area in publications such as Of Sea and Shore.

Finally, I would suggest that the larger shell organizations, throughout the world, put the subject of abnormal molluscs on the agenda of their annual conventions, where so much seems to be accomplished in the fields of conchology and malacology. This might create an interest in the subject on the part of governments who are in a much better position to carry out broad studies. Who knows, maybe the lowly sea shell may be our best indicator of where and why other sea dwellers and sea structures are showing signs of stress and abnormalities.

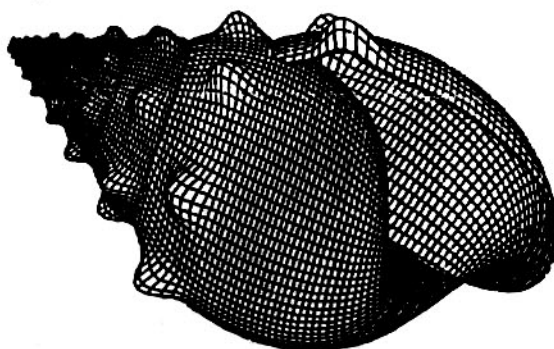
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\* For further information contact:

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### The Cowry n.s.

The first issue of the new series of this publication, devoted to the superfamily Cypraceae and the related Velutinacea, has appeared. Articles include "Lt.-Col. R.J. Griffiths and his cowry journal" by J. Zidek & J.H. Black, "Catalog of fossil and Recent Cypracidae and Eocypracinae (Ovulidae) described since 1971" by L.T. Groves and "Beach-collecting cowries: Possibilities and limitations" by W. Krommenhoek. Information: Jiri Zidek, Editor, P.O. Box 95; Socorro, NM 87801 U.S.A.



# Abnormal Molluscs II: Philippine Islands

James L. Barnett\* & Manuel O. Montilla\*\*

An earlier article on abnormal molluscs (*Of Sea & Shore*, Winter 1993) dealt with a number of abnormal shells from a variety of tropical and sub-tropical areas. The present article deals with abnormal shells from the Philippines only. Included are shells from a number of families and genera.

The senior author would like to acknowledge the contribution to the study of abnormal Philippine molluscs to Mr. Manuel Montilla. Mr. Montilla provided all of the abnormal and most of the normal shells depicted herein. He has also supplied significant current information on the subject of abnormal shells found in Philippine waters. It is all too infrequently that an individual from a shell-rich country, such as the Philippines, becomes involved in scientific research. Mr. Montilla is to be commended for his participation in such studies, and he is to be thanked for his contribution to our further knowledge of the biology of the Philippine Islands.

In the earlier article, such topics as what are abnormal shells, where are they found and what are some of the possible causes of shell abnormalities, were discussed in some length. The following is a brief review of those topics.

Abnormal, or unusual molluscs, go by a variety of names, including "freaks", "seconds", "diseased shells", "defective shells" and other terms which indicate that they are not the normal shell representative of their genus and species. Abnormal shells can be unusual in color, shape, pattern and size.

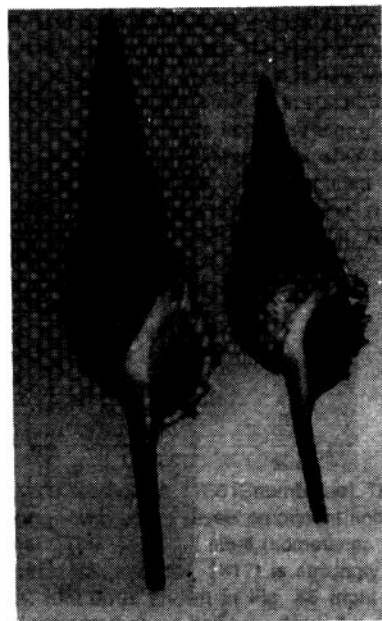
At this time abnormal shells have been found in every region of the tropical and sub-tropical world. This includes the Pacific and Indian Oceans, the Caribbean and Red Seas and the South Atlantic Ocean. Most abnormal molluscs are associated with coral formations, and most have been found in or near warm water coral reefs.

There are many possible causes of the recent appearance of large numbers of abnormal shells, but as yet the exact cause(s) is unknown. Some of the suggested causes of the appearance of abnormal

molluscs (and possibly the phenomenon of coral bleaching) are waters which are polluted with industrial wastes, silted waters, waters with too high or too low salinity levels, waters which are too warm due possibly to universal global warming, and other man-made causes. Present research indicates that the cause is probably the presence of a combination of the above factors.

The molluscs which are depicted and described below have all been taken in Philippine waters in the last two or three years. Most authorities on Philippine shells are of the opinion that large numbers of abnormal shells began appearing during the 1986-87 period.

In the accompanying photographs, the normal shell will be shown on the left and the abnormal shell(s) will be shown on the right.



1. *Tibia fusus* (Linné, 1758) [Strombidae]. The typical *T. fusus* presents the appearance of a long, slender shell with a tall spire and a long anterior canal. The final whorl and the spire whorls are well-rounded and the sutures are slightly impressed between each whorl. The abnormal *T. fusus* presents the appearance of a short, blunt shell. The anterior canal is unusually short and straight. While the final whorl is well-rounded, the spire whorls are squared-off rather than rounded. The normal shell averages about 200mm, while the abnormal shell averages about 115mm. Both shells from Basilan Island, Mindanao.

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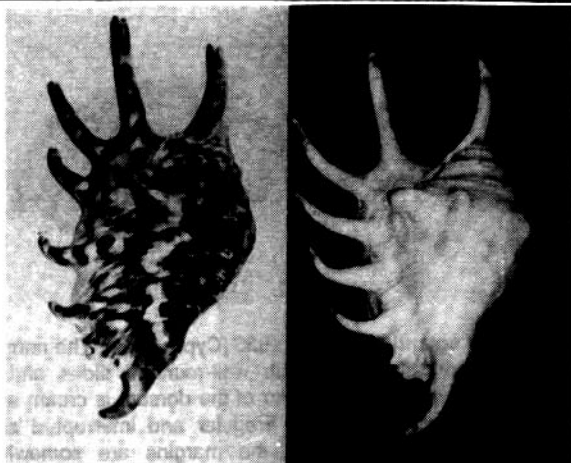


2. *Lambis millepeda* (Linné, 1758) [Strombidae]. The typical shell is generally thought of as having nine short digits. The normal shell is usually heavily marked with light to dark brown, and averages about 140 mm. The abnormal shell (center) has ten digits and, in addition, has a second row of four digits growing at the back of the top of the shell. This large (150 mm) shell has a total of 14 digits, and its color ranges from a light brown to white. Another abnormal specimen (right) has only four digits - while this specimen might be a semi-adult, it is fully developed in all respects. All specimens are from Santa Cruz Island, off Zamboanga, Mindanao.

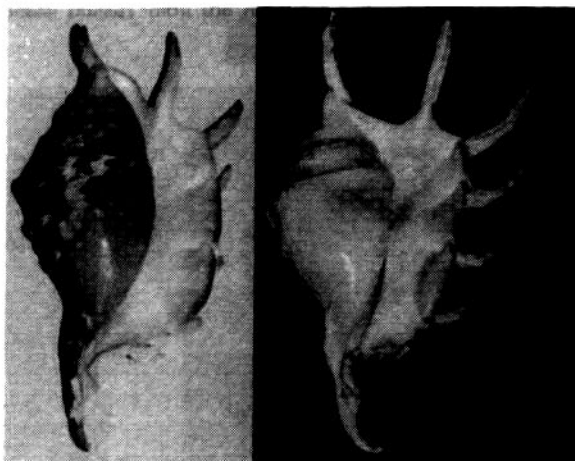


3. *Lambis scorpius* (Linné, 1758) [Strombidae]. The normal specimen is characterized by the presence of six relatively long digits, which are, more or less, evenly spaced along the top and the outer lip of the shell; the shell is cream, orange and brown, and averages about 135 mm. The abnormal specimen has ten digits and there is a large space between the two longest digits on the shell's top, but the digits along the outer lip are very closely placed; the shell is much darker than usual and the specimen measures 145 mm. Both specimens are from off Bulan, Sorsogon, Albay Gulf, Southern Luzon.

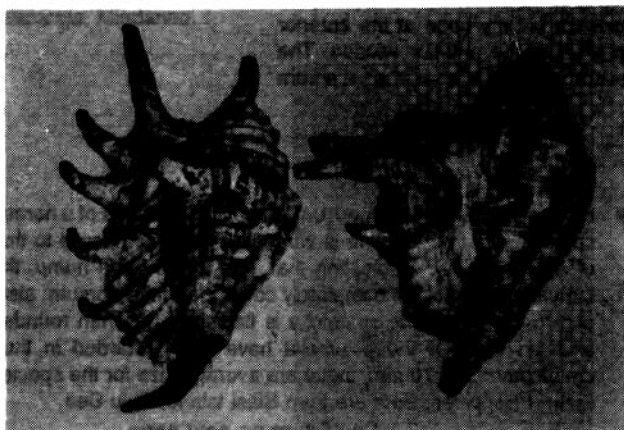




4a. *Lambs lambs* (Linné, 1758) [Strombidae]. The normal shell generally has a dorsum heavily marked with dark brown bands and blotches, and the six digits as well as the anterior canal are similarly marked. The dorsum of the abnormal *L. lambs* is almost completely white and the digits and anterior canal are similarly unmarked, showing only traces of light brown at the tips.



4b. The ventral side of the normal *L. lambs* is marked like the dorsum - heavily covered with dark brown blotches and streaks at the outer edge of the columella. The columella itself and the interior of the aperture as well as the outer lip are usually a deep orange-brown. In the abnormal shell too, the ventral side is like the dorsal, totally devoid of all color - here the columella, interior of the aperture and the outer lip just show traces of very light oranges and browns. Both shells, at around 135 mm, are just below average in length. Both specimens are from the Visayan Sea, off Cebu.



5. *Strombus auradianae* Linné, 1758 [Strombidae]. A normal shell is characterized by a prominent digit at the top of the outer lip and both the dorsal and ventral sides are a heavy dark grey and the aperture is dark orange within. In the abnormal shell the digit at the top of the outer lip is split and the color of the entire shell is lighter - both dorsal and ventral sides are a very light brown and while orange is present inside the aperture, both the columella and the outer lip are a shiny white. Both shells measure about 60 mm and both are from the Visayan Sea, off Cebu.

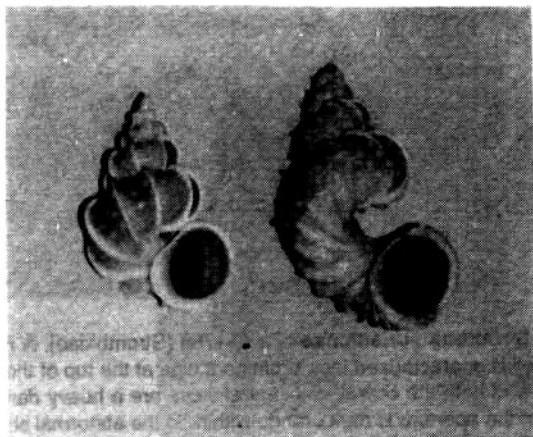


6. *Strombus luhuanus* Linné, 1758/ The normal shell is cone-shaped and, indeed, some *S. luhuanus* have been mistaken as cone shells. Like a cone, the shell is wide at the top, narrow at the bottom and has straight sides. The shell in the center began normal development, but then the process was apparently interrupted and the last one-third of the shell's normal cone shape became distorted as a large, strangely-shaped notch appeared at the base of the columella. The shell at the right had this notch appear even earlier in development and it distorts both the columella and the outer lip - also, a large dimple appeared where the notch met the outer lip. All three shells come from the Visayan Sea, off Cebu.

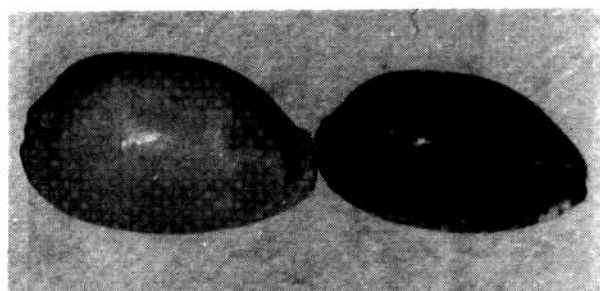


7. *Strombus urceus* Linné, 1758 [Strombidae]. The typical shell here is smooth, with about seven prominent knobs across the shoulder area. The abnormal shell (sometimes referred to as form *ustulatus* Schumacher, 1817) is strikingly similar to the abnormal *S. luhuanus* shown in Fig. #6 (right specimen). A large notch appeared about half-way down the shell, distorting the main body whorl and the outer lip - again a dimple appeared where the notch met the lip. In addition, the knobs at the shoulder were, more-or-less, subdued. At 40-42 mm these are average size for the species. Both shells are from Siasi Island, Sulu Sea.

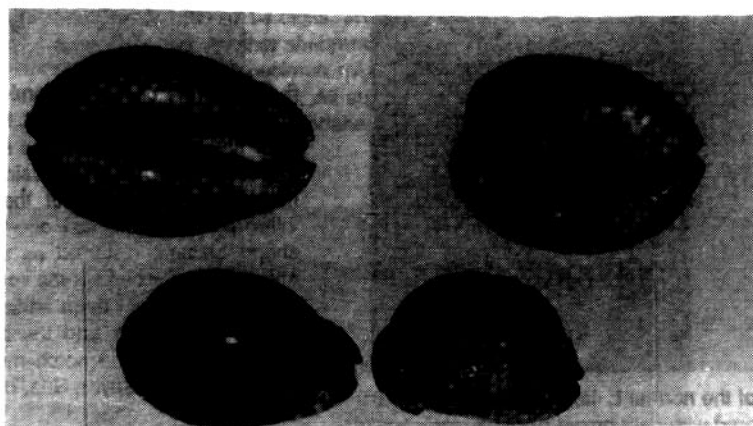
4c. Another pair of *L. lambs*. Here the normal shell has the usual six digits and the main body color is brown, with darker brown at the tips of the digits. The abnormal shell appears to have begun the normal growth pattern, but apparently something interfered at about mid-point - the first half is normal, but then there is an added appendage and the digits failed to form as usual. Both shells average about 135 mm in length and are from off Cebu.



8. *Epitonium scalare* (Linné, 1758) [Epitoniidae]. A normal shell is medium to large in size (50-65mm), very light brown in color and has thin, sharp, white varices which connect at the sutures. The abnormal shell shown here is very long (72 mm) and a very light grey in color and the varices fail to meet at the sutures; also the normal coiling process was interfered with, resulting in an elongated shell with unconnected whorls. Both shells are from of Corregidor Island, Manila Bay, Central Luzon.



10. *Cypraea eglantina* Duclos, 1833 [Cypraeidae]. The normal shell is cylindrically ovate, with well-rounded sides and a somewhat convex base; the color of the dorsum is cream and brown, the brown lines being irregular and interrupted and forming a reticulated pattern; the margins are somewhat prominent and dotted with dark brown spots; the base of the shell is cream, with brown teeth. The abnormal shell (left specimen) is quite regular in all respects except as to color - the dorsum pattern is completely obliterated and is completely covered with a cloudy, grey-green; there is no black at either end and the marginal and basal spots are somewhat covered by an olive green film; only the brown teeth are unchanged. The shells measure 60-63 mm and both are from Talikud Island, Davao Gulf, Mindanao.



9. *Cypraea arabica* Linné, 1758 [Cypraeidae]. Normally the shell is generally subcylindrical in shape, with well-rounded sides; the margins are well-developed and usually heavily marked with dark brown spots; the base is flat and the aperture quite narrow and more-or-less straight; short teeth are located on both the columella and the outer lip. Our abnormal shell is distorted almost beyond recognition as a *C. arabica* - the shell itself appears almost square rather than ovate; the margins have all but disappeared and the labial spotting has been interrupted; the base is concave and the aperture is very open at the anterior end; the teeth have disappeared at the anterior section. The shells measure 45-50 mm, average for the species, and are from Siasi Island, Sulu Sea.

11. *Cypraea tigris* Linné, 1758 [Cypraeidae]. A normal shell is usually ovate to pyriform, with well-rounded sides; the ground color is an off-white and the dorsum and margins are heavily covered with closely placed, large and small dark brown spots; the mantle line is generally straight and narrow, and of a yellow-orange color, both the columella and the outer lip are well-rounded. In this abnormal shell - similar to the abnormal shell of *C. arabica* (#9. above) - the shape is somewhat squared-off, rather than ovate-pyriform; there is a large hump near the

columella, and this is ridged, unlike the smooth sides of a normal specimen; the mantle line is very wide when compared to that of a normal shell - indicating that, due to the large hump, the mantle was unable to completely cover the entire dorsum; also, due to the hump, the columella is flattish rather than rounded and the teeth of the columella have been retarded in their development. At 70 mm, these are average size for the species in the Philippines. Both are from Siasi Island, Sulu Sea.

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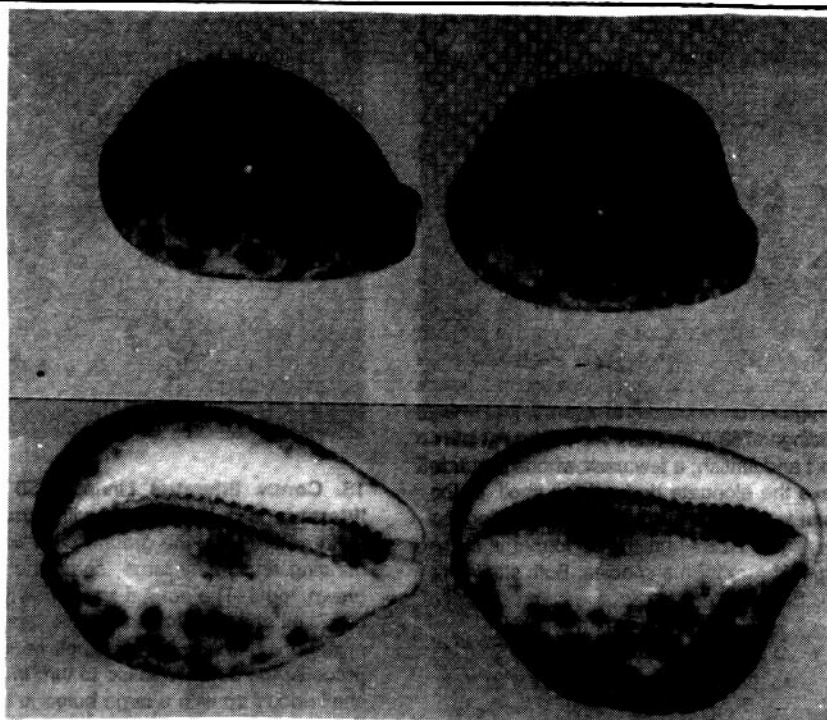
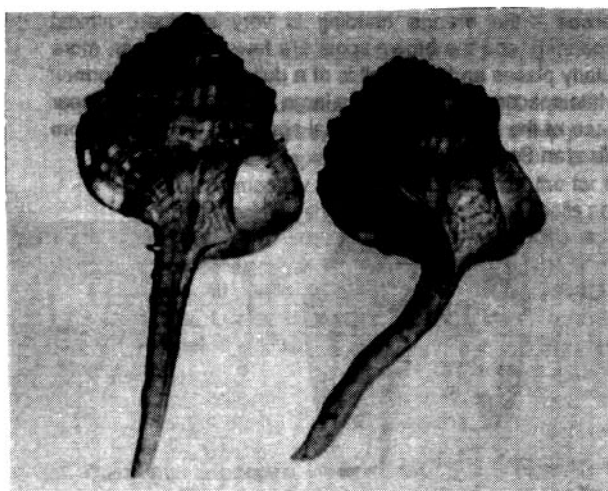
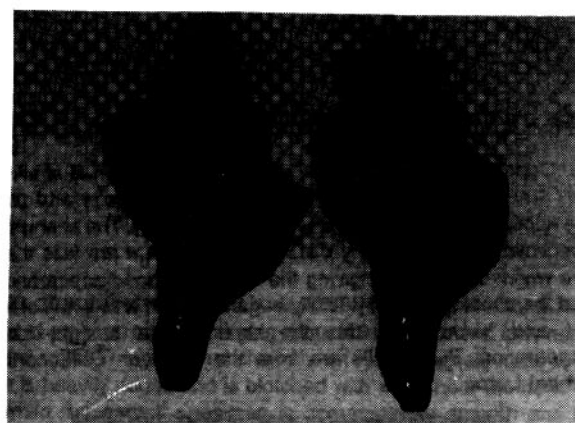
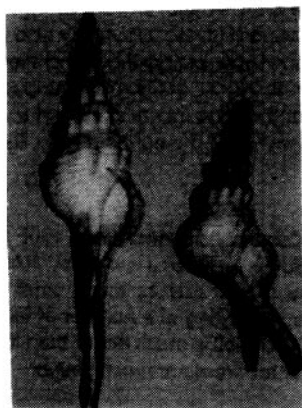


Figure 11



12. *Haustellum haustellum* (Linné, 1758) [Muricidae]. A normal shell has a long, solid siphonal canal, which extends straight down from the main body whorl. The abnormal shell illustrated began a normal siphonal canal, but after a few millimeters it began to curve backward; at the conclusion of its growth the tip of this canal was positioned well behind the body whorl. The normal specimen is from Samar, the abnormal from off Zamboanga, Mindanao.

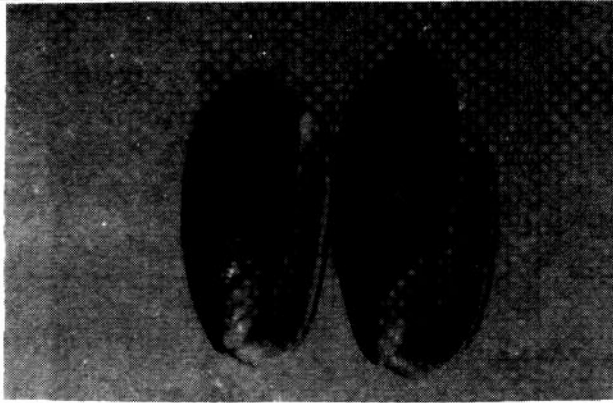


13. *Fasciolaria trapezulum* (Linné, 1758) [Fascioliidae]. A normal specimen is generally a comparatively light colored shell, with a tall cone-shaped spire; there is a row of sharp, pronounced tubercles on each whorl, these being much larger on the final whorls. In the abnormal specimen the color is much darker, and both the conic spire and the tubercles have failed to develop, giving the shell a smooth, flat appearance. The normal specimen is from Manila Bay, the abnormal one from Batangas Bay.

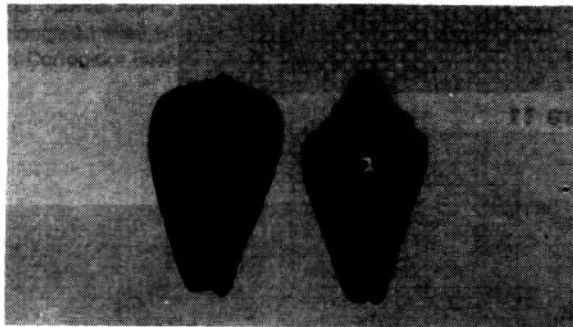


14. *Fusinus colus* (Linné, 1758) [Fascioliidae]. A normal shell of this species is medium size, with a tall spire and a single long siphonal canal; the base color is white, with light brown between the ribs and on the siphonal canal. The abnormal shell shown here has developed a second siphonal canal, bending off to the left and has very dark brown marking on the body whorl and the siphonal canals. Both shells were collected in Manila Bay.

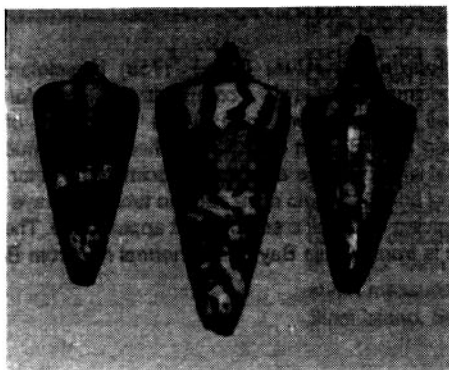




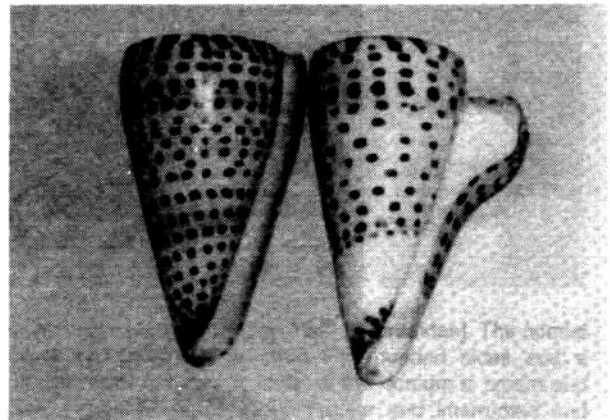
15. *Oliva sericea* Röding, 1758 [Olividae]. As with most olive shells, the spire is short and flattish; a few early whorls protrude a few millimeters above the elongate body of the shell. In the abnormal shell the spire is very long, almost 15 mm, giving the shell a very tall appearance. At 88 mm the abnormal is much longer than the average 71 mm for the species. Both shells are from Siasi Island, Sulu Sea.



16. *Conus figulinus* Linné, 1758 [Conidae]. A normal shell of this species has a low, moderately descending spire and give the appearance of a round-shouldered, stout shell. The abnormal specimen here has a very distorted spire - there are less than five whorls in the spire, giving the shell a terraced appearance and the shoulder, when it finally began to form, was completely flat and because of this the shell has a straight-sided appearance. Both shells are from the Lingayen Gulf, north-central Luzon.



17. *Conus generalis* Linné, 1767 [Conidae]. This cone's shell is very variable in size, shape and color - it is a problem deciding what is and what is not normal for the species. Sizes range from 45 to about 65 mm, averaging about 55 mm. Colors range from a golden brown to a very dark brown. The spire is usually short, but a few specimens can be found with extremely tall (up to 15 mm) spires. Shells with spires over 15 mm and over 85 mm in length are very scarce and could be considered abnormal. Large, dark forms of *C. generalis* are from Palawan and the Sulu Sea islands, while the more common small, light forms are from of Marinduque Island, central Luzon.



18. *Conus litteratus* Linné, 1758 [Conidae]. A normal *C. litteratus* is a large shell, with straight sides and a narrow, uniform aperture; the ground color is white, with some orange banding and many large, somewhat square, regularly placed brown spots. The normal shell shown, at about 75 mm, is from off Zamboanga, Mindanao; the abnormal specimen lost its symmetrical shape as the shell neared the end of its growth process; the outer lip failed to turn in at the usual point and the shell ended up with a large bulge at the top of the outer lip. As the form was distorted so too were the color and pattern processes - the orange banding is very subdued, almost disappearing, and the brown spots are fewer in number, more irregularly placed and the shell is of a duller white than normal; the white spaces are larger and a large white band formed near the base of the shell. The abnormal shell, also 75 mm, is from the Visayan Sea, near Cebu.



19. *Conus furvus* Reeve, 1843. [Conidae]. The normal *Conus furvus* has a low terraced spire, a flat shoulder and straight sides. The usual color of the shell is cream with wide and narrow light brown bands. The abnormal form of *C. furvus* (center) has two large spiral whorls, and the shell's profile is more rounded than square. The color of the shell is a very dark brown, with a few light brown bands. The second abnormal *C. furvus* is the white form. Whatever went wrong with the growth process of *C. litteratus* (Fig. 18) apparently also went wrong with this shell. As the shell approached the end of the growth process, the outer lip failed to turn in, and the shell ended up with a large bulge at the top and a large gap at the top of the aperture. All shells from off Palawan, and the northern Sulu Sea islands.

20. *Conus striatellus* Link, 1807 [Conidae]. A normal shell is medium-sized with a low spire. This abnormal specimen has the same abnormality as many other unusual cone shells - a tall spire, consisting of a number of large squared-off whorls. At 64 mm this shell is much larger than the 40 mm average size. Both shells are from northeast Samar.

See figure on next page.

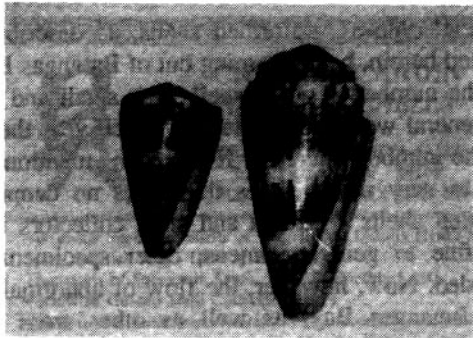
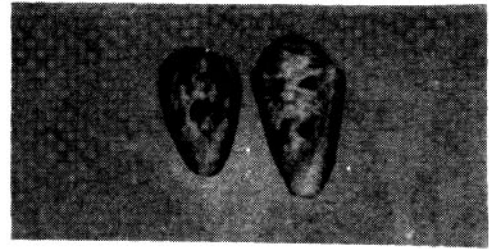
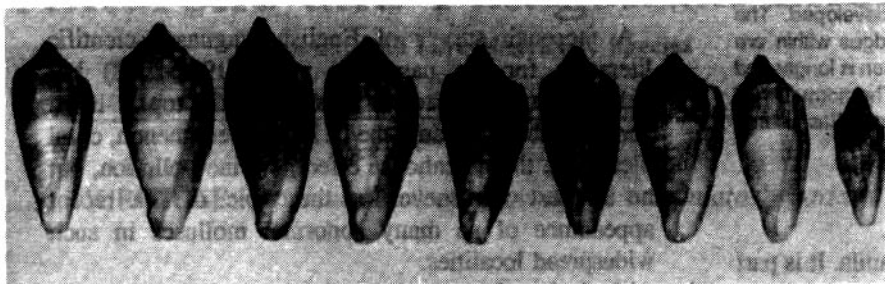


Figure 20.



21. *Conus arenatus* Hwass in Bruguière, 1792 [Conidae]. A normal specimen of this shell is small, with a flat spire and a number of small tubercles on the shoulder. The abnormal shell illustrated is medium-size and, like so many other abnormal cones discussed above, has a tall terraced spire. Each spire layer has a number of tubercles, and larger tubercles are found on the shoulder. Both shells are from Santa Cruz Island, off Zamboanga, Mindanao.



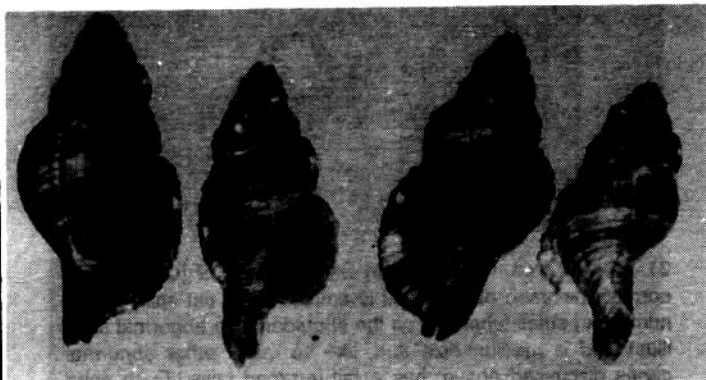
22. *Conus ochroleucus* Gmelin, 1791 [Conidae]. Normal shells are of medium size, cylindrical, with a sharply angled shoulder and smoothed tapering sides. The aperture is usually narrow, and also smoothly tapering. The shell on the far left is the only normal specimen shown. Most abnormal shells are either larger or smaller than usual; on many the bodies are twisted and distorted, some apertures are either larger or narrower than usual. All shells are from Batangas Bay, south of Manila, in central Luzon. Batangas Bay is a major source of abnormal Philippine molluscs and will be discussed in length later.



23. *Conus marmoreus* Linné, 1758 [Conidae]. A normal shell is of medium size, averaging around 91 mm, with a low, nearly flat spire. The abnormal shell shown has a very elevated spire; it is heavily ridged and is blotched with white near the outer lip, while the normal specimen is comparatively smooth and the pattern is constant. The normal shell is from Siasi island, Sulu Sea; the abnormal shell is from Coron Island, north of Palawan.

24. *Casmaria erinaceus vibex* (Linné, 1758) [Cassidae]. A normal specimen is usually smooth, and the fold on the back of the outer lip is marked with alternating dark brown and white squarish blotches. The abnormal shell here is heavily ridged above the aperture and the brown and white blotched fold, which is found behind the outer lip, has also formed just above the columella, thus giving the abnormal shell a bloated appearance, and two outer lip folds. The normal specimen is from northeast Samar, the abnormal form from Bantayan Island, north of Cebu.





25. *Cymatium pileare* (Linné, 1758) [Ranellidae]. A normal shell is usually of a fusiform-ovate shape, with a well-developed axial fold just above the columella. The aperture is large, ovate, and heavily ridged within. The abnormal shell shown here is fusiform, but not ovate; and the axial fold is poorly developed. The aperture is small and well-rounded and the ridges within are light. The siphonal canal of the abnormal specimen is longer and more curved than the canal of a normal form. The normal shell is from northeast Samar; the abnormal one is from Siasi island, Sulu Sea.

### BATANGAS BAY

Batangas Bay is located just south of Manila. It is part of the Verde Island Passage, which separates southern central Luzon from the island of Mindoro. The Verde Island Passage has a few islands and, until recent times, it had some of the Philippines' most beautiful coral formations.

During the 1960's and 1970's and into the 1980's Batangas Bay was one of the world's most popular destinations for scuba divers. One coral region was so striking that divers referred to it as an underwater cathedral.

From 1973 to 1980 (when I was living in the Philippines) it was known that some fishermen were using explosives to stun food fish. It was also known that some collectors of small reef fish for aquariums were using toxic substances to stun these fish. During this period both of these unlawful practices were carried out in a rather modest scope. However, beginning in the early 1980's competition for the Bay's fish became fierce and dynamite-fishing was practiced on a very wide scale. By the mid 1980's the use of these explosives had reduced many coral formations to rubble and the underwater cathedral became an underwater cemetery.

Sometime after 1985 the Bay began receiving other blows. Significant changes in water temperatures, possibly caused by the El Niño phenomenon, or global warming, or maybe both. There were also reports of mud running down the sides of denuded hills, carrying silt out to and over the coral formations. Raw sewage and garbage were also being dumped into the Bay. Recently an oil refinery has been built on the Bay and a nearby river carries factory wastes into the Bay.

During 1986-87, deformed shells, as described and depicted herein, began coming out of Batangas Bay. At first the number of these shells was small and only a few general were represented, but each year thereafter saw the numbers increase. It should be mentioned that prior to very recent times there was no demand for abnormal shells - dealers and shell collectors wanted only fine to gem specimens, other specimens were discarded. Now, however, the flow of abnormal shells from Batangas Bay, as well as other areas of the Philippines is fairly large-scale and quite regular. The supply is so large and so regular that shell dealers are including "freaks" on their sales lists.

### DISCUSSION

A thorough survey of English language scientific literature for the past five years (1989-1993) has indicated a great interest in most of the topics listed above: global warming, the El Niño phenomenon, coral bleaching, the greenhouse effect, marine pollution, but no interest whatsoever in the topic of the recent appearance of so many abnormal molluscs in such widespread localities.

Much has been written, in particular, on global warming and coral bleaching. There is no consensus of opinion on the cause and effect of either. In fact, there is a wide divergence of opinions on both subjects. At present the scientists concerned with the major topic, global warming, break down into three groups: those who believe that global warming is a threat, those who believe that it is not a threat, and those middle-of-the-roads who are not sure whether it is a threat or not. The latter group, while feeling that much more study-time is necessary to make a decision, tend to support those who believe that global warming is a threat and they advocate measures to lessen the suspected causes of global warming of the earth and its oceans.

Some climatologists are convinced of the inevitability of global warming, and its dire consequences, if the accumulation of greenhouse gases in the atmosphere goes unabated. This, in turn, has led some scientists to join in a movement to control industrial processes. Others have called upon the highly industrialized nations to improve their efforts at lowering the production of greenhouse-producing gases. Developing countries have been warned that increased global warming would lead to higher temperatures, which, in turn, would lead to droughts and greatly decreased food production.

The U. S. National Academy of Sciences carried out a study on global change in 1992. The study concluded that the pollution, the wasteful use of resources and the increased use of fossil fuels will eventually lead to an increase in global warming, and the study recommended that the signatories to the 1992 climate treaty take the

Continued on page 132





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## Oops!

Please refer to the article "A Checklist of Ovulidae" by Charles Cardin (Of Sea and Shore, Summer 1992, 17:2, 99).

Somehow your Editor missed the section of the Ovulidae checklist with species beginning with the letters "n" and "o". Well, here they are, plus an addition received from the author.

***navinosa* Cate 1973 (Primovula)**

Reference: Veliger 15(Supplement) January 31, 1973 Fig 81: Holotype

***nebula Azuma* Cate 1971 (Testudovolva)**

Reference: Veliger 13(3): 262; Fig 2

*neglectum* Reeve 1865 (Ovulum)

= *aequalis* Sowerby

Reference: Veliger 15(Supplement) January 31, 1973 Fig 129 Orig. illus.  
Conch. Icon., Ovulum: pl. 14, figs. 62a,b; 1865

***nicaeensis* Risso 1826 (Simnia)**

Reference: Veliger 15(Supplement) January 31, 1973: Fig 157

Hist. Nat. Europe Merid. 4: 235; pl. 10, fig. 150: 1826

Synonyms: *purpurea* Risso 1826

*triticea* Payraudeau 1826

*spelta* Tryon 1885

***nielsenii* Cate 1976 (Diminovula)**

Reference: Aust. Mar. Shells. Vol 1, B. Wilson: 1993 Pg 200 Desc only  
*nigerina* Dufo 1840 (Ovula)

= *striatula* Sowerby

Reference: Ann. Sci. Nat., Paris 14: 186

*nigerinum* Sowerby II 1848 (Ovulum)

= *striatula* Sowerby

Reference: Thes. Conch., Ovulum 2: 482

***nimbosa* Cate 1978 (Galeravolva)**

Reference: Venus 37(4): 191-204; Pl 1, fig. 2; 1978

***nipponensis* Pilsbry 1913 (Testudovolva)**

Reference: Veliger 15(Supplement) January 1973

Synonyms: *brevis* in Allen

***nivea* Cate 1974 (Primovolva)**

Reference: Veliger 16(4): 381-384; 1 pl.

***nossibeensis* Cate 1973 (Phenacovolva)**

Reference: Veliger 15(Supplement) January 31, 1973: Fig 226 Holotype

***nubeculata* A. Adams (Reeve 1848) (Pseudosimnia)**

Reference: Veliger 15(Supplement) January 31, 1973

Voy. Samaarang, Moll., Ovulum: 23; pl. 6, figs. 12a-c; 1948

Synonyms: *fruticum* Kuroda 1958

***nubila* Cate (Azuma 1973) (Primovolva)**

Reference: Veliger 15(Supplement) January 31, 1973

*oblongata* Requien 1848 (Ovula)

= *adriatica* Sowerby

Reference: Cat. Coq. Corse: 84

*obsoleta* Schilder 1941 (Simnia)

= *spelta* Linne

Reference: Arch. Molluskenk. 73 (2/3): 108; 1941

*obtusa* Schilder 1941 (Pellissimnia)

= *spelta* Linne

Reference: Arch. Molluskenk. 73 (2/3): 110; 1941

*obtusum* Sowerby 1828 (Ovulum)

= *spelta* Linne

Reference: Zool. Journ. London 4: 156; 1828

Veliger 15(Supplement) January 31, 1973: Fig 202 Holotype

***orientis* Pilsbry 1913 (Testudovolva)**

Reference: Veliger 15(Supplement) January 1973

***ostheimerae* Cate 1973 (Crenavolva)**

Reference: Veliger 15(Supplement) January 31, 1973 Fig 122: Holotype

*oviformis* Lamarck 1801 (Ovula)

= *O. ovum* Linne 1758

Reference: Anlm. s. Vert: 72 (fig 140): 1801

*ovoldea* Paetel 1887 (Ovula)

= *bimaculata* A. Adams 1854

Reference: Veliger 15(Supplement) January 31, 1973

*ovoides* H. Adams 1872 (Ovula)

= *bimaculata* A. Adams 1854

Reference: Veliger 15(Supplement) January 31, 1973

***ovum* Linne 1758 (Ovula)**

Reference: Veliger 15(Supplement) January 31, 1973; Fig 139 Lectotype

Synonyms: *cygnaea* Roding 1798

*oviformis* Lamarck 1801

*pygmaea* Sowerby 1828

*gallinaceum* Reeve 1860

These species, described by Cate in The Veliger 19(2): 1976, were not included in the original list.

***kurziana* Cate 1976 (Cymbovolva)**

Reference: Veliger 19(2) October 1, 1976: Fig 3

***macleanii* Cate 1976 (Delonovolva)**

Reference: Veliger 19(2) October 1, 1976: Fig 5: Holotype

***malaita* Cate 1976 (Cymbovolva)**

Reference: Veliger 19(2) October 1, 1976: Fig 2

***sedlaki* Cate 1976 (Cyphoma)**

Reference: Veliger 19(2) October 1, 1976: Fig 4-4c



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## LURE of the Liguus, continued

**LOSSMANICUS:** This is a widely distributed family, from the extreme north central and northwest areas (Immokalee and Clewiston) through Pinecrest (sparingly) and the Coastal Ridge to Cape Sable, Lossman's Key and Key Vaca. It is found in many Coastal Ridge hammocks where no other form is found. Simpson reported it from the Upper Keys, but no one else has done so, so I think his report may have been inaccurate. He also reported *marmoratus* from Key Largo, which most collectors (including Pilsbry) regard as inaccurate. It is possible that *matecumbensis* and *lossmanicus* arose from a common ancestor, and evolved differently as they were exposed to different influences.

**MARMORATUS:** This family of shells was found throughout the Pinecrest area, Middle Cape Sable, Chokoloskee (?) Marco (?) and Key Vaca. As I discussed earlier, a shell that is also called *marmoratus* is found somewhat sparingly along the Coastal Ridge from Long Pine Key to Brickell Hammock. The question is, how is this shell related to the western *marmoratus*? Is this shell a hybrid or is it a variant of *TESTUDINEUS*, which would mean that it arose from *TESTUDINEUS* ancestors? Or is it directly related to the western *marmoratus*? Refer to my comments on *testudineus* for further discussion of this puzzling problem.

**MARMORATUS** from the northern and especially the northwestern areas of Pinecrest do not show much variation. **MARMORATUS** from the middle and southern Pinecrest areas show great variations, suggesting a longer period of evolution.

**TESTUDINEUS:** This family was found along the Coastal Ridge from Brickell Hammock to western Long Pine Key, Middle Cape Sable, and surprisingly in the northeast area of Pinecrest. Did the Pinecrest *TESTUDINEUS* evolve from *MARMORATUS* ancestors? Or was a *TESTUDINEUS*-type shell introduced into this area, with its unique influences:

pink or jeweled tips, comma-shaped sub-sutural spots and axial streaks that fork? *Evergladesensis* has a pink tip, with streaks that fork. There is also a *floridanus* in this northeast corner that has conspicuous streaks that fork (Plate XII - 2), and even *floridanus* from Pinecrest #91 seem to show this unusual influence (Plate XI - 14). This hammock also contains *gloriosylvaticus* and *nebulosus*, variations of *MARMORATUS* that might also have been influenced by *TESTUDINEUS*. Further south is Pinecrest #22, with its *testudineus*-type shell (Plate XX - 5); Pinecrest #11, with its *lucidovarius* (Plate III - 12); and *clenchi*, *solisoccatus* and a jewel-tipped *ornatus*, which are found in many of these northeast Pinecrest hammocks. It is also possible that the *MARMORATUS* from Key Vaca show some *TESTUDINEUS* influence, since they often have streaks that are different from those on typical Pinecrest *MARMORATUS*. Of course, having streaks that fork may also be a characteristic of the original *MARMORATUS*; it may not be an exclusively *TESTUDINEUS* characteristic.

*TESTUDINEUS* from Brickell Hammock show an enormous diversity (Plates XIX - 9 - XX - 3); in the Long Pine Key area there is a lot of diversity; but there is not so much diversity among shells from the Coastal Ridge in between these places. Archie Jones told me that about 60% of the *testudineus* from Brickell Hammock had pink tips. I think that approximately that ratio persists throughout the Coastal Ridge hammocks until you get to Long Pine Key. In that area, the overwhelming majority of *TESTUDINEUS* have pink tips.

*Septentrionalis* is found only in the northern hammocks of the Coastal Ridge, very close to the coast, from Arch Creek in northern Dade County to Yamato Hammock in the extreme southern part of Palm Beach County. There is a little overlap in the southern area of this range, with hybrids in Arch Creek, and with other forms being found inland in southern Broward County.

## CHAPTER VI

### DISPERSAL

A discussion of migration patterns of these snails must begin with geology and ocean levels. About 120,000 years ago, all of south Florida was under 20 - 30 feet of water. The Atlantic Coastal Ridge was a shoal, and the first dry land was north of what is now Lake Okeechobee. Then followed a long period of much colder weather in which there were several ice ages. Much of the earth's water (up to 20 million cubic miles) was locked on the land in the form of ice.

Glaciers covered much of North America (Fairbridge, 1974, p. 223) as far south as Illinois. The ocean level dropped some 400 feet, leaving south Florida a high plateau. The region was rather dry, with scattered trees and a few small rivers and streams. The temperature was 5 - 7 degrees F. cooler than present, and there was snow in the winter. Almost certainly it was too cold and dry for *Liguus* snails to have survived during this period.

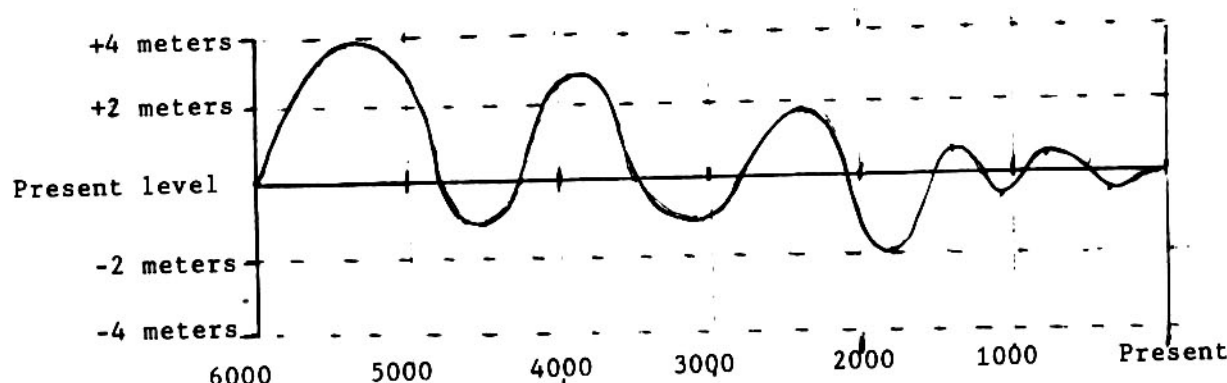


Figure 3. Changes in ocean level during the past 6000 years.

There is a difference of opinion among scientists about the ocean level during the past 20,000 years. According to Dr. Rhodes Fairbridge, Dept. of Geology at Columbia University, the world began a warming trend about 17,000 years ago, with the ocean level rising rapidly until it reached present levels about 6000 years ago. From that time, there have been several oscillations in the ocean level (see figure 3). Especially important for the study of *Liguus* migration patterns is the possibility that the ocean level was about 12 feet higher than present about 5000 years ago, with a fall to slightly lower than present levels, followed by another rise to about 9 feet above present levels about 3800 years ago, with another fall to slightly lower than present levels (Fairbridge, 1974).

Dr. Harold Wanless, a University of Miami geologist, disagrees. He says the ocean level began rising about 20,000 years ago, rapidly at first, and then more gradually until it reached present levels. He does not think the ocean has exceeded present levels during the past 20,000 years (personal conversation).

As we will see, the *Liguus* distribution is much easier to understand from Dr. Fairbridge's conclusions than those of Dr. Wanless. The following discussion is based on Dr. Fairbridge's conclusions, with the understanding that these conclusions are very tentative.

It is probable that as the ocean began to rise, the area became warmer and wetter, and all of south Florida became a more or less continuous tropical forest. This would have allowed for a rapid migration of *Liguus* throughout all of south Florida. Then as the ocean continued to rise, the Florida Bay area would have been submerged, much of south Florida would have become swampy, creating the Everglades and much of the forest area would have been flooded, leaving only the isolated hammocks (tree islands) that we know today. So there

were two or three periods during the oscillation of the ocean level where there were conditions for rapid migration followed by isolation. Figure 4 shows the different kinds of soil/rock composition of south Florida. The areas where the limestone is close to the surface are generally higher than other areas. By and large, it is these areas where the dense tropical hammocks grow that support the *Liguus* populations. Notice that there is a large slough of fresh water peat running from the northeastern part of the Everglades down to the Cape Sable area. There is a large limestone area to the south and east of this, called the Atlantic Coastal Ridge. It tapers in elevation from almost 20 feet in Miami to almost 5 feet at the entrance to the Long Pine Key area, to about 2 feet at Mahogany hammock, which is a couple miles west south west of Long Pine Key. To the north and west of this slough, there are patches of limestone. This is the Pinecrest area, which was once a lumbering center for cypress. There are few if any hammocks in the slough, so it would hinder the migration of the snails.

We have no way of knowing when the first *Liguus* reached Florida shores. If there were any here before 120,000 years ago, they almost certainly could not have survived the cold conditions of the ice ages. (Roth and Bogan suggest the possibility that *Liguus* originated in North America and migrated to Cuba and Haiti, but I do not think this could have been possible.) Delcourt and Delcourt said that the subtropical hardwood forests, that would support a *Liguus* population, arose about 5000 years ago in south Florida (cited in Roth and Bogan). This is probably as good a date as any to assign to the arrival of *Liguus*. This may seem too short a time to account for the amazing *Liguus* diversity, but since these snails mate in their third year, they would have over 1500 generations in which to inter-breed and evolve.



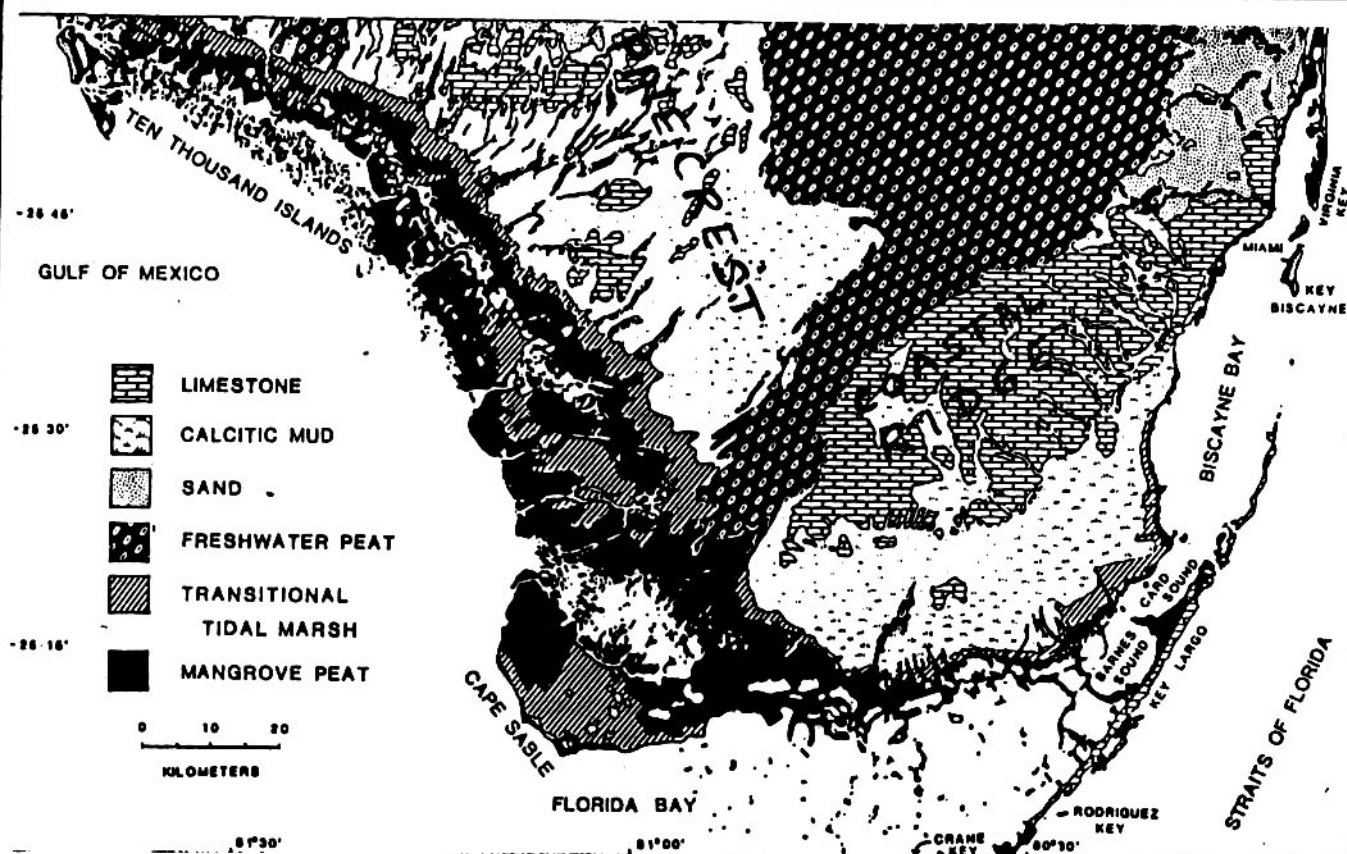


Figure 4 The geology of south Florida. Prepared by Dr. Harold Wanless, the University of Miami,

## ORIGINS OF *LIGUUS* AND THEIR INTRODUCTION INTO FLORIDA

Most naturalists agree that the Florida *Liguus* originated in Cuba. According to Abbott (1989), they are members of the sub-family *Orthalicinae*, a division of the family *Bulimulidae*. This family is of South American origin, and has spread throughout tropical America. Clench on the other hand says that *Liguus* are not closely related to any *bulimulid* genera now existing in Central or South America. I am not competent to comment on this, except to say that I have seen *Orthalicus* from Central America, which look very much like *Liguus*.

There are several ways that the *Liguus* may have made their way to Florida shores from Cuba. (1) They may have floated over attached to tree trunks that had been washed into the sea by hurricanes. But research (Tuskes, 1981, p. 168 f) has shown that these snails are extremely sensitive to salt water. If a limb to which they are clinging is immersed in salt water, they will quickly release their grip and sink, where they soon die

(both Simpson and Jones have immersed them in fresh water for up to 20 hours, with no harmful results). After exposure to salt water for only a couple hours on a flat board, they die. Remember, most hurricanes occur during the season when the snails are active, not when they are estivating. They are therefore more vulnerable to the influence of salt water. Even if they were in estivation, the exposure to water would soften the seal and activate the animal. It is possible that eggs or very small shells were in protected crevices of trees, and thus protected from the salt water during the long journey. But 90 miles of ocean is a lot of water to traverse. It is possible that the shells that made their way here were gravid, and if the snails themselves died, their eggs might have survived. Since eggs from one parent may produce more than one color form (Pilsbry, 1946, p. 98), one ancestor could account for two or maybe more color forms. Dr. Edward Petuch suggested that large tree-islands might have been blown from Cuba to Florida in a hurricane. Many (most?) tropical trees do

not have tap roots that grow deep in the ground, but have roots that spread out and interlock with the roots of other trees. If running water undercuts an area of forest -- say at the edge of a river bank -- the trees might be so interlocked that several acres of them could break loose and be swept into the sea. (2) They might have been blown over by hurricanes while attached to small branches. We might expect branches to be blown a few yards, maybe even a few hundred yards, but 90 miles? I just don't think that is possible. (3) They could have been brought over by Indians. According to Robert Carr, a well-known Miami archeologist, there were Indians in Florida 10,000 - 13,000 years ago, and there is evidence that they were in the Cutler area of Dade County about 10,000 - 11,000 years ago. There is also evidence of trade with Cuba as early as 1000 - 1500 years ago. But he thinks it is extremely unlikely that the snails were brought over by Indians. There is no evidence to support that hypothesis. Except for one specimen found in an Indian mound on Plantation Key, no *Liguus* shells have been found in Indian graves, while shells from other edible mollusks have been. (4) Some have suggested that the snails or their eggs were brought over by birds. This seems most unlikely to me, although it has been suggested by Dr. Clench (personal conversation) that certain marine and fresh-water mollusks might have been transported from one place to another in the form of eggs in the digestive tracks of birds that had eaten the mollusk. Birds have been seen carrying *Liguus*. If a gravid snail fell from a bird's beak some distance from its original location, that would help explain the rapid migration from hammock to hammock. But it is unthinkable to me that a bird would carry a snail from Cuba.

So there is really no satisfactory explanation of how the *Liguus* reached Florida. If it could be shown that it was a simple matter for these snails to have made their way here, that would simplify our analysis of their development here. We could simply presuppose that many different forms arrived, and their inter-breeding easily produced the multiplicity of forms we now have in Florida. But since it is clear the for any snail to have arrived on our shores is a great rarity -- almost impossible, -- then we must be extremely parsimonious in our attribution of ancestors. We must look diligently for the fewest possible number of ancestors that can possibly offer explanations for the existing varieties.

In discussing dispersal, there are several assumptions that need to be made. Most of these are rather obvious, but still they need to be stated. (1). The earlier a form arrived in Florida, the more likely it is that its descendants will have migrated to other locations. Similarly, the earlier a form arrived, the farther its descendants will have migrated. This means that the forms we now find farthest from the coast

probably descended from the very earliest arrivals. (2). The greatest variety of forms will be found in the older colonies. Newer colonies, those most distant from the original colonies, will have less variety. However, it must be noted that when two forms hybridize, their descendents often show enormous variety in just a few generations (see Chapter IV). (3). Periodic hurricanes can destroy hammocks along the coast, and all the *Liguus* in them. This has been known to happen. A tidal wave created by the 1935 hurricane destroyed the Beach Hammock on Lower Matecumbe Key, thus consigning *dohertyi* to extinction. Hurricane Donna in 1960 also produced a great tidal wave that swept over that island. According to naturalist Laymond Hardy, there was not a single leaf left on a tree on the island, and there was seaweed on the highest branches of the trees that survived. He hunted carefully for *Liguus* there for four years afterward, but found none. He thinks that the *Liguus* that are now on Lower Matecumbe were planted there after Hurricane Donna. But I can find no one who knows of any replanting, and both Archie Jones and Loyd Lysinger think the shells survived naturally. They apparently survived the 1935 hurricane also, which was even worse. Jones told me that the snails seem to sense the approach of a hurricane, and descend from the trees to bury themselves in the ground, where their chance for survival would be greater. Donna came late in the season (Sept. 10), so it is possible that some of the snails had laid their eggs. The eggs might have survived even if the parents did not. Donna also devastated the Middle Cape Sable hammock. No doubt many hurricanes of equal or greater destructiveness have swept over the Keys during the past several hundred years, and higher ocean levels would have given some of these hurricanes access to coastal hammocks. These hurricanes would have the effect of wiping the slate clean of *Liguus* in a given area. (4). Descendants from a single color form might evolve differently in different areas. For instance, *septentrionalis*, *subcrenatus* and *elliottensis* probably had a common ancestor (probably the ancestor of the Cuban *crenatus*). (5). As different color forms arrived at existing colonies, the development of new varieties by inter-breeding and evolution would be accelerated. (6). When snails migrate from one place to another, they will leave a "trail" -- their descendants will be established along the path of migration. However, the effects of hurricanes, floods, fires or rises in ocean levels may obliterate such trails. (7). If all other factors are equal, in a mixed colony the population ratios will give a rough indication of the relative times of arrival of different color forms. For instance, if a colony had 80% *vacaensis* and 20% *marmoratus*, we would assume that the *marmoratus* ancestors arrived much later than the *vacaensis* ancestors. (8). Evolutionary change can take place in either of two ways: from the simple to the complex, or



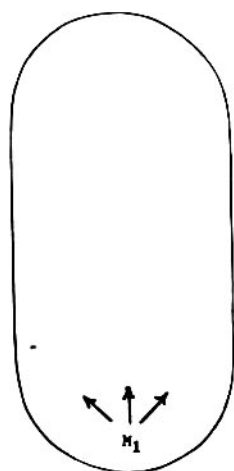


Figure 5  
Hypothetical Pinecrest,  
4500 years ago

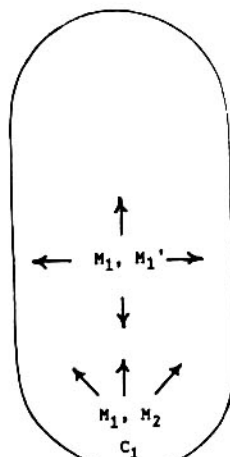


Figure 6  
300 years later

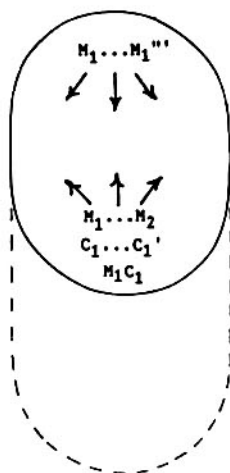


Figure 7  
Another 300 years later,  
ocean level higher

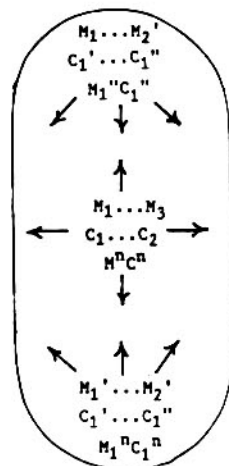


Figure 8  
Another 300 years later,  
ocean level lower.

*vice versa*. The expected process would be from the simple to the complex. There is at least one place where that seems clear. On Lower Matecumbe Key, *pseudopictus* was an uncommon form. A similar but more complex form, *splendidus* was found in the same hammock, but was much rarer. The rarity suggests that it evolved much later than *pseudopictus*. An example of the converse process may be the existence of *dryas*, a more simple form of *graphicus*. *Dryas* is rarer and is found in a much narrower range. We do not know if all color forms reproduce at the same rate, or if they are all equally hardy, so that they would have the same rate of survival. We do not know if cross-breeding produces equal numbers of descendants with each parent's pattern. We do not know if certain color forms are more vulnerable to predators. At the present time, the large and colorful shells are much depleted by certain predators (*Liguus* collectors), but that is a recent phenomenon. However, it should be recognized that this selective collecting does alter the balance of *Liguus* populations, thus making any future population analyses

inaccurate. Until all of these questions can be answered, it is difficult to draw detailed conclusions from population studies. (9). Since the common dark shells (*MARMORATUS*, *TESTUDINEUS* AND *CASTANEOZONATUS*) are more variable than the light ones, the trails of migration can be more easily followed by studying the dark shells whenever possible.

Evolution, hybridization and migration might take place something like this: Figure 5 represents the continuous tropical forest that south Florida may have supported say 4600 years ago when the ocean was lower than present. M-1 is a form (*MARMORATUS* ancestor) that arrived at the southern portion of this forest and began migrating and diversifying. Carol Brown noted that there was a lot of movement within a hammock and especially at the edges. Many snails left the hammock she was studying to make their way to a clump of trees some 60' - 75' away. Jones thinks the *Liguus* can sense the presence of other suitable hammocks, and have a natural tendency to migrate. Some of the M-1

descendants will migrate northward, probably not changing very much in the process. Most descendants will remain behind, where their greater number will lead to greater diversification (M-2, etc.). After say 300 years, the picture may look something like figure 6. M-1 will be the dominant variety in the northern limit of migration, with certain variations of its own (M-1', etc.), while much more variation will have taken place in the original locations (M-1 - M-2, etc.), all of which are migrating in all directions.

Perhaps about this time another form was introduced, say a *CASTANEOZONATUS* ancestor (C-1), which would also begin diversifying, migrating and inter-breeding. After another 300 years, the picture may be something like that in figure 7. By now, the ocean has risen and destroyed the southern part of the original *Liguus* area, leaving behind only those forms that had migrated.

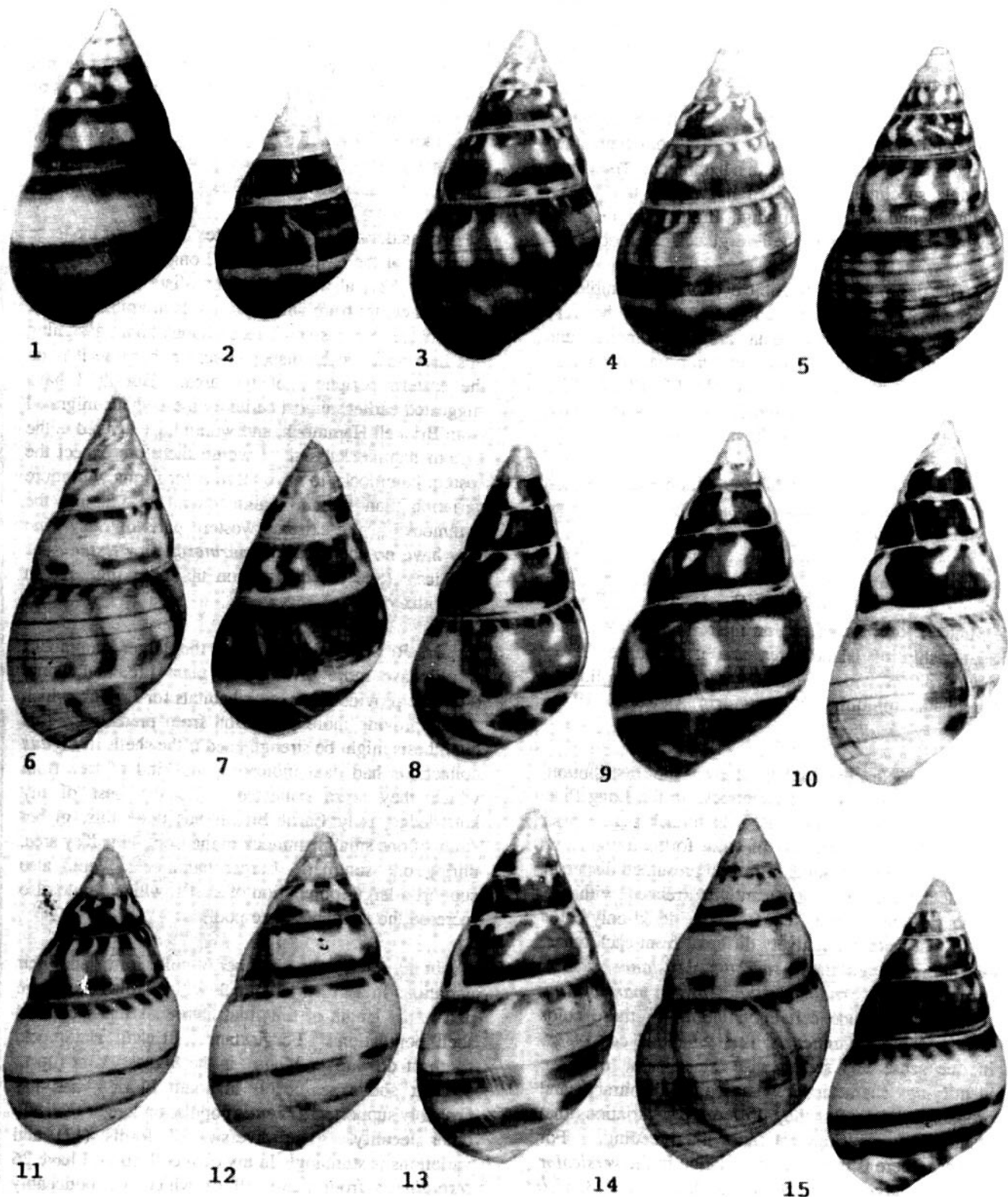
Perhaps after another 300 years, the ocean level has fallen, creating the situation in figure 8. Notice that in this situation, the most variety will be in the center of the area, with less variation in the northern and southern extremities. Please keep this process in mind as a possible factor in explaining the present *Liguus* distribution.

## DISPERSAL

Here is one possible sequence of events that might explain at least some of the present *Liguus* distribution. Remember that this is only a speculation, based on extremely complex data about the shells and on opinions about changes in ocean level that are not universally accepted.

- (1). About 5000 years ago, when the ocean level was a few feet above present levels and all of south Florida was a fairly continuous tropical forest, the ancestors of *LOSSMANICUS*, *CASTANEOZONATUS* and *ELLIOTTENSIS* arrived at our shores and began to migrate, diversify and inter-breed.
- (2). The ocean level fell until about 4500 years ago, exposing new land and allowing for re-forestation of southernmost areas.
- (3). The ocean now began to rise until about 3800 years ago, submerging all localities except parts of the Coastal Ridge and possibly a few islands in the Keys. The only snails to survive were on the Coastal Ridge and maybe Key Largo.
- (4). The ocean level then began to fall, allowing for re-forestation and for renewed spread of *Liguus*.
- CASTANEOZONATUS*, *ELLIOTTENSIS* and *LOSSMANICUS* spread over all the mainland locations and the upper Keys. Later, *MARMORATUS* arrived in the south central Florida area and began its spread throughout the Pinecrest area. *TESTUDINEUS* evolved or arrived at Brickell Hammock and began its spread to the south and west. A large slough between Pinecrest and the Coastal Ridge prevented overlapping of these families. Perhaps during this period, *LIGNUMVITAE* was introduced to Lower Matecumbe Key, where it spread westward, eventually occupying all of the middle and lower Keys. By the time these shells had migrated to the lower Keys, they had become the *GRAPHICUS* family, which is today somewhat different from the *LIGNUMVITAE* family.
- (5). Then about 3100 years ago, the ocean began to rise again, eventually reaching a level about 6 feet higher than present, and submerging the southern Everglades, all of the middle and lower Keys except Lignumvitae Key, Big Pine Key and Key West. *LIGNUMVITAE* shells would be destroyed on those islands between Lignumvitae Key and the Lower Keys (Key Vaca, for instance). The rising ocean would have "followed" the spread of *MARMORATUS* as it migrated up the Pinecrest area. Much diversification and natural hybridization would have taken place during this time in the Central Pinecrest and Brickell Hammock areas.
- (6). Then about 1800 years ago, the ocean again fell to below present levels, allowing for the final spread of *MARMORATUS* southward to Pinecrest and even to Cape Sable. An early form of *TESTUDINEUS* spread southwest throughout the Coastal Ridge. A *TESTUDINEUS*-type shell either evolved or was introduced into the central Long Pine Key area. *Ornatus* had an earlier beginning than *testudineus*, and had spread as far west as Mahogany Hammock and on to Cape Sable, and also to the upper Keys. As the ocean continued to fall, *MARMORATUS* and other Cape Sable shells made their way across Florida Bay to Key Vaca, which is directly south of there, and which was now devoid of other *Liguus*. Perhaps at this time, *matecumbensis* made its way from Upper Matecumbe Key to Flamingo.
- (7). Finally the ocean began to rise again, slowly reaching present levels. In the process, it slowed the flow of water from the Everglades so that it became a swamp, with isolated hammocks. At some fairly recent time, *septentrionalis* was introduced into the Broward County area, and migrated south and north.
- (8). At some relatively recent time, a *TESTUDINEUS*-type shell either evolved or was introduced into the extreme northeast corner of the Pinecrest area, and its influence spread south and

## Plate XXI



1, *Castaneus*, Long Pine Key #55. 2, *Castaneus*, M.C.S. 3, *Castaneus*, Silver Palm Hammock, probably not a native shell. 4, *Castaneus*, Long Pine Key; this is typical of many Long Pine Key shells. 5, *Evergladensis*, 6 miles north of the Forty Mile Bend in U.S. #41. 6, *Evergladensis*, probably a plant whose ancestors came from hammocks as in #5. 7, *Evergladensis*, dark form, 6 miles north of the Forty Mile Bend. 8, *Humesi*, from the type locality in East Everglades. 9 & 10, *Humesi*, probably same as #8. 11 - 14, *Versicolor*, Long Pine Key #23 (the presumed type locality). 15, *Versicolor*, north of Long Pine Key.



southwest. Also, there seems to have been an overlapping of *MARMORATUS* and *TESTUDINEUS* influences in the East Everglades area, which lies between Long Pine Key Pinecrest.

Among the isolated hammocks of the Everglades, there would occasionally be a fire or something that would destroy all the *Liguus* in a hammock. Then later a single specimen would find its way to that barren hammock and begin multiplying. In this way, there are several pure colonies in the Everglades hammocks.

This description of possible events is not completely satisfactory, and perhaps no attempt could be very satisfying, because the data are so complex and uncertain. The most difficult question has to do with the existence of large colonies of the *TESTUDINEUS* family in both Brickell Hammock and Long Pine Key, but with rather different shells in between.

I hope this discussion of distribution and migration has raised some questions for you that will lead to your own explanations.

\* \* \* \* \*

#### NOTES

I. Michael Rex has written an interesting article, "The Relationship of Island Area and Isolation to Color Polymorphism in *Liguus fasciatus* (Mollusca: Pulmonata: Bulimulidae)", *Brevioria*, August 11, 1972, #391.

In this article, the author studies the distribution of *Liguus* in a number of hammocks in the Long Pine Key area. He found that a hammock's size was correlated with the number of color forms found in it, but the hammock's isolation from a presumed dispersal hammocks was not significantly correlated with the number of color forms. Dr. Rex considered only color forms that were qualitatively different from each other: *eburneus*, *cingulatus*, *roseatus*, *castaneozonatus*, *deckerti*, *luteus*, *ornatus*, *testudineus* and *marmoratus*. He did not include certain variations of these color forms, such as *miamiensis*, *versicolor* and *castaneus*. In one sense this seems wise, since some of these identifying characteristics are quite arbitrary and probably trivial. But they do represent variations that result from development and interbreeding. For instance, there is tremendous variation in the *versicolor* from one large hammock (Long Pine Key #23, also called Osteen Hammock), ranging from shells that are almost totally blue with a few flecks of yellow, to shells that are almost completely yellow, with a very few blue spots and streaks (see Plate XXI-11 to XXII-2). So there is more variation within this color form than there is between certain other color forms, such as *deckerti* and

*castaneozonatus*, or between a dark *luteus* and a light *ornatus*. Also relevant would be the relative number of different color forms from each hammock. Unfortunately, this is unknown. From the very beginning, even serious scientific collectors did not always collect representatively. They would take lots of the pretty shells, and leave many of the others. So we cannot know the relative frequency of shells in most of these hammocks (There are some exceptions to this, of course, such as McGinty, DeBoe and Pilsbry.)

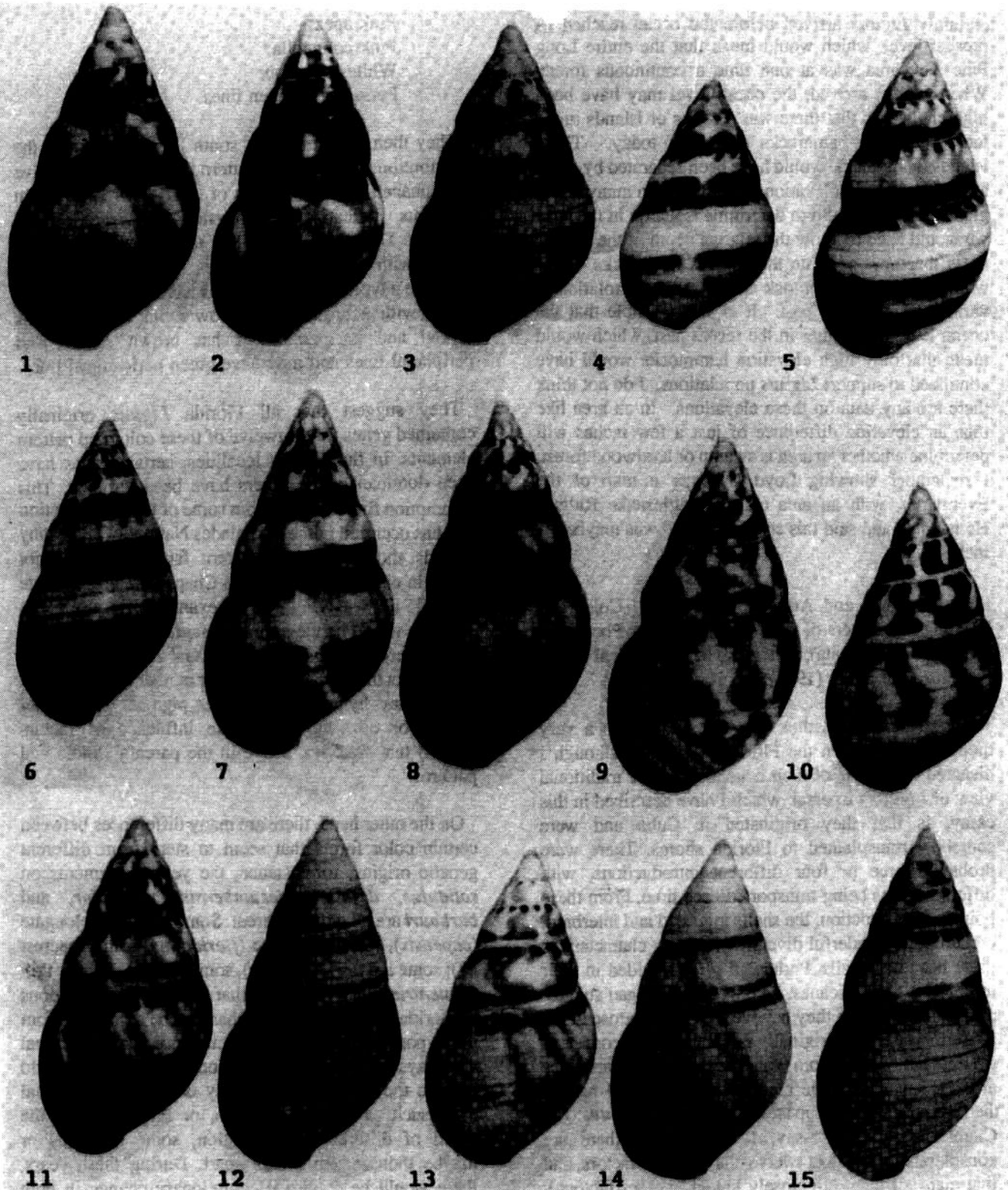
In considering isolation, Dr. Rex considered the large hammock at the eastern edge of Long Pine Key (Long Pine Key #27, also called Palma Vista #1) to be the dispersal center from which the shells migrated to other hammocks. He has some reservations about assigning this hammock as the dispersal center, because it is on the eastern periphery of the area. But as I have suggested earlier, almost certainly these shells migrated from Brickell Hammock, and would have arrived at the eastern hammocks first. I would therefore expect the eastern hammocks to have more color forms with more variation than western hammocks. As I noted, the hammocks in the extreme western parts of Long Pine Key have no shells of the *marmoratus* or *testudineus* families. (See the distribution tables of this area in Appendix o.)

Dr. Rex hypothesizes that the larger hammocks would have more diversity in plant life, and would therefore provide more microhabitats for *Liguus*, which would provide more protection from predators. This hypothesis might be strengthened if the shells in *Liguus* collections had data indicating the kind of tree from which they were collected. To the best of my knowledge, only Carol Brown has done this, in her study of one small hammock in the Long Pine Key area, during one summer. Larger hammocks would also support a larger population of shells, which would also increase the available gene pool.

In my opinion, the number of color forms and their variations in a given hammock will be related in large part to the length of time that hammock has supported shell populations. For instance, Brickell Hammock, south of downtown Miami, is the highest point (up to 19 feet above sea level) in south Florida, and has probably supported a *Liguus* population longer than any other locality. The diversity of forms (17) and variations is stunning! In my own collection, I have 26 *testudineus* from there, all of which are noticeably different. (See Plate X - 9 to XX - 3).

Dr. Rex's study would be more persuasive if the geography of this area were known to have been stable throughout the time they have supported *Liguus* populations. But that is highly unlikely. Almost





## Plate XXII

1 & 2, *Versicolor*, Long Pine Key #23. 3 & 4, *Versicolor*, Long Pine Key #74 (Gold Hammock). 5, *Versicolor*, East Everglades, 1½ miles north of Long Pine Key #103. 6, *Versicolor*, Long Pine Key Glade #9. 7 & 8, *Versicolor*, East Everglades. 9, *Versicolor*, this specimen was found in Central Plains 14, where it is undoubtedly been introduced from Long Pine Key or the East Everglades. 10, *Versicolor*, locality unknown. 11, *Versicolor*, Silver Palm Hammock, in south Dade County; this is not a native shell, but was introduced here in the 1930's or 1940's. 12, *Clenchi*, locality uncertain, probably ancestors from PC-88. 13, *Clenchi*, 2 miles east of Pinecrest #91. 14, *Clenchi*, 3 miles north northeast of Pinecrest #91. 15, *Clenchi*, locality unknown.

certainly *Liguus* arrived before the ocean reached its present level, which would mean that the entire Long Pine Key area was at one time a continuous forest. When *Liguus* arrived, the ocean level may have been high enough so that there was a series of islands much larger than the hammocks that exist today. These islands (hammocks) would have been separated by glade areas in which the elevation was lower than many of the glade areas today. So to determine isolation in the past, we would need to know the relative depth of the swamp areas that now separate the various hammocks. This would determine hammock size as well as isolation at various times in the past. It is also possible that the ocean level was higher in the recent past, which would mean that only high elevation hammocks would have continued to support *Liguus* populations. I do not think there are any data on these elevations. In an area like this, an elevation difference of just a few inches will determine whether an area is swamp or hardwood forest. I remember showing Loyd Lysinger a map of the Everglades, with an area called "Rattlesnake Ridge". He laughed and said this so-called ridge was maybe six inches high.

II. Roth, Barry and Arthur Bogan, "Shell Color and Banding Parameters of the *Liguus fasciatus* Phenotype (Mollusca: Pulmonata), American Malacological Union Bulletin, Vol. 3 (1) (1984): 1 - 10.

Barry Roth and Arthur Bogan have written a very thoughtful article on the Florida *Liguus* - although I disagree with some of their conclusions. The traditional view of *Liguus* dispersal, which I have described in this essay, is that they originated in Cuba and were somehow transplanted to Florida shores. There were probably three or four different introductions, with different forms being transported each time. From these points of introduction, the shells migrated and interbred, creating the wonderful diversity that now characterizes these beautiful snails. Perhaps they were aided in their migrations by hurricanes. Drs. Roth and Bogan suggest an alternative view: they believe the *Liguus* arose in the United States, were originally widespread, and contained a large gene pool from which the present variations arose. They list twelve elements of color and pattern that may or may not appear on a particular *Liguus*: (In Chapter II of this essay, I suggest that there are considerably more than twelve color/pattern factors, and that many of them are closely linked to other factors.).

Ground color (yellow or white);

Presence or absence of *dryas* bands (yellow and/or brown);

Spreading of *dryas* band pigment;

Vacant center of *dryas* band;

Marbling of *dryas* bands;

Sutural line (brown, yellow or pink);

Peripheral line (brown, yellow or pink);

Pink apex;

Pink columella;

White suffusion;

Periostracal green lines.

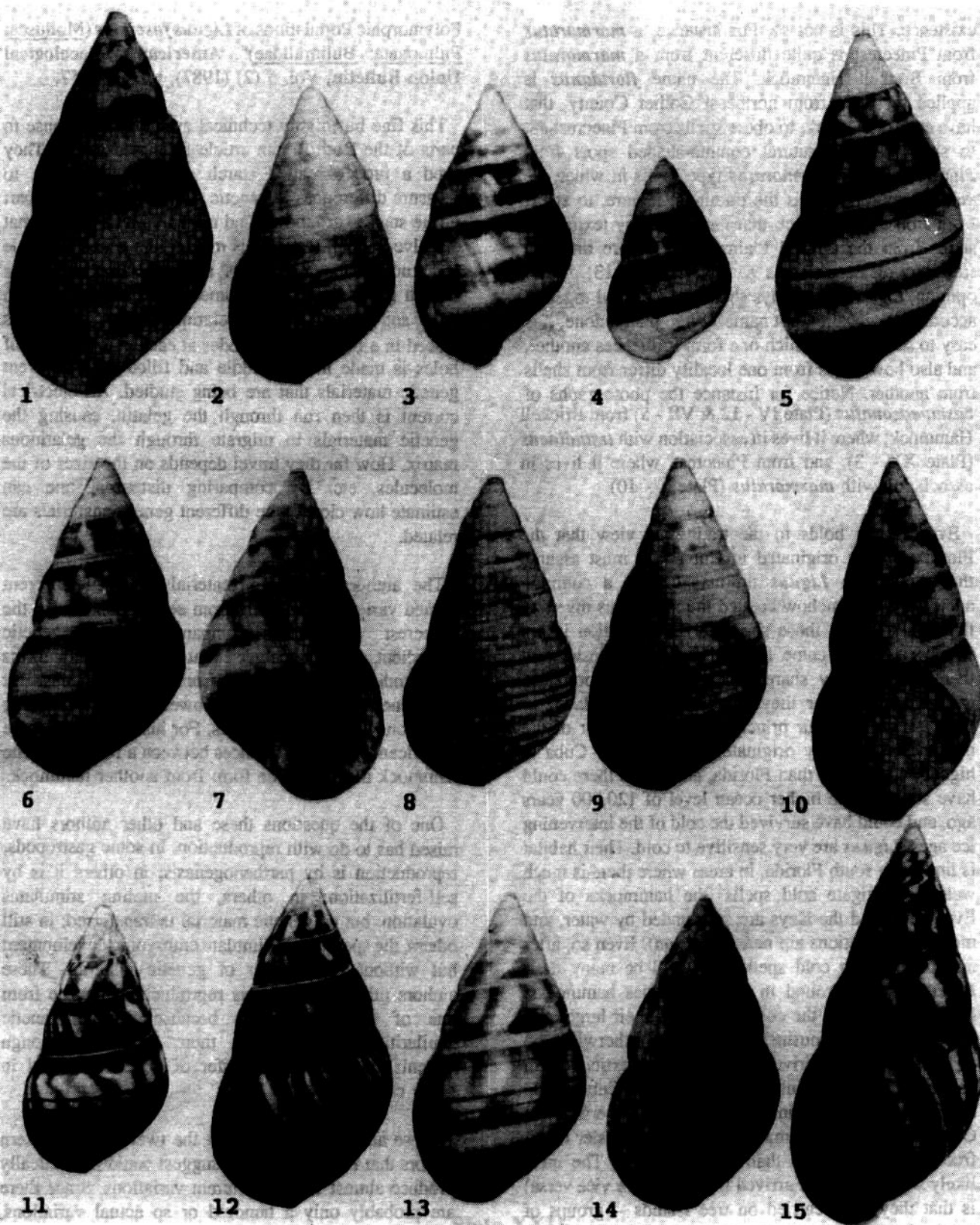
They then give a map of south Florida, showing the distribution of these color/pattern factors. They also give an alphabetical code to each of these color and pattern elements, indicating the presence or absence of that element. They then list all 58 of the named color forms, along with the relevant codes. For instance: they describe a typical *marmoratus* as having a white ground color, with a brown and yellow *dryas* band that has spread and is marbled. It has brown sutural and peripheral lines and may have green periostracal lines.

They suggest that all Florida *Liguus* originally contained genes for all twelve of these color and pattern elements. In the various localities, certain genes have been dominant while others have been dormant. This assumption finds support from some of the hybridization that has occurred in the Everglades National Park. Many hybrids show color and pattern factors that are not found in either parent (refer to Chapter IV and to Plate XIII - 15 to Plate XXV - 13 for examples). A prominent example would be the hybrid of *septentrionalis* and the blue variety of *barbourni* (Plate XXIV - 10). This hybrid has streaks that fork - a character neither parent shows. Also, many hybrids have darker pigment than either parent, or otherwise show the influence of factors (genes) that were not active in the parental colors and patterns.

On the other hand, there are many differences between certain color forms that seem to stem from different genetic origins, for instance, the yellow pigments on *solidulus*, *dryas*, *matecumbensis*, *versicolor*, and *barbourni* are all quite different. Some shells are elongate (*capensis*), some are obese (*floridanus* from Pinecrest #8); some are thick (*crassus*), some are consistently thin (*septentrionalis*). So I think that the *Liguus* populations in Florida are more complex than can be explained from the hypothesis of a common gene pool. The traditional view says that different populations (a population would refer to the shells in a relatively isolated geographical area, such as the Lower Keys, or Pinecrest) are the result of different transportation, some hundreds or maybe thousands of years apart. During these years, there would be continual evolutionary change in both the Florida and the Cuban shells, which would then be reflected in the differences we now see in the different *Liguus* populations.

All of the museum collections I have seen have *Liguus* separated by the named color forms. This is very misleading, because it gives too much importance to the names, and assumes they have a kind of objective





## Plate XXIII

1, *Clenchi* taken from the loop road near Fred Dayhoff's home, undoubtedly planted from some other location. 2, *Clenchi*, locality unknown. 3 & 4, *Clenchi* Cape Sable, this specimen collected by McGinty (now in Museum of Natural History, University of Florida). 5, *Solleococcus*, 2½ miles west of Poppenhager's Camp. 6 & 7, *Solleococcus*, Collier County #6, the type locality. 8 & 9, *Beardi*, probably from the East Everglades type locality. 10, *Framptoni*, probably from the East Everglades type locality. 11 & 12, *Marmoratus*, Hattie Bauer Hammock; not a native shell (note on #12 how close the streaks are together). 13, A hybrid or intergrade of unknown ancestry. 14, *Testudineus*, this specimen was taken from Pinecrest #39, where many Brickell Hammock shells were introduced many years ago. 15, *Splendidus/pseudopictus/testudineus* hybrid.

existence. This is not so. For instance, a *marmoratus* from Pinecrest is quite different from a *marmoratus* from Brickell Hammock. The name *floridanus* is applied to shells from northeast Collier County, that have streaks that fork, to obese shells from Pinecrest #8, to shells with subsutural comma-shaped spots from Pinecrest #91, to *marmoratus* type shells in which the yellow ground color is the dominant feature, to shells from Iron Pot hammock that have a glossy texture, to shells from the Central Plains area that are different from any of these (Plates XI - 11 to XII - 13). In my opinion, *Liguus* in displays should be grouped together according to locality, not name. When that is done, it is easy to see ways in which one form influences another, and also how shells from one locality differ from shells from another. Notice for instance the photographs of *castaneozonatus* (Plate IV - 12 & VII - 5) from Brickell Hammock, where it lives in association with *testudineus* (Plate XX - 3), and from Pinecrest, where it lives in association with *marmoratus* (Plate X - 10).

Even if one holds to the traditional view that the Florida *Liguus* originated in Cuba, one must assume that the Cuban *Liguus* originated from a common ancestor, and somehow created the marvelous diversity that characterizes those shells. So the question is not whether they all came from a common ancestor and therefore probably share a common gene pool. The question is whether they originated in Florida or in Cuba. There are four principle factors in favor of the hypothesis that they originated in Cuba: (1) Cuba is higher and warmer than Florida, and shells there could have survived the higher ocean level of 120,000 years ago, and could have survived the cold of the intervening ice ages. *Liguus* are very sensitive to cold. Their habitat is limited to south Florida, in areas where there is much water to mitigate cold spells (the hammocks of the Everglades and the Keys are surrounded by water, and most other locations are near the ocean). Even so, after an exceptionally cold spell, there will be many dead *Liguus* on the ground in the Everglades hammocks. *Liguus* do tolerate the cold better than their larger and more voracious cousins, *Orthalicus*. Otherwise the *Orthalicus* would drive the *Liguus* to extinction in hammocks they both inhabit. (2) *Liguus* in Cuba would have a much longer time to evolve and diversify. (3) Ocean currents would make it much more easier to get from Cuba to Florida than vice versa. (4) The most likely way the *Liguus* arrived from Cuba (or vice versa) is that they were carried on tree islands - groups of trees whose roots were undercut by a flooding river. There are many rivers in Cuba where this would be possible; there are none in Florida.

III. Hillis, David M., David S. Rosenfeld, and Mosesto Sanchez, Jr., "Allozymic Variability and Heterozygote Deficiency Within and Among Morphologically

Polymorphic Populations of *Liguus fasciatus* (Mollusca: Pulmonata: Bulimulidae)", *American Malacological Union Bulletin*, Vol. 5 (2) (1987), p. 153 - 157.

This fine but highly technical article is a response to parts of the Roth/Bogan article discussed above. They used a process called starch gel electrophoresis, to measure differences in genetic material. The fleshy part of the snail is ground up and mixed with chemicals that dissolve the cell walls, thus making the genes available for study. Other chemicals are then used to isolate certain genes that are presumed to be associated with color and pattern. Then a gelatinous starch solution is placed in a box with electrodes at each end. A series of holes is made in the middle and filled with different genetic materials that are being studied. An electrical current is then run through the gelatin, causing the genetic materials to migrate through the gelatinous matrix. How far they travel depends on the sizes of the molecules, etc. By comparing distances, one can estimate how closely the different genetic materials are related.

The authors examined material from 14 different named varieties of *Liguus* from seven locations in the Pinecrest area, and compared several genetic ingredients. They concluded that all of the color forms they studied do indeed come from the same genus. But the genetic material also showed some interesting variations between hammocks. For instance, there were significant genetic differences between a form from one hammock and that same form from another hammock.

One of the questions these and other authors have raised has to do with reproduction. In some gastropods, reproduction is by parthenogenesis; in others it is by self-fertilization; in others, the mating stimulates ovulation, but no genetic material is transferred; in still others, the sperm may stimulate embryonic development but without the transfer of genetic material. These authors think some *Liguus* reproduction may be from one of these processes, because of the genetic similarities revealed in their studies, although undeniably there is a transfer of genetic material in many cases.

These authors point out that the twelve color/pattern factors that Roth and Bogan suggest could theoretically produce almost 16,000 different variations. Since there are probably only a hundred or so actual variations, many of these color/pattern factors must be closely linked. See Chapter II for my discussion of this.

It would be interesting to use the starch gel electrophoresis processes to study the variations between all of the Florida *Liguus*, between all of the Cuban *Liguus*, and between certain Florida *Liguus* and their supposed



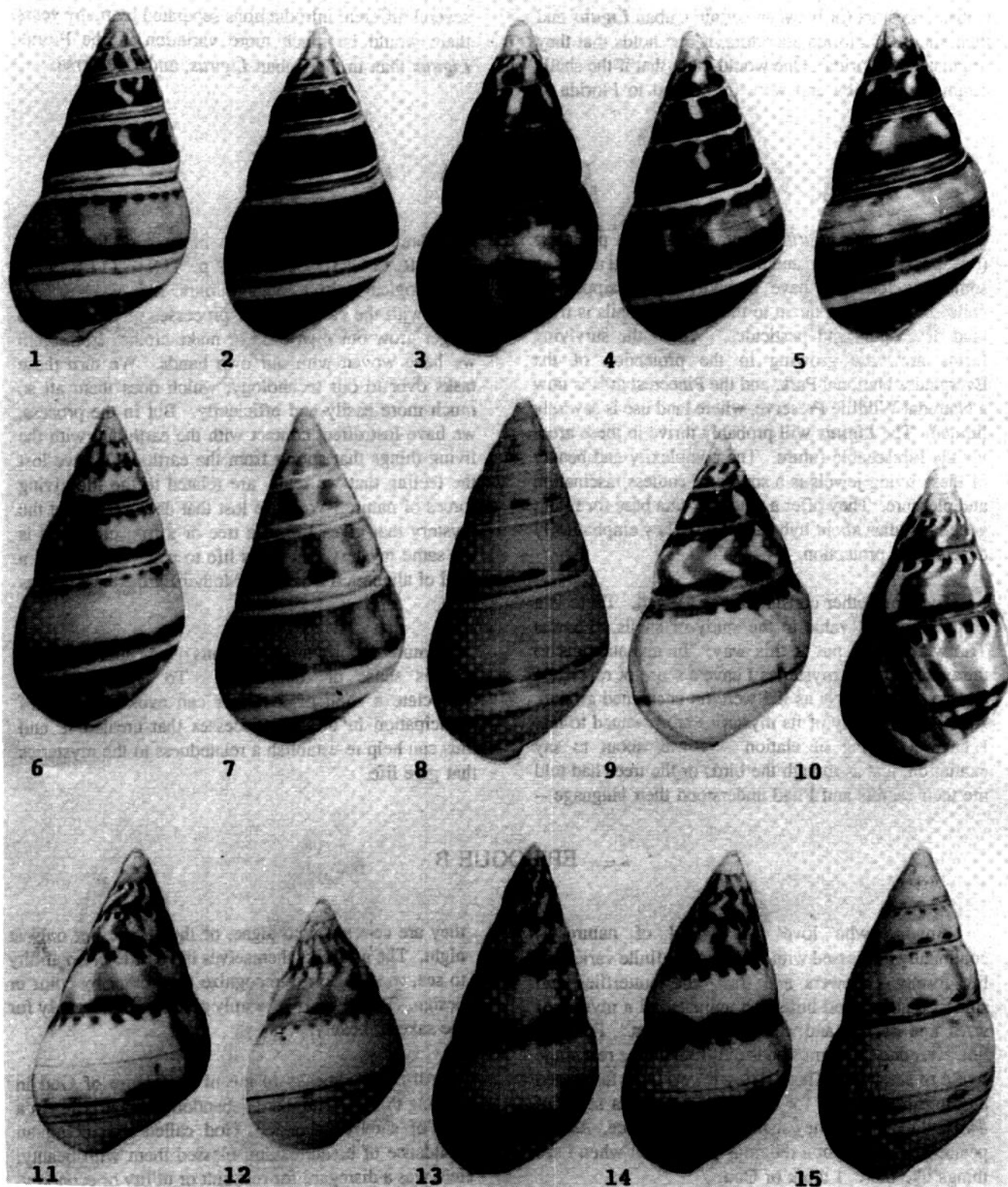


Plate XXIV

1 - 3, *Graphicus/wintel* hybrids. 4 - 6, *Vonpausen/lossmanicus* hybrids. 7 & 8, *Dryas/lucidovarius* hybrids. 9, *Septentrionalia/barboursi* (blue variety) hybrid. 10, *Septentrionalia/barboursi* (blue variety) hybrid; notice the streaks that fork (!); does this characteristic come from the *barboursi* or *septentrionalis*? 11 & 12, *Septentrionalia/barboursi* (blue variety) hybrids. 13 - 15, *Dryas/pseudopictus* hybrids (in #13, note the similarity to *pictus*).

Cuban ancestors (or between certain Cuban *Liguus* and their supposed Florida ancestors, if one holds that they originated in Florida). One would think that if the shells originated in Cuba and were introduced to Florida in

several different introductions separated by many years, there would be much more variation in the Florida *Liguus* than in the Cuban *Liguus*, and vice versa.

## EPILOGUE A

Although the *Liguus* have a few natural predators (rats, possum, raccoon and possibly birds), and although some few localities have probably been stripped by collectors, the main threat to these lovely snails is from land developers and pesticides. All of the surviving forms are now growing in the protection of the Everglades National Park, and the Pinecrest area is now a National Wildlife Preserve, where land use is severely limited. The *Liguus* will probably thrive in these areas for the foreseeable future. The complexity and beauty of these living jewels is a source of endless fascination and pleasure. They offer a potential data base for future genetic studies about hybridization. They emphatically deserve our protection.

There are other considerations as well. There is a certain spiritual value to the study of shells. Charles Torrey Simpson put it this way: "In my attempts to unravel [nature's] mysteries I have a sense of reverence and devotion. I feel as if I were on enchanted ground. And whenever any of its mysteries are revealed to me, I have a feeling of elation -- I was about to say exaltation, just as though the birds or the trees had told me their secrets and I had understood their language --

and Nature herself had made me a confidant." (IN LOWER FLORIDA WILDS, p. 116 - 117.) In a technological culture such as ours, it is easy to lose touch with the earth and the processes of life. We no longer grow our own food or make clothes from cloth we have woven with our own hands. We turn these tasks over to our technology, which does them all so much more easily and efficiently. But in the process, we have lost direct contact with the earth and with the living things that spring from the earth. We have lost the feeling that we really are related to the life-giving forces of nature. We have lost that deep sense that the mystery that gives life to a tree or a frog or a snail is the same mystery that gives life to us. We thus feel a kind of alienation from the "Mother Earth" that sustains us.

Nature hobbies are one means of re-capturing some of this sense of relatedness. To understand and appreciate a shell or a flower can evoke a sense of participation in the life-processes that created it, and thus can help re-establish a relatedness to the mysteries that give life.

## EPILOGUE B

Anyone who loves the world of nature is continually impressed with the almost infinite variety of life forms -- flowers and trees and butterflies and spiders and fish and birds and animals, all a myriad of sizes and shapes and colors and designs. For me, however, one life form stands out from all the rest -- the world of seashells. These living jewels have fascinated and intrigued people for centuries, evoking a sense of awe and wonder as they stand in their presence. As one person said, "I'm not a religious person, but when I see things like these, I think of God."

Much of the beauty of other life forms is functional. The colors and designs of birds and fish are for identification or camouflage; the color and fragrance of flowers attract the insects that are so necessary for their propagation. But seashells are not like this. With a very few exceptions, their beauty is of no value to them. They live buried in the sand or mud or under rocks, or

they are covered with algae, or they come out only at night. The mollusks themselves have little or no ability to see, so they do not recognize each other by color or design. Their beauty is simply a bonus. It is beauty for the sake of beauty.

All of this speaks to me of the nature of God in creating things. The word "abandon" says it best. In a kind of carefree abandon, God called into being an abundance of creatures and blessed them with beauty. Here was a disregard for restraint or utility or economy. And the God who is witnessed to by a seashell is a God who dances and laughs and claps his hands.

The God who abandoned Himself so in creating is the same God who creates in me the capacity to see and appreciate and wonder. And I am grateful anew for the privilege of being part of this world. (from OF SEA AND SHORE, Spring, 1973).

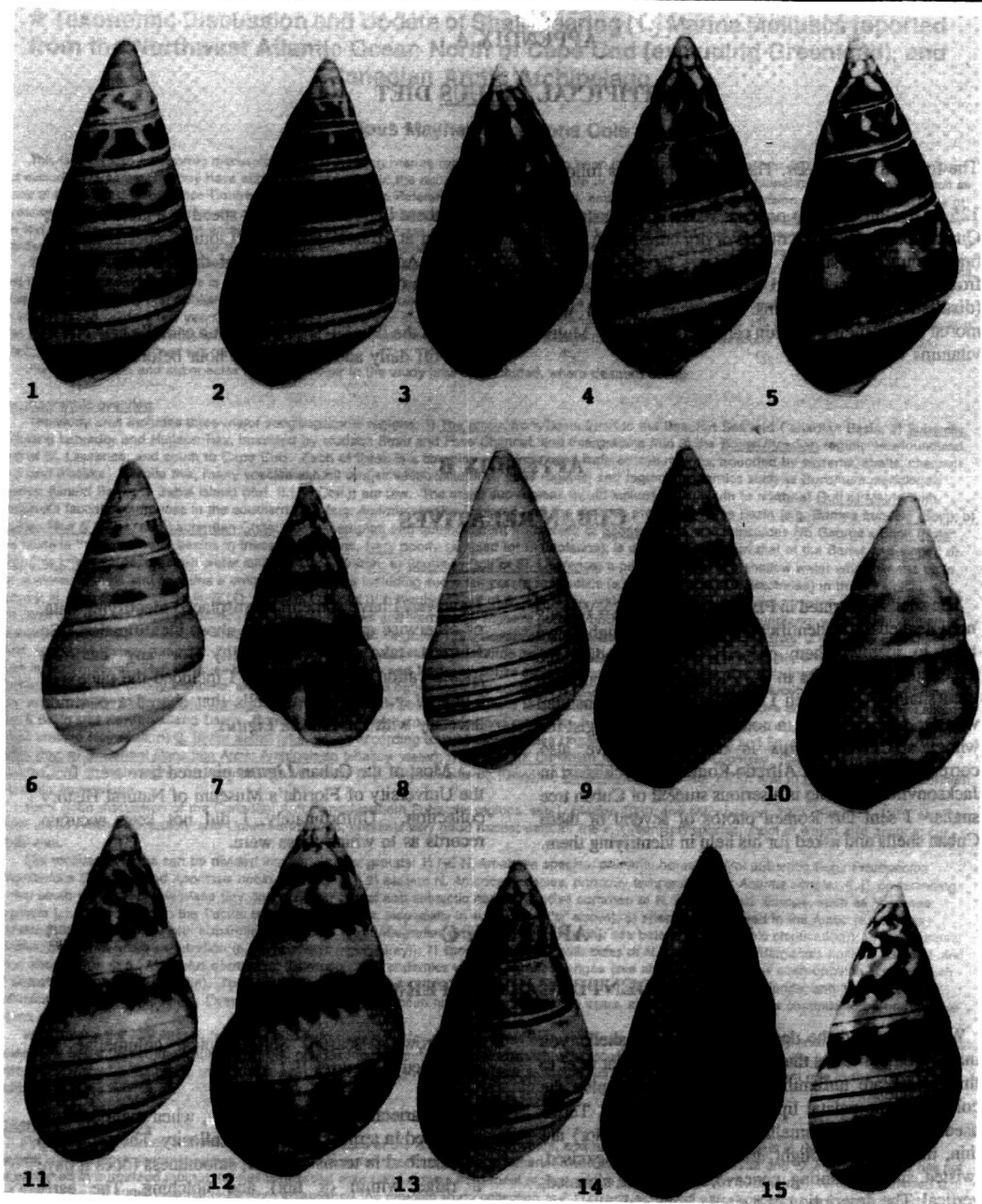


Plate XXV

1 & 2, *Graphicus/clingulatus* hybrids. 3 - 5, *Osmentii/castaneus* hybrids. 6 & 7, *Pictus/roseatus* hybrids. 8, *Osmentii/dryas* hybrid. 9, *Pictus/solidulus* hybrid. 10, *Aurantius/floridanus* (Central Plains variation) hybrid. 11. & 12 *Pseudopictus/marmoratus* hybrids. 13, *Lignumvitae/ornatus* (Totten Key variety) hybrid. 14, Probably a *graphicus* or *vonpaulseni* hybrid. 15, no information.



## APPENDIX A

ARTIFICIAL *LIGUUS* DIET

The formula used by Dr. Thomas Emmel is as follows:

125 ml. volume of dry oatmeal flakes (Old Fashioned Quaker Oats); 175 ml. volume of dry corn starch (Argo brand pure corn starch); ½ package (= 5 oz weight) frozen Pictsweet chopped spinach; 150 ml. deionized (distilled?) water; 12 gms. limestone (ground with mortar and pestle); 1 vitamin capsule ("Vitamins" Multi-vitamins with minerals).

Chop these ingredients at slow speed in a table blender, then run at "Blend" and then "Liquify" speeds for one minute. Add another 100 ml. of deionized water and blend briefly.

Paint on the lid of a container with a camel's hair brush, clean off daily and re-paint one hour before "night".

## APPENDIX B

## CUBAN RELATIVES

The shells illustrated in Plates XXVIII and XXVIII are not intended to be identification models, although I have tried to identify them properly. I have studied the excellent photographs in R. Tucker Abbott's book on land snails. Also, when I lived in Miami, I consulted with Dr. Oscar Alcalde, a noted Cuban malacologist for whom a Cuban *Liguus* is named. I have also corresponded with Dr. Alfredo Romeu, a psychiatrist in Jacksonville, FL, who is a serious student of Cuban tree snails. I sent Dr. Romeu photos of several of these Cuban shells and asked for his help in identifying them.

However, I have sometimes misplaced identifying data, or otherwise gotten mixed up about identification. So I must take full responsibility for any incorrect identification of these shells. I included the photos of Cuban *Liguus* to show shells that shared a common ancestry with the Florida *Liguus*.

Most of the Cuban *Liguus* pictured here were from the University of Florida's Museum of Natural History collection. Unfortunately, I did not keep accurate records as to which these were.

## APPENDIX C

## IDENTIFICATION TERMS

When you read the descriptions of these shells, you may encounter terms that are unfamiliar, or that refer to things that are unfamiliar. These mainly involve the columella, the palatal lip and the parietal wall. Terms used to describe columellae (in addition to color) are thin, thick, wide, straight, truncate, obliquely excised, twisted, simple, slanting, concave, continuous, sinuated, vertical. The description of a single form may allow for much variety in the columella. For instance, Pilsbry says the columella of *roseatus* is "... usually slender but sometimes strongly truncate." Some of this variety is probably genetic; much of it may be environmental, depending on food supply, moisture and the length of

the growing season. Some typical columellae are illustrated in Figures II 1 - 8.

The parietal wall (see Figure 1), when mentioned, is described in terms of color and callosity. The palatal lip is described in terms of color, smoothness (does it have a ridge within or not) and notching. The early descriptions used the term "crenation" to describe notching at the lip where the green spiral lines terminate. The term "emarginate" seems more popular today. It means literally, "deprived of a margin," meaning in this case that the margin is not smooth.



# A Taxonomic Discussion and Update of Shell-Bearing (1.) Marine Molluscs reported from the Northwest Atlantic Ocean North of Cape Cod (excluding Greenland), and Canadian Arctic Archipelago

Ross Mayhew and Fiona Cole

This is a list and taxonomic discussion of shell-bearing marine molluscs which have been identified from the western Atlantic, north of Cape Cod, but excluding Greenland. They have either been reported in the recent molluscan literature or reliably identified in regional mollusc collections such as those at the Atlantic Geoscience Centre (A.G.C.), the Atlantic Reference Collection (A.R.C.), and the Habitat Ecology Division of the Bedford Institute of Oceanography (B.I.O.) (by ourselves, and various malacologists to whom we have sent specimens). Since Abbott's *American Seashells* (2nd Ed.) was the last work covering the entire area, it has been used as a "base compilation." Subsequent taxonomic changes have been noted, documented, and clarified, and "problematic" taxa or reports indicated. Supra-generic taxonomy is according to Vaught, 1989, except where indicated.

The molluscan fauna of eastern Canada and the Gulf of Maine are relatively under-studied in comparison to more southerly parts of North America, and the corresponding literature is sparse, scattered, often contradictory, and pertaining largely to the Arctic. Fiona Cole and I hope to alleviate this situation somewhat by first publishing an illustrated and annotated checklist of the region's shell-bearing molluscs, hopefully in late 1995, followed by an identification guide a few years later, pending funding and support for this larger undertaking. In the interim, we will complete a "summary checklist" with basic information, such as range and general habitat, can be completed. Also, a large number of range extensions found in lots in the A.G.C., A.R.C., and B.I.O. collections will be published.

Forms, varieties, and subspecies known to occur in the study area are included, where deemed useful.

## Zoogeographic overview

The study area includes three major zoogeographic regions: 1) The Arctic, from Davis Strait to the Beaufort Sea and Canadian Basin; 2) Subarctic, including Labrador and Hudson Bay, bounded by Hudson Strait and Foxe Channel, and intergrading into 3) the Boreal/Atlantic region: Newfoundland, Gulf of St. Lawrence, and south to Cape Cod. Each of these is a complex mosaic of semi-isolated sub-regions, bounded by currents, straits, channels, and land masses. Despite this, many species exhibit ranges which include all three regions, and regional endemics such as *Buccinum meridionale* Harmer (Grand Banks to Sable Island (Ref. B.I.O. Coll.)) are few. The major sub-regions would include, from south to north: a) Gulf of Maine, with temperate faunal occurrences in the southern part (e.g. *Anomia simplex* Orbigny) and the shallow, protected Minas Basin (e.g. *Bamea truncata* (Say)); b) Scotian Rise & Slope, and Laurentian Cone: poorly sampled and quite different from shelf; c) Scotian Shelf, which includes NE George's Bank (Note: the fauna in the deep water basins in these two regions, very poorly sampled for macrofauna), is quite different from that of the Banks and slope); d) Bras D'or Lakes: large, brackish water lakes of Cape Breton; e) Southern Gulf of St. Lawrence: a pocket of relatively shallow water which warms up in the summer months and contains a unique assemblage including some temperate-zone relics (e.g. *Mulinia lateralis* (Macræidae) in the Miramichi estuary, N. New Brunswick (Refs. B.I.O. and A.G.C. Colls.)); f) Northern Gulf of St. Lawrence, which is chilled by the Labrador current coming through the Strait of Belle Isle (high proportion of subarctic species and forms, e.g. *Thyasira gouldi* Phillips, 1845)); g) W. Newfoundland: very poorly studied, includes unique deep fiord communities (see Haedrich and Gagnon, 1991: *Acesta excavata* (Fabricius)); h) The Grand Banks: a vast area of continental shelf, quite little known (example: The two most common species of *Cyclocardia* on the Grand Banks (*C. novangliae* (Morse) and *C. sp.* below), are not even in the literature! (Ref. samples taken in 1992, Hibernia and N. Grand Banks area)). The adjacent Flemish Cap is faunally similar; i) E. Newfoundland: very poorly sampled, and geographically and bathymetrically complex; j) Labrador Coast and Shelf: subarctic. Ungava Bay is faunally very similar; k) The Mid-Oceanic Canyon, which extends from South Baffin Island to the Sohm Abyssal Plain, and includes areas known as the Labrador Sea & Basin and Newfoundland Basin. Contains Milne Seamount complex and other little-studied areas; l) Hudson Bay; m) James Bay and Belcher Island area, to Hopewell; n) S. Baffin Island area, which according to Lubinsky includes Ungava Bay; o) Foxe Basin and Foxe Strait; p) Davis Strait and Baffin Bay; q) S. Central Canadian Arctic Archipelago (shallow water); r) Central NE Canadian Archipelago (see Lubinsky, 1980); s) Amundsen and Coronation Gulf: high degree of Beaufort Sea influence (e.g.: *Neptunea heros* (Gray)); t) Baffin Bay (see Clarke, 1974); and u) High Arctic Zone: northern Canadian Archipelago.

For a good discussion of the Canadian Arctic and Northern Subarctic regions, see Lubinsky, 1980, and Macpherson, 1971. Bernard, 1979, also has much useful Arctic information, and Ockelmann, 1958, presents very good habitat data for the E. Greenland species, most of which also occur in our study area.

Our molluscan fauna can be divided into nine major groups: 1) NE N. American species, primarily boreal and/or subarctic (e.g.: *Plicapecten magellanicus* (Gmelin), and *Aporrhais occidentalis* Beck); 2) eastern N. American species, primarily temperate (e.g.: *Anomia simplex* (L.)), or extending further south (e.g.: *Crepidula plana* Say: to Brazil); 3) boreal and subarctic Atlantic species common to N. America and Europe, such as *Neptunea despecta* L.; 4) species from the Pacific subarctic and Arctic (especially in subregional "q" above); 5) species widespread in the Arctic (e.g.: *Colus conulus* (Aurivillius)), many with subarctic penetration (e.g.: *Margarites groenlandicus* ((Gmelin): see below for taxonomic clarification)); 6) circumboreal species, often with arctic penetration (e.g.: *Musculus niger* (Gray)); 7) species found on both sides of N. America (e.g.: *Margarites costalis* (Gould)), and often also Europe (e.g.: *Musculus corrugatus* (Stimpson)); 8) endemics with very limited ranges (see above); and 9) a few cosmopolitan species, such as *Delectopecten vitreus* (Gmelin). Total confirmed shell-bearing fauna includes 282 gastropods, 190 bivalves, 10 scaphopods, and 11 chitons for a preliminary total of 487 species. Over 15% of these have only been recorded in the past 25 years, and taxonomic changes continue to be proposed at a brisk rate.

In summary, the NW Atlantic is a large and extremely complex oceanographic area, whose fauna is still relatively poorly known. For the foreseeable future, government funding of benthic, taxonomic, and ecological research will probably continue to decline, as the public sector becomes more impoverished. Alternative means of support must be sought, and dedicated amateurs will continue to play an important role in the field of malacology.

## A Note about the Authors

Fiona Cole has worked with foraminifera and molluscs at the A.G.C. for many years, and has published several papers in recent years. Ross Mayhew is an independent researcher, and subcontracts for the Department of Fisheries and Oceans in Atlantic Canada and Quebec. While he has not yet published in a refereed journal, he has processed over 500 samples from most regions of the study area (about 20,000 lots), re-curated the A.G.C. and A.R.C. (August 1994) regional collection, established the regional study collection at B.I.O., and examined other collections in Eastern Canada.

Current research interests of F. Cole and R. Mayhew include the Turridae, Astartidae, Trochidae, and Polyplacophora of the study area.

**NB:** If anyone examining this list notices any errors or omissions, we would be very pleased to hear about them. This is a circulating draft for comment, correction, input, and opinion.

Thank you,  
Ross Mayhew and Fiona Cole, September 1994

1: This list has been restricted to shell-bearing molluscs because these are the subject of our studies. Dr. Sherman Blakeney of Acadia University, Nova Scotia, has prepared a treatment of the Sacoglossans and Nudibranchs of Nova Scotia, to be published in 1995. This should be useful for much of the region. No corresponding work for Cephalopods is in progress.

**Notes on Synonymization:** There are two opposing tendencies in taxonomy: "lumping" and "splitting." At the specific level, "lumpers" take the viewpoint: "synonymous until proven distinctly different." Conversely, "splitters" act on the principle: "distinct until conclusively proven synonymous." We tend to steer a middle course, using the criteria: 1) Are the forms in question easily distinguishable? and 2) Do they often appear together in the same population, with intergrades, or are they usually found in more or less "pure" populations with minimal intergrading? At the sub-specific level, where there are described forms of a given species, do they appear to be related to environmental conditions (i.e., are they "ecophenotypes")? In cases where observed morphic intergrading is minimal or only apparent (i.e., involving some important features but not others), we generally retain separate species, especially in cases where no clear consensus has been achieved. Where forms intergrade at times, yet seem to be legitimately ecologically determined, we prefer to keep the taxa as named "forms," rather than simply synonymizing them completely. The objective is to not lose useful data via excessively zealous "lumping," which can severely limit the usefulness of a data set, from an ecological perspective.

**Note:** Species entries below are of three types: 1) **bolded, unbracketed** - signifying adequately confirmed members of our fauna; 2) **bolded, bracketed** - possible, questionable, unconfirmed, or species needing more verification (in our opinion); and 3) **unbolded, bracketed** - taxa reported from study area which are no longer valid, because of synonymy (only recently used names) or re-assignment, or which are "unlikely" (i.e., probable errors of identification).

**Class: POLYPLACOPHORA**

**Order: Neoloricata**

**Suborder: Lepidopleurina**

**Family: LEPIDOPLEURIDAE (= LEPTOCHITONIDAE)**

**N** : This family is poorly known for the N. Atlantic, and there is extreme literature confusion. (Private observations, Kaas & van Belle and Poppe & Goto, 1991). Kaas & van Belle give excellent descriptions.

**Genus: Leptochiton** Gray, 1847

*Leptochiton alveolus* (Sars, in Lovén, 1846)

\* *Leptochiton arcticus* (G.O. Sars, 1878) (Ref. B.I.O. coll.: SW Nova Scotia; 50-60 fthms)

**N** : Apparently confounded with *L. cancellatus* (Sowerby) in N. America until now. Kaas & van Belle describe and illustrate well.

*Leptochiton cancellatus* (Sowerby, 1839)

**Family: HANLEYIDAE**

**Genus: Hanleya** Gray, 1857

*Hanleya hanleyi* (Bean, 1844) (Ref. B.I.O. Coll.)

**N** 1: *H. dalli* Kaas, 1957, is a synonym. *H. mendicaria* (Mighels & Adams, 1842) considered by Kaas & van Belle, 1985, to be a *nomen neglectum*.

**N** 2: This is an extremely variable species.

\* *Hanleya negalliar* (Lovén, 1842) (Ref. B.I.O. coll.: off Yarmouth, N.S.: Not rare, on Lurcher Bank)

**N** : Warén and Klitgaard, 1991, have recently shown this to be a valid species, distinct from *H. hanleyi*. Also, A.R.C. Coll.: Passamaquady Bay, south New Brunswick.

**Suborder: Ischnochitonia**

**Family: ISCHNOCHITONIDAE**

**Genus: Chaetopleura** Shuttleworth, 1853

\* *Chaetopleura apiculata* (Say, 1830) (York Co. and Lamoine Beach, Maine: Ref. U. Me, 1937, and Anderson, et al., 1978 (ex Shoals, MS))

**Genus: Ischnochiton** Gray, 1847

*Ischnochiton albus* (Linnaeus, 1767)

**N** : Generic placement of this species is still under debate. Macpherson, 1971, suggests *Lophyochiton* Yakovlev, 1952.

**Genus: Tonicella** Carpenter, 1873

*Tonicella marmorea* (Fabricius, 1780)

**N** 1: The name *caerulea* Winkley, 1894, has been given to a rare blue-green form of *T. marmorea* which occurs in Maine, Nova Scotia, & N. Europe. (Note: The green color does not preserve, except by drying methods. Freeze-drying is best.)

**N** 2: Kaas and van Belle have placed *T. blaneyi* Dall, 1905 in synonymy with *T. marmorea*. It was described from a single deformed specimen.

*Tonicella rubra* (Linnaeus, 1767)

**Family: MOPALIDAE**

**Genus: Amicula** Gray, 1847

*Amicula vestita* (Broderip & Sowerby, 1829)

**Genus: Placiphorella** Carpenter in Dall, 1879

*Placiphorella atlantica* (Verrill & Smith, 1882)

**Class: SCAPHOPODA**

**Order: Dentaliida**

**Family: DENTALIIDAE**

**Genus: Antalis** H. & A. Adams, 1854

**N** : Reference for genus unknown.

*Antalis entale* (Linnaeus, 1758)

**N** : *stimpsoni* Henderson, 1920, is a non-useful form designation.

*Antalis occidentalis* Stimpson, 1851

**N** 1: Quite local distribution, in low-energy offshore environments. Often confused with striate form of *Antalis entale* L.

**N** 2: There may be a form of this species with 25-30 ribs (vs. 16-20 typically) in the Bay of Fundy (Ref. A.R.C. Coll.). Or it could be another species.

(*Antalis* sp.) (Ref. A.R.C. Coll.: Emerald Bank)

**N** : Up to 70 mm long with very little curvature and many very faint "riblets." Possibly a form of *A. entale* L.

*Antalis subagilis* Henderson, 1920

**Genus: Dentalium** Linnaeus, 1758

*Dentalium ensiculus* Jeffreys, 1877

**N** : Generic placement uncertain.

\* *Dentalium* sp. (Ref. B.I.O. Coll.: Grand Banks)

**N** : A robust, octagonal species. Only 2 fragments found, so cannot identify.

**Order: Gadilida**

**Family: SIPHONODENTALIIDAE**

**Genus: Siphonodentalium** M. Sars, 1859

*Siphonodentalium bushi* Henderson, 1920

*Siphonodentalium lobatum* (Sowerby, 1860)

(*Siphonodentalium vitreum* M. Sars, 1851)

**N** : We are not entirely convinced that *S. vitreum* M. Sars, 1851, is synonymous with *S. lobatum*. It is nearly transparent, and fragile, while typical *lobatum* is more opaque, and stronger.

**Family: GADILIDAE**

**Genus: Cadulus** Philippi, 1844

*Cadulus agassizii* Dall, 1881

*Cadulus rushii* Pilsbry & Sharp, 1898

*Cadulus spectabilis* Verrill, 1885

\*: Species and forms not reported as such for our region, in *American Seashells*, 2nd Ed.

## Class: BIVALVIA

N 1: Scott, Paul, and Coan, Eugene, are nearly finished a monograph on the bivalves of western North America (Scott & Coan, MS, below). We follow their taxonomy and systematics throughout, where they disagree with Vaught, 1989. All such changes will have (Scott & Coan, MS) after them if a longer note is deemed unnecessary. Some of these are, of course, secondary references.

N 2: Despite the flood of work being done with North Atlantic Gastropoda, very little corresponding taxonomic work has been completed recently for our bivalves. It is anticipated that as this situation is remedied, there will be many changes. Therefore, the list below is offered as "provisional, with apologies!"

## Subclass: PROTOBRANCHIA

N : The recent work of Warén, 1989, and Scott & Coan, MS, has somewhat simplified the taxonomy of our Protobranches. Where they differ, we follow Scott & Coan.

## Order: Solemyoidea

## Superfamily: Solemyoidea

## Family: SOLEMYIDAE

Genus: *Solemya* Lamarck, 1818

*Solemya borealis* Totten, 1834

*Solemya velum* Say, 1822

## Order: Nuculoida

## Superfamily: Nuculoidae

## Family: NUCULIDAE

Genus: *Ennucula* Maxwell, 1988 (Scott & Coan follow Maxwell's 1988 split of *Nucula* Lamarck.)

\* *Ennucula corticata* (Müller, 1842) (Ref. Soot-Ryen, 1966: off south Newfoundland (M. Sars Sta. 70), 1100 m)

*Ennucula tenuis* Montagu, 1808

*E. t. forma belloti* A. Adams, 1856

N 1: = *expansa* Hancock, 1846, and *inflata* Reeve, 1855 (Lubinsky, 1980). These 2 synonyms probably refer mostly to *belloti* A. Adams, which is inflated.

N 2: Scott & Coan, MS, have synonymized *N. belloti* with *N. tenuis*. However, it would still seem to be a valid and useful *forma* designation, indicating cold water influence. In eastern North America, it does not occur south of the N. Gulf of St. Lawrence Saguenay River estuary (Coll. at Maurice Lamontagne Institute, Quebec - Luci Bosse, curator.) While variable, no inflated forms of *N. tenuis* have been found in "warmer" waters, in E. Canada.

*E. t. forma subovata* Verrill & Bush, 1898, non Orbigny, 1850

*Ennucula zophos* A.H. Clarke, 1960

N : Placed in *Ennucula* based on similarity to *tenuis*.

Genus: *Nucula* Lamarck, 1799

*Nucula alticellana* Schenk, 1939 (Ref. Clarke, 1974: Labrador Sea, and Ockelmann, 1958: "deep water")

N : = *N. cancellata* Jeffreys, non Meek: Ref. Clarke, 1974)

*Nucula delphinodonta* Mighels & Adams, 1842

*Nucula proxima* Say, 1822

*N. p. forma annulata* Humpson, 1971

*N. p. forma ovata* Verrill & Bush, 1898

*N. p. forma truncata* Dall, 1898

N : Formae appear to be ecophenotypical.

*Nuculana minuta* (Fabricius, 1776)

*Nuculana pemula* (Müller, 1771)

\* *N. p. buccata* Steenstrup, 1842 (Ref. Lubinsky, 1980)

\* *N. p. b. forma brevis* Müller (Ref. Lubinsky, 1980)

\* *N. p. costigera* Leche, 1883 (Ref. Lubinsky, 1980)

N 1: An extremely variable species. *costigera* is the arctic form; *buccata* is primarily subarctic, while *pemula* s.s. is boreal.

N 2: *N. jacksoni* Gould, 1870, is a synonym.

N 3: = *N. radiata* (Krause, 1885) (Ref. Bernard, 1979: Union St., N.W.T.) (see Scott & Coan).

\* (*Nuculana subaequilatera* (Jeffreys, 1879)) (Ref. Ockelmann, 1958: deep water. Also throughout N. Europe.)

(*Nuculana tamara* Gorbunov, 1946): = *Ledella tamara*

*Nuculana tenuisulcata* (Couthouy, 1838)

Genus: *Pristigloma* Dall, 1990

\* *Pristigloma nilens* Jeffreys, 1876 (Ref. Clarke, 1974: Labrador Sea)

## Family: MALLETIIDAE

Genus: (*Malletia* Des Moulins, 1832)

(*Malletia abyssopolaris* A.H. Clarke, 1960)

N : = *Tindaria derjugini* Gorbunov, 1946 (see Bouchet & Warén, 1979).

\* (*Malletia obtusa* (M. Sars, 1872)) (Ref. Ockelmann, 1958: deep water)

## Family: NEILONELLIDAE

Genus: *Neilonella* Dall, 1881

*Neilonella striolata* (Brugnone, 1876) (= *N. subovata* (Verrill & Bush, 1897))

N : For an interesting account of the tangled string of synonyms of *N. striolata*, see Warén, 1989b. (*Neilonella subovata* (Verrill & Bush, 1897))

## Family: SAREPTIDAE Stolixzka, 1871 (= YOLDIIDAE)

Genus: *Portlandia* Mörch, 1857

*Portlandia arctica* (Reeve, 1855)

N : = *P. collinsoni* (Dall, 1919) (Ref. Bernard, 1979)

\* *P. a. var portlandica* (Reeve, 1855) (Ref. Lubinsky, 1980)

\* *P. a. var siliquea* (Reeve, 1855) (Ref. Lubinsky, 1980)

N : Forms appear ecologically determined.

(*Portlandia glacialis* (Wood, 1828))

N : = *P. arctica* (Reeve) (Ref. Scott & Coan, MS)

*Portlandia intermedia* (M. Sars, 1865) (Genus Scott & Coan, MS)

*Portlandia lenticula* (Möller, 1842) (Genus Scott & Coan, MS)

\* *Portlandia sulcifera* (Reeve, 1855) (Ref. Lubinsky, 1980)

N : Appears to be quite valid, and endemic to high Arctic Canada.

Genus: *Yoldia* Möller, 1842

*Yoldia hyperborea* (Gould, 1841, ex Lovén, MS)

N : = *Y. amygdala* Valenciennes, 1846 (Ref. Scott & Coan, MS)

*Yoldia limatula* (Say, 1831)

*Yoldia myalis* (Couthouy, 1838)

\* *Yoldia regularis* Verrill, 1884 (Ref. Theroux & Wigley, 1983: "Newfoundland to Cape Cod," especially common nearshore Gulf of Maine. Possibly confounding with another species, such as a *Yoldiella*.)

*Yoldia sapotilla* (Gould, 1841)

*Yoldia thracaeformis* (Storer, 1838)

Genus: *Yoldiella* Verrill & Bush, 1897

\* *Yoldiella annenkovi* (Gorbunov, 1946) (Ref. Warén, 1989b: widely distributed in Polar Basin)

*Yoldiella casta* Verrill & Bush, 1898

\* (*Yoldiella curta* Verrill & Bush, 1898)

## Superfamily: Nuculanoidea

## Family: NUCULANIDAE

Genus: *Ledella* Verrill & Bush, 1899

N : Placement per Scott & Coan, MS.

*Ledella tamara* Gorbunov, 1946

N : Deep-water. Clarke's 1963 records in shallow water were based on *Portlandia lenticula* (Möller), according to Warén, 1989b. In *Nuculana* in Abbott, 1974.

Genus: *Nuculana* Link, 1807

*Nuculana caudata* (Donovan, 1801) (Gulf of Maine)



- N : "Possibly" (Warén, 1989b) south of Newfoundland (M. Sars expedition Sta. 70) in 1100 m. (Ref. Soot-Ryen, 1966) Definitely off Mass. to North Carolina.
- \* *Yoldiella confinis* (Smith, 1885) (Ref. Clarke, 1974: Labrador Sea)
- N : Generic placement uncertain.
- Yoldiella expansa* (Jeffreys, 1876)
- N : Northern European reports from Spitzbergen and Barentz Sea, are *Y. lucida* Lovén (see Warén, 1989b).
- (*Yoldiella fraterna* (Verrill & Bush, 1898)) (Ref. Kyte, 1974 (Ex Shoals, MS): Rockland Harbor, Maine)
- N 1: = *Y. nana* (G. Sars) below.
- N 2: Warén, 1989a, "finds it likely" that the Arctic species usually called *Y. fraterna*, is distinct and undescribed, see "Y. sp." below.
- Yoldiella frigida* (Torrell, 1859)
- N : Often confused with other species.
- (*Yoldiella inconspicua* (Verrill & Bush, 1898))
- N : = *Y. nana* (G. Sars) below.
- \* (*Yoldiella inflata* (Verrill & Bush, 1897)) (Ref. Soot-Ryen, 1966: off New Hampshire. Also, Shoals (Maine: Rockland Harbour))
- N : Probably misidentification (Warén, 1989b).
- (*Yoldiella intermedia*) (See Genus *Portlandia*)
- (*Yoldiella iris* (Verrill & Bush, 1897))
- N : = *Y. lucida* (Lovén) below.
- Yoldiella jeffreysi* (Hidalgo, 1879)
- (*Yoldiella lenticula*) (See Genus *Portlandia*)
- Yoldiella lucida* (Lovén, 1846)
- N : = *Y. subangulata* Verrill & Bush, 1898 and *Y. iris* Verrill & Bush, 1898. (Ref. Warén, 1989c)
- Yoldiella minuscula* (Verrill & Bush, 1897)
- Yoldiella nana* (G.O. Sars, 1865)
- N : = *Y. fraterna* (Verrill & Bush) and also *Y. inconspicua* Verrill & Bush, 1898. (Ref. Scott & Coan, MS)
- Yoldiella sericea striolata* (Jeffreys, 1876)
- Yoldiella siliqua* (Reeve, 1855)
- \* (*Yoldiella subangulata* Verrill & Bush, 1898) (Ref. Ockelmann, 1958: from less than 400 m)
- N : = *Y. lucida* (Lovén) above.
- ("Yoldiella sp.?" (Possible: Arctic waters, N. Europe and possibly N. America: Warén, 1989c: see note under *Y. fraterna*)

Family: TINDARIIDAE Scarlato & Starobogatov, 1971

Genus: *Tindaria* Bellardi, 1875

\* *Tindaria derjugini* Gorbunov, 1946

- N : By type comparison, Bouchet & Warén, 1979, found *Malletia abyssopolaris* Clarke, 1960, to be this species. E. Coan also agrees (personal communication).

Subclass: PTERIOMORPHIA

Order: Arcoida

Superfamily: Arcoidea

Family: ARCIDAE

Genus: *Anadara* Gray, 1847

\* *Anadara transversa* (Say, 1822) (Ref. Normandeau, 1974: "Casco Bay, subtidal" (ex Shoals, MS) (unconfirmed). Also, B.I.O. Coll.: N. Mass (unmistakeable))

- N : Also, St. Croix River estuary, New Brunswick (Bay of Fundy): A.R.C. Coll.

Genus: *Batharca* Kobelt, 1891

\* *Batharca frielei* (Jeffreys in Friele, 1879 or Friele, 1877)

- N 1: An arctic species, with outposts to central Labrador (A.G.C. Coll.).

- N 2: Warén (unpublished) has determined that this is not the fossil species, *B. raridenta* Wood, 1840 (actually a *Bentharca* (ibid)), as Bernard, 1979 proposed.

*Batharca glacialis* (Gray, 1824)

*Batharca pectunculoides grandis* (Hägg, 1904; Leche, 1878)

- N 1: The *Batharca* found off New England and Eastern Canada (to North Labrador (see B.I.O. Coll.)) has long been the subject of debate, but never a detailed study. Bernard, 1979, posits it is a form of *friele* but the juveniles are quite different. While it most closely resembles *grandis* (Hägg), which Ockelmann feels is at least a subspecies of *pectunculoides* Schaccl, its teeth seem more complexly variable. Anatomical study is recommended.

- N 2: Having compared our material to *B. grenophila* (Risso, 1826), I (R.M.) cannot agree with Warén (personal communication to Coan) that they are the same species.

- N 3: *septentrionalis* Jensen, 1905, is a synonym.

- N 4: *B. anomala* (Verrill & Bush, 1898) is a synonym (Lubinsky, 1980).

Genus: (*Bentharca* Verrill & Bush, 1898)

(*Bentharca raridenta* Wood, 1840)

- N : = *B. friele* above.

Superfamily: Limopsoidae

Family: LIMOPSIDAE

Genus: *Limopsis* Sassi, 1827

*Limopsis minuta* Philippi, 1836

(*Limopsis sulcata* Verrill & Bush, 1898) (Ref. Theroux & Wigley, 1983: off NE George's Bank, 2000 m, which is suspect, as this is usually a shallow-water species)

Order: Mytiloida

Superfamily: Mytiloidea

Family: MYTILIDAE

Genus: *Amygdalum* Megerle, 1811

*Amygdalum politum* (Verrill & Smith, 1880)

Genus: *Arcuatula* Lamy, 1919 (Genus per Scott & Coan, MS)

*Arcuatula demissa* (Dillwyn, 1817)

Genus: *Arvelia* Bartsch in Scarlato, 1960

- N : Valid genus - Vaught, 1989, and Coan (personal communication).

*Arvelia faba* (Müller, 1776)

- N : Type species of *Arvelia*.

Genus: *Crenella* Brown, 1827

*Crenella decussata* (Montagu, 1808)

(*Crenella faba* (Müller, 1776)): *Arvelia*

*Crenella glandula* (Totten, 1834)

*Crenella pectinula* (Gould, 1841)

- N : *C. pectinula* does not appear as closely related to *C. faba* as Lubinsky, 1980, suggests.

Genus: *Dacrydium* Torell, 1859

*Dacrydium vitreum* (Holboll in Möller, 1842)

- N : None of the specimens we have seen from the study area correspond with Ockelmann's 1958 *Dacrydium* sp. or formae a, b, or c.

Genus: (*Geukensia* van der Poel, 1959)

(*Geukensia demissa* (Dillwyn, 1817))

- N : Now in *Arcuatula* Lamy (Scott & Coan, MS)

Genus: *Modiolus* Lamarck, 1799

\* *Modiolus americanus* (Leach, 1815) (Ref. B.I.O. coll.:

Annapolis Basin, N.S.; identity quite certain)

*Modiolus modiolus* (Linnaeus, 1758)

Genus: *Musculus* Röding, 1798

(*Musculus corrugatus* (Stimpson, 1851))

- N : = *M. glacialis* Leche. *corrugatus* is a junior homonym (non Brongniart, 1823).

*Musculus discors* (Linnaeus, 1767)

*M. d. var laevigata* (Gray, 1824)

*M. d. var substriata* (Gray, 1824)

- N : *M. discors* L., is a variable, polymorphic species. The two forms, above, are generally more northerly in distribution than *discors* s.s. They are separable, but intermediates occur occasionally. Probably not ecophenotypes, as they often occur together, in the same "nest" (see Lubinsky, 1980).

*Musculus glacialis* Leche, 1883



- \* (*Musculus marmoratus* (Forbes, 1838)) (Ref. La Rocque, 1953, but nowhere else. Must be considered questionable. Probably a misidentification of *M. discors* (Linn.))

N : = *corrugatus* (Stimpson) (Scott & Coan, MS)  
*Musculus niger* (Gray, 1824)

N : Young specimens of this species and *M. discors* L., are often confused with *glacialis* Leche (formerly, *corrugatus* (Stimpson)); *glacialis* has far fewer anterior ribs, is more inflated, is much more oval, and has a distinct "notch" on the posterior lower margin, where the central zone begins.

Genus: *Mytilus* Linnaeus, 1758

*Mytilus edulis* Linnaeus, 1758

- \* (*Mytilus galloprovincialis* Lamarck, 1819)

N : Possible: Should be looked for. Common in N. Europe, and west coast of North America (Scott & Coan, MS).

- \* *Mytilus trossulus* Gould, 1850 (Refs. B.I.O. Coll. and McDonald et al., 1991)

N : Nova Scotia and Quebec. Does not seem to be introduced. When cultivated, causes problems because of its thinner shell, which breaks more often during washing and separating.

Order: Limnoida

Superfamily: Limnoidae

Family: LIMIDAE

Genus: *Lima* Bruguière

- \* *Lima excavata* (Fabricius, 1779) (Ref. Haedrich & Gagnon, 1991: SW Newfoundland)

Genus: *Limatula* Wood, 1839

- Limatula hyperborea* Jensen, 1909

- \* *Limatula lutea* Clarke, 1974 (Ref. Clarke, 1974: Labrador Sea)

- Limatula subauriculata* (Montagu, 1808)

Genus: *Limnaea* Bronn, 1831

- Limnaea subovata* Jeffreys, 1876

Order: Ostreoida

Suborder: Ostreina

Superfamily: Ostreidae

Family: OSTREIDAE

Genus: *Crassostrea* Sacco, 1897

- Crassostrea virginica* (Gmelin, 1791)

Genus: *Ostrea* Linnaeus, 1758

- Ostrea edulis* Linnaeus, 1758 (Ref. Stickney, 1953, and Cowger, 1975 (ex Shoals, MS): Maine, introduced: Sheepscott & Booth Bay)

N : May have also escaped from aquaculture experiments in Halifax County, Nova Scotia, in the 1970s.

Suborder: Pectinina

Superfamily: Pectinoidea

Family: PECTINIDAE

Genus: *Chlamys* Röding, 1798

- Chlamys iradians iradians* (Lamarck, 1819)

- (*Chlamys iradians sabiensis* A.H. Clarke, 1965)

N : Sub-fossil specimens only.

- Chlamys islandica* (Müller, 1776)

N : No useful form names for study area.

Genus: *Delectopecten* Stewart, 1930

- Delectopecten vitreus* (Gmelin, 1791)

Genus: *Hyalopecten* Verrill, 1897

- \* *Hyalopecten frigidus* (Jensen, 1904) (Ref. Bouchet & Warén, 1979: "Abyssal parts of Norwegian and Arctic Basins," including off NW Ellesmere Island (see Paul and Menzies, 1974))

Genus: *Palliolium* Monterosato, 1884

- Palliolium imbrifer* (Lovén, 1846)

N : Synonym: *subimbrifer* Verrill & Bush, 1897. Extremely variable.

(*Palliolium ringnesia* (Dall, 1924))

N : Possibly not a valid species. We have not yet examined the types, so cannot be certain.

*Palliolium stratum* (Müller, 1776)

*Palliolium undatum* (Verrill & Smith, 1885)

N : *Palliolium*, *Delectopecten*, and related genera in the N. Atlantic, are in need of a good revision, using a study of large numbers of specimens from N. America and N. Europe. As per Ockelmann, 1958, it should include anatomical studies to be complete.

Genus: *Placopecten* Verrill, 1897

- Placopecten magellanicus* (Gmelin, 1791)

Family: PROPEAMUSSIDAE

Genus: *Cyclopecten* Verrill, 1897

- Cyclopecten abyssorum* (Lovén, ?) (Ref. Clarke: Davis Strait, 314 fthms)

- Cyclopecten groenlandicus* (G.B. Sowerby II, 1842)

N 1: May represent more than one species in Arctic and boreal Europe, and North America. Does anyone know if the "treatise" of Ockelmann, 1958, p. 72, was ever published?

N 2: Has been placed in several genera, recently.

- Cyclopecten pustulosus* Verrill, 1873

N : Possibly a form of *Palliolium imbrifer* (Lovén)

Superfamily: Anomioidea

Family: ANOMIIDAE

Genus: *Anomia* Linnaeus, 1758

- Anomia simplex* Orbigny, 1842

N : *A. simplex* most probably only reaches Maine. We have seen no convincing specimens from Nova Scotia. Confusion exists because *Heteranomia squamula* is so extremely variable. Umbone is off-centre, and concealed. (Umbone of *squamula* is "always" visible and more central.)

Genus: *Heteranomia* Winkworth, 1822

- Heteranomia squamula* Linnaeus, 1758

N : Generic placement per Skarlato & Starobogatov, 1979, who argued that *Heteranomia* Winkworth, be the type genus of a new family. *Heteranomia* was not accepted, but *squamula* has been retained in *Heteranomia* by European taxonomists since then.

Subclass: HETERODONTA

Order: Veneroida

Superfamily: Lucinoidea

Family: LUCINIDAE

Genus: *Lucinoma* Dall, 1901

- Lucinoma filosa* (Stimpson, 1851)

Family: THYASIRIDAE

Genus: *Axinodon* Verrill & Bush, 1898

- Axinodon symmetros* (Jeffreys, 1876)

Genus: *Axinopsida* Keen & Chavan in Chavan, 1951

- Axinopsida orbiculata* (G. Sars, 1878)

Genus: *Axinulus* Verrill & Bush, 1898

- Axinulus brevis* (Verrill & Bush, 1898)

- \* *Axinulus careyi* Berard, 1979 (Ref. A.G.C. Coll.: Northwest Territories)

- Axinulus eumyrius* M. Sars, 1870

- \* *Axinulus succisa* Jeffreys, 1876 (Ref. Clarke, 1974: off Labrador)

- \* *Axinulus tortuosus* (Jeffreys, 1881) (Ref. Clarke, 1974)

Genus: *Leptaxinus* Verrill & Bush, 1898

- Leptaxinus incrassatus* (Jeffreys, 1876)

Genus: *Thyasira* Leach in Lamarck, 1818

N : A difficult, confusing genus, in need of revision for our area.

- Thyasira croulinensis* Jeffreys, 1847

- Thyasira cycladia* S. Wood, 1853

- \* *Thyasira dunbari* Lubinsky, 1976 (Ref. Lubinsky, 1980: northernmost Canadian archipelago)  
(*Thyasira elliptica*? (Verrill & Bush, 1897)) (Ref. Theroux & Wigley, 1983: Central Maine: one specimen; possibly misidentified.)

*Thyasira equalis* Verrill & Bush, 1898

*Thyasira ferruginea* Winckworth, 1932

- N : Deep-water, along edge of Shelf and on Continental Slope (see Theroux & Wigley, 1983).

*Thyasira flexuosa* (Montagu, 1803)

*T. f.* forma *gouldii* Philippi, 1845 (Refs. Bernard, 1979, Lubinsky, 1980, and several B.I.O. and A.G.C. lots: probably pan-arctic, with subarctic populations as well)

- N : This is a distinct, cold-water form; probably pan-arctic (Lubinsky, 1980), with subarctic and northern boreal outposts, (e.g. Lake Melville, Labrador, and Saguenay River estuary, Quebec).

*Thyasira pygmaea* Verrill & Bush, 1898

*Thyasira simplex* Verrill & Bush, 1898

*Thyasira succisa* Jeffreys, 1876

*Thyasira trisinuata* Orbigny, 1842

#### Family: UNGULINIDAE

Genus: *Diplodonta* Bronn, 1831

\* *Diplodonta cf. punctata* (Say, 1822) (Ref. B.I.O. Coll.: Burin Harbour, Nfld.)

\* (*Diplodonta verrilli* Dall, 1900) (Ref. Kyte, 1974 (ex Shoals, MS): Rockland Harbour, Maine)

- N : There is probably only one species in our region. We have not compared the specimens yet.

#### Superfamily: Galeommatoidae

##### Family: KELLIDAE

Genus: *Kellia* Turton, 1822

*Kellia suborbicularis* (Montagu, 1803)

##### Family: MONTACUTIIDAE

Genus: *Montacuta* Turton, 1822

\* *Montacuta dawsoni* Jeffreys, 1864

- N : Scott & Coan, MS, do not think this is a proper *Montacuta*, but are unsure where to place it.

\* *Montacuta substriata* Montagu, 1808 (Ref. Lubinsky, 1980: Barrow Strait, NWT)

Genus: *Mysella* Angas, 1877

*Mysella moelleri* (Mörch, 1875)

*Mysella planulata* (Stimpson, 1857)

##### Family: CORBULIDAE

Genus: *Corbula* Brugière, 1797

\* *Corbula contracta* Say, 1822 (Ref. Theroux & Wigley, 1983: Central George's Bank and Gulf of Maine: Uncommon. Also, Hardy, MS, 1984: Grand Banks, Newfoundland (Ex Gilkinson, 1986)

##### Family: LASAEDAE

Genus: (*Aligena* H.C. Lea, 1843)

\* (*Aligena elevata* (Stimpson, 1851)) (Ref. Ockelmann, 1958)

- N : Unconfirmed.

#### Superfamily: Carditoidea

##### Family: CARDITIDAE

Genus: *Cyclocardia* Conrad, 1867

\* *Cyclocardia sp.* (Ref. B.I.O. Coll.: Grand Banks, and St. Mary's Bay, Nova Scotia (backlog)).

- N : This is the most common *Cyclocardia* species on the northern Grand Banks, but is apparently reported as *C. borealis* in the literature. It superficially resembles *C. crassidens* (Broderip & Sowerby, 1829), but has no hairs

whatsoever on the periostracum. May be undescribed, or a northern European species.

*Cyclocardia borealis* (Conrad, 1831)

*Cyclocardia novaeangiae* (Morse, 1869)

- N : These two species have been confused in the literature, but are easily distinguishable through examination of the periostracum and hinge.

#### Superfamily: Astartoidea

##### Family: ASTARTIDAE

- N : A difficult, confusing family. In addition to several species being poorly dispersing, some may also be hermaphroditic (Dr. K. Boss, private communication). Thus, local populations may develop forms difficult to classify. Also, most species are remarkably variable. Data sets are very seldom completely accurate for this important family.

Genus: *Astarte* Sowerby, 1816

- N : Following Scott & Coan, MS, we place the *Tridonta* Schumacher, 1817, group back in *Astarte*.

\* *Astarte acuticostata* Friele, 1877

- N : Warén, 1989a, regards *A. acuticostata* Friele, as a distinct species. We concur.

\* *Astarte arctica* (Gray, 1824) (Ref. Lubinsky, 1980)

- N : An Atlantic subarctic species often confused with *T. borealis* Schumacher. Uncommon.

*Astarte borealis* Schumacher, 1817

\* *A. b. var. placenta* Mörch (Ref. Lubinsky, 1980)

\* *A. b. var. withami* Wood (Ref. Lubinsky, 1980)

- N : These are arctic forms.

*Astarte castanea* (Say, 1822)

\* *Astarte crenata* (Gray, 1824)

- N : *crenata* s.s. occurs in Arctic Canadian waters (Refs. Lubinsky, 1980, B.I.O. and A.G.C. Colls.). *A. c. inflata* Hägg, 1904, has been reported only from Europe.

*A. c. subaequalata* Sowerby, 1854

*A. c. s. crebricostata* MacAndrews & Forbes, 1847

*A. c. s. whiteavesii* Dall, 1903

*Astarte elliptica* (Brown, 1827)

(*Astarte laurentiana* Lyell, var. *soror* Dall, 1903)

- N : See *A. soror*, below.

*Astarte montagui* (Dillwyn, 1817)

- N : After re-examining the material at B.I.O. and A.G.C., and comparing figures and descriptions, we agree with Scott & Coan, MS, that *A. striata* (Leach, 1819) is synonymous. However, we must follow Lubinsky, 1980, in retaining *warhami* Hancock, as a distinct species. Its tooth structure is consistently different from *montagui* var. *striata*, as is the microsculpture of the periostracum, which while not diagnostic in itself, is often a useful identification aid. See Lubinsky's, 1980, line of reasoning.

(*Astarte polaris* Dall, 1903)

- N : Scott & Coan (MS) state *A. polaris* is a Pacific synonym of *A. crenata*.

\* *Astarte portlandica* Mighels, 1843 (Ref. Mighels, 1843, Whiteaves, 1901 (ex Shoals, MS), Johnson, 1915: Casco Bay and Mt. Desert Area, Maine)

*Astarte quadrans* Gould, 1841

*Astarte soror* Dall, 1903

- N : *A. laurentiana* Lyell, is a fossil species.

*Astarte undata* Gould, 1841

\* *Astarte warhami* Hancock, 1846 (Ref. Lubinsky, 1980: an Arctic species)

#### Superfamily: Cardioidea

##### Family: CARDIIDAE

Genus: *Carastoderma* Poli, 1795

*Carastoderma ? sp.* (Ref. A.R.C. Coll.: Bay of Fundy)

- N : A single, live specimen, quite different from our other three Cardiidae.

- \* *Cerastoderma elegantulum* (Beck, in Möller, 1842) (Ref. A.G.C. Coll.: Emerald Basin, N.S.; Clarke, 1974: Baffin Bay)  
*Cerastoderma pinnulatum* (Conrad, 1831)

Genus: *Clinocardium* Keen, 1936  
*Clinocardium ciliatum* (Fabricius, 1780)

Genus: *Laevicardium* Swainson, 1840  
*Laevicardium morioni* (Conrad, 1830)

Genus: *Serripes* Gould, 1841  
*Serripes groenlandicus* (Bruguiere, 1789)

Superfamily: Mactroidea

Family: MACTRIDAE

Genus: *Mactromeris* Conrad, 1868  
*Mactromeris polymya* (Stimpson, 1860)

Genus: *Mulinia* Gray, 1837  
*Mulinia lateralis* (Say, 1822)

Genus: *Spisula* Gray, 1837  
*Spisula solidissima* (Dillwyn, 1817)

Family: MESODESMATIDAE

Genus: *Mesodesma* Deshayes, 1831 (*Paphies* Lesson, 1831)  
*Mesodesma arctatum* (Conrad, 1830)  
*Mesodesma desuratum* (Turton, 1822)

N : These two may be synonyms. Literature confusion exists.

Superfamily: Solenoidea

Family: PHARIDAE (= CULTELLIDAE: Scott & Coan, MS)

Genus: *Ensis* Schumacher, 1817  
*Ensis directus* Conrad, 1843

Genus: *Siliqua* Megerle, 1811  
*Siliqua costata* Say, 1822  
*Siliqua aquama* Blainville, 1824

Superfamily: Tellinoidea

Family: TELLINIDAE

Genus: *Macoma* Leach, 1819  
*Macoma balthica* (Linnaeus, 1758)

N 1: = *M. inconspicua* (Broderip & Sowerby, 1829), which is a name often used for small or dwarf *M. balthica* in the arctic.

N 2: *M. balthica* is an unusual species, in that it has a disjunct habitat - living happily on intertidal mud flats, and also in great depths. It has good tolerance of low salinity.

*Macoma calcarea* (Gmelin, 1791)

*Macoma crassula* (Deshayes, 1855) (= *M. inflata* Stimpson)

\* (*Macoma inconspicua*) (Broderip & Sowerby, 1829)

N : See *M. balthica* (L.), above.

(*Macoma inflata* "Stimpson" Dawson, 1872)

N : = *M. crassula* (Deshayes, 1855) (Ref. Scott & Coan, MS)

\* *Macoma lama* (Bartsch, 1929)

N : = *M. planiuscula* Grant & Gale, 1931, as reported by Lubinsky, 1980, for Amudsen Gulf.

*Macoma loveni* (Jensen, 1905)

*Macoma moesta* (Deshayes, 1855)

\* (*Macoma planiuscula* Grant & Gale, 1931)

N : = *M. lama*, above.

\* (*Macoma tenta* (Say, 1834))

N : Over the years, this species has been reported from N.S. and Maine several times. However, as it is easily confused with *Thracia septentrionalis*, we will reserve judgement until viewing these lots.

\* *Macoma torelli* (Steenstrup) (Jensen, 1905) (Refs. Ockelmann, 1958, and Lubinsky, 1980, (Jones Sound, N.W.T.))

Genus: *Tellina* Linnaeus, 1758  
*Tellina agilis* Stimpson, 1857

N : Formerly known as *T. tenera* Say, 1822 (non Schrank, 1803)

Family: SEMELIDAE

Genus: *Abra* Leach in Lamarck, 1818  
*Abra longicollis americana* Verrill & Bush, 1898  
 Genus: *Cumingia* Sowerby, 1833  
*Cumingia tellinoides* (Conrad, 1831)

Family: PSAMMOBIIDAE

Genus: *Tagelus* Gray, 1847  
 \* *Tagelus plebius* (Lightfoot, 1786) (Ref. Theroux & Wigley, 1983: N. Cape Cod. Also, Haefner (ex Shoals, MS): Lamoine Beach, Maine)

Superfamily: Arcticoidea

Family: ARCTICIDAE

Genus: *Arctica* Schumacher, 1817  
*Arctica islandica* (Linnaeus, 1767)

N : Small juveniles can be confused with several species. Check hinge.

Superfamily: Veneroidea

Family: VENERIDAE

Genus: *Gemma* Deshayes, 1850  
*Gemma gemma* (Totten, 1834)

Genus: *Liocyma* Dall, 1870  
*Liocyma fluctuosa* (Gould, 1841)

Genus: *Mercenaria* Schumacher, 1817  
*Mercenaria mercenaria* (Linnaeus, 1758)

Genus: *Pitar* Römer, 1857  
*Pitar montuanus* (Linsley, 1848)

N : Juveniles have adhering sand grains and resemble a roundish *Lyonsia*. Check hinge!

Family: TURTONIIDAE

Genus: *Turtonia* Alder, 1848  
*Turtonia minuta* (Fabricius, 1780)

Family: PETRICOLIDAE

Genus: *Petricola* Lamarck, 1801  
*Petricola pholadiformis* (Lamarck, 1818)

Order: Myoida

Suborder: Myina

Family: MYIDAE

Genus: *Mya* Linnaeus, 1758  
*Mya arenaria* Linnaeus, 1758  
*Mya pseudorenenaria* Schlesky, 1931

N : See discussions in Bernard, 1979, and Lubinsky, 1980, who assign all N. American arctic reports of *M. arenaria* L., and some *M. truncata* L., to this species. Ockelmann, 1958, did not report it from N. Europe.

*Mya truncata* Linnaeus, 1758

Superfamily: Hiatelloidea

Family: HIATELLIDAE

Genus: *Cyrtodaria* Reuss, 1801  
*Cyrtodaria kumtana* Dunker, 1862  
*Cyrtodaria siliqua* (Spengler, 1793)

Genus: *Hiatella* Daudin in Bosc, 1801 ?  
*Hiatella arctica* (Linnaeus, 1767)  
*Hiatella striata* Fleuriau, 1802

N : These are virtually indistinguishable conchologically. *H. striata* is usually found boring into soft rock or sometimes wood. Scott & Coan, MS, feel they are synonyms, but the differences in habitat (*arctica* does not bore) and breeding habits seem to indicate they are distinct.

Genus: *Panomya* Gray, 1857  
*Panomya arctica* (Lamarck, 1818)



Superfamily: PholadoideaFamily: PHOLADIDAE

- Genus: *Barnes* Leach in Risso, 1826  
*Barnes truncata* (Say, 1822)  
Genus: *Zirfaea* Gray, 1842  
*Zirfaea crispata* (Linnaeus, 1758)

Family: XYLOPHAGIDAE

- Genus: *Xylophaga* Turton, 1822  
 \* *Xylophaga abyssorum* (Ref. Dunbar et al., 1980: E. Gulf of St. Lawrence)  
*Xylophaga atlantica* H.G. Richards, 1942

Family: TEREDINIDAE

- Genus: (*Notoleredo* Bartsch, 1923)  
 \* (*Notoleredo norvegicus* (Spengler, 1792)) (Refs. La Rocque, 1953, and Ockelmann, 1958)  
Genus: *Psiloleredo* Bartsch, 1922  
*Psiloleredo megotara* (Hanley, 1848)  
Genus: *Teredo* Linnaeus, 1758  
*Teredo navalis* Linnaeus, 1758

Subclass: ANOMALODESMATAOrder: PholadomyoideaSuperfamily: PholadomyoideaFamily: PHOLADOMYIDAE

- Genus: *Pholadomya* G.B. Sowerby, 1823  
 \* *Pholadomya fragilis* (Grieg, 1920) (Ref. Soot-Ryen, 1966: M. Sars Sta. 70 (off south Newfoundland: 1100 m))

Superfamily: PandoroideaFamily: PANDORIDAE

- Genus: *Pandora* Bruguière, 1797  
*Pandora glacialis* Leach, 1819  
*Pandora gouldiana* Dall, 1886  
*Pandora inomata* Verrill & Bush, 1898

Family: LYONSIIDAE

- Genus: *Lyonsia* Turton, 1822  
*Lyonsia granulifera* Verrill & Bush, 1898  
*Lyonsia arenosa* Möller, 1842  
*Lyonsia hyalina* Conrad, 1831

Superfamily: Thracioidea

N : Per Scott & Coan, MS.

Family: THRACIIDAE

- Genus: *Thracia* Leach in Blainville, 1824  
*Thracia conradi* Couthouy, 1838  
 \* *Thracia devesa* G. Sars, 1878 (Ref. Lubinsky, 1980: Hudson Bay and Canadian Arctic)  
*Thracia myopsis* Möller, 1842  
*Thracia septentrionalis* Jeffreys, 1872

To comment, make additions, etc.:

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Family: PERIPLOMATIDAE

- Genus: *Periploma* Schumacher, 1817  
 \* (*Periploma abyssorum* Verrill (MS), Bush, 1893)  
 N : = *P. aleuticum* (Krause, 1885) (Ref. Scott & Coan, MS)  
 \* *Periploma aleuticum* (Krause, 1885) (Refs. Clarke, 1974: Baffin Bay; Ockelmann, 1958; and Lubinsky, 1980: "Panarctic")  
*Periploma fragilis* (Totten, 1835)  
*Periploma leanum* (Conrad, 1831)  
*Periploma papyratum* (Say, 1822)

Superfamily: PoromyoideaFamily: POROMYIDAE

- Genus: *Poromya* Forbes, 1844  
*Poromya granulata* (Nyst & Westendorp, 1839)  
 \* *Poromya nitica* (Verrill, 1884 or 1885) (Ref. Clarke, 1974: off Grand Banks)

Order: "Septibranchia" Pelseneer, 1888

N : Per Scott & Coan, MS.

Superfamily: CuspidaroideaFamily: CUSPIDARIIDAE

- Genus: *Cardiomya* A. Adams, 1864  
*Cardiomya striata* (Jeffreys, 1876)  
Genus: *Cuspidaria* Nardo, 1840  
 N : This is a difficult genus, easily confused. Overnaming possible.  
*Cuspidaria arctica* (M. Sars, 1878)  
 \* *Cuspidaria edgusa* Jeffreys, (Ref. Clarke, 1974: Baffin Bay)  
*Cuspidaria cf. fraterna* Verrill & Bush, 1898  
*Cuspidaria glacialis* (G. Sars, 1878)  
 \* *Cuspidaria lamellosa* (M. Sars, 1878) (Ref. Ockelmann, 1958: deep water)  
*Cuspidaria obesa* (Lovén, 1846)  
*Cuspidaria parva* Verrill & Bush, 1898 (Ref. Theroux & Wigley, 1983: Off S. Maine: Rare)  
*Cuspidaria pellucida* Stimpson, 1853  
*Cuspidaria rostrata* (Spengler, 1793)  
*Cuspidaria suborta* (G. Sars, 1878)

Superfamily: Verticoidae

N : Per Scott & Coan, MS.

Family: VERTICORDIIDAE

- Genus: *Halocardia* Dall, 1895  
*Halocardia flexuosa* (Verrill & Smith, 1881)  
Genus: *Lyonsiella* M. Sars in G. Sars, 1872  
*Lyonsiella abyssicola* (G. Sars, 1872)  
*Lyonsiella* sp. (Ref. Clarke, 1974: Labrador Sea)  
 N : Two juvenile specimens found. Definitely appear different from other Verticordidae in our region.  
*(Lyonsiella uschakovii* Gorbunov, 1946) (Ref. Bernard, 1979: Common in Laurentian Basin)  
Genus: *Policordia* Dall, Bartsch & Rheder, 1938  
 \* *Policordia gemma* (Verrill, 1880) (Ref. Soot-Ryen, 1966: M. Sars Sta. 70, off Newfoundland, 1100 m)

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When the two valves of a bivalve do not jibe in pattern and texture it may seem that they're distinct and separate species. Look closely at the accompanying photograph. The upper valve is obviously that of a *Chama lazarus*, with vivid orange and red colors; the other valve is just the opposite - an unidentifiable

## An Adaptive Bivalve

Brian C. K. Dy \*

species, decayed and fossilized. In spite of this sharp contrast the bivalve is, in fact, one single specimen. Close scrutiny reveals that the valves are no longer hinged at the cardinal teeth area as they are eroded. A clincher is convincing enough - when shut the two valves fit snugly, definitely an inseparable pair.

Further study tends to sustain a creditable observation as to why it's in such unfamiliar situation. In its natural habitat a veliger of *Chama lazarus* happened to descend on a worn-out valve of a bivalve species. As the *Chama* developed and grew somehow the right chemistry began to work and its developing lower valve "melted" and assimilated with the ready-made shelter. Thus the progeny of this fateful union produced a reconditioned bivalve.

A very adaptive and bewildering specimen - this bivalve.

\*Manila, Philippines

# Update On Octopus giganteus Verrill

## Part 1:

### More forgotten fragments of its 19th century history.

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#### INTRODUCTION

##### 19th Century Thoughts on the Assumed Mythical Kraken

In centuries prior to the 19th, Scandinavian seafarers told of seeing the "Giant Kraken" - a mythical sea monster - along the northern coasts of the old world. Most writers of natural history assumed that their Great Kraken was simply the tales of local legends and the imagination of the mariners. A few naturalists, however, ventured that these sea myths may, in fact, have been based upon actual encounters with large, unknown marine animals. In 1801 the great French naturalist Pierre Denys de Montfort advanced the hypothesis of the existence of two species of giant cephalopoda which he named Poulpe Kraken and Poulpe Colossal.

The legendary "Poulpe Kraken" of Pierre Denys was ultimately and tentatively identified by zoologists as being the giant squid Architeuthis, specimens of which may reach at least 60 feet in length. The giant squid Architeuthis had been accurately described since antiquity (by Aristotle, Pliny and Aelian, among others) and some anatomical fragments were available in European museums even of the 17th and 18th centuries. It was, however, in 1847, after the works of a Danish (cryptozoologically open-minded) teuthologist, Johan Japetus Steenstrup, that the giant squid Architeuthis entered official zoology; this followed several centuries of cryptozoological purgatory (Heuvelmans 1958 & 1974).

The existence of the other proposed giant cephalopod - the "Poulpe Colossal" - remained unconfirmed. Whalers

related numerous instances of harpooned whales which, in their death throes, vomited enormous arms of cephalopods. But these appendages were invariably considered to be those of the giant squid Architeuthis rather than parts of some unknown species of gigantic octopod.

Towards the end of the 19th century the corpse of a giant cephalopod was washed ashore near St. Augustine, Florida. This find reopened the controversy in marine biology regarding the validity of Denys de Montfort's "Poulpe Colossal". (Raynal and Dethier, 1991).

##### A Summary and Update on the History of the Poulpe Colossal of St. Augustine, Florida - 1896

Readers might consult back issues of Of Sea and Shore for two articles by Mangiacopra (1975, 1977) for what was, at that time, the definitive historical account of this carcass beached in Florida. One might also consult the article published in Natural History magazine by Wood and Gennaro (1971).

On the 30th of November, 1896, two young bicyclists, Herbert Coles and Dunham Coreter, while cycling along Anastasia Beach near the Florida city of St. Augustine, came upon the exposed remains of an enormous carcass deeply embedded in the sand. Their discovery was brought to the attention of Dr. DeWitt

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Webb, a medical doctor and President of the St. Augustine Historical Society. Dr. Webb examined the carcass on the first day of December. Initially the carcass was assumed to be the beached remains of a whale. Dr. Webb's examination revealed the following: the carcass was much mutilated at one end and in an advanced state of decomposition; dimensions visible above the sand indicated a length of 23 feet, height of 4 feet and 18 feet across the widest part of the "back"; hide coloration was a light pink, nearly white, with a silvery appearance. Dr. Webb concluded that he was examining the remains of a monstrous octopus.

Dr. Webb was most fortunate that his city of St. Augustine had as residents a number of amateur and professional photographers. These photographers, in the forthcoming months, took four series of photographs of the beached monster in various stages of examination. Photographers Edgar Van Horn and Ernest Howatt shot four different views of the carcass on December 1.

These photographs were sent to Professor Addison Emery Verrill of Yale University who acknowledged their receipt. Regrettably, only one of these photographs (Figure 1) has survived to the present time.

Attempts, in 1977, by G. Mangiacopra, to locate descendants of the photographers produced confirmation from William Howatt (Ernest's son) that he possessed nothing in relation to his father's involvement with this case (Mangiacopra, 1977). But, in addition to the single surviving actual photograph, there are three visual images redrawn by Prof. Verrill's son, Alpheus Hyatt Verrill. Two drawings (Figure 2) were subsequently published in the *American Naturalist* (Verrill, 1897a). A third drawing (Figure 3), though more simply and crudely done bears a strong similarity to the surviving photograph and was used to illustrate an article Alpheus Verrill wrote telling of his father's involvement with this monstrous Florida octopus (Verrill, 1897b, 1897c). Publication of this article and the illustration was limited, however, to only two Connecticut newspapers.

Beginning on December 7, 1896, the carcass was partially excavated. Sand was removed around the carcass and the stump of an arm, 36 feet long and 10 inches in diameter where it was broken off distally, was found still attached. A statement was given by a Mr. Wilson to Dr. Webb regarding these excavated areas:

"One arm was lying west of body, 23 feet long; one stump of arm, west of body, about 4 feet; three arms lying south of body and from appearances attached to same (although I did not dig quite to body, as it laid well down in the sand, and I was very tired, longest one measured over 32 feet the other arms were 3 to 5 feet shorter."

Only one known surviving, unpublished, photograph (Figure 4), taken on December 7, 1896 (or soon thereafter) shows one of the tentacles described by Wilson. Though the clarity of the photograph leaves much to be desired, what is determinable is the carcass on the right, with a tentacle (?) extending towards the left. In the background, towards the right, is a wooden pole with ropes attached to the farthest tip of the monster.

Author M.P.R.R., using as a comparison Figure 8 which shows the carcass with Dr. Webb standing next to it and with the wooden pole behind him, calculated the stump of the arm as about 14 inches in diameter, quite consistent with Webb's statement that an arm-stump was 10 inches in diameter where it was cut distally (Raynal, 1993).

Among those making examinations this first week was Dr. George W. Grant, who owned a hotel on Anastasia Island and was also in charge of the pavilion at South Beach. Oddly, Dr. Grant's rather lurid description of the beached monster was published in the December 13, 1896 edition of a weekly newspaper in, of all places, Williamsport, Pennsylvania! (*The Grit*, 1896):

"The head is as large as an ordinary flour barrel and has the shape of a sealion head. The neck, if the creature may be said to have a neck, is of the same diameter as the body. The mouth is on the under side of the head and is protected by two tentacles tubes about eight inches in diameter and thirty feet long. These tubes resemble as elephant's trunk, and obviously were used to clutch on a sucker-like fashion any object within their reach.

"Another tube or tentacle of the same dimensions stands out on the top of the head. Two others, one on each side, protrude from behind the monster's neck and extend fully 15 feet along the body and beyond the tail. The tail which is separated and jagged with cutting points for several feet, is flanked with two more tentacles of the same dimensions as the others and 30 feet long. The eyes are under the back of the mouth, instead of over it.

This specimen is so badly cut up by sharks and saw-fish that only the stumps of the tentacles remain, but pieces of them were found strewn for some distance on the beach, showing that the animal had a fierce battle with its foes before it was disabled and beached by the surf."

This somewhat vivid account confirms descriptions

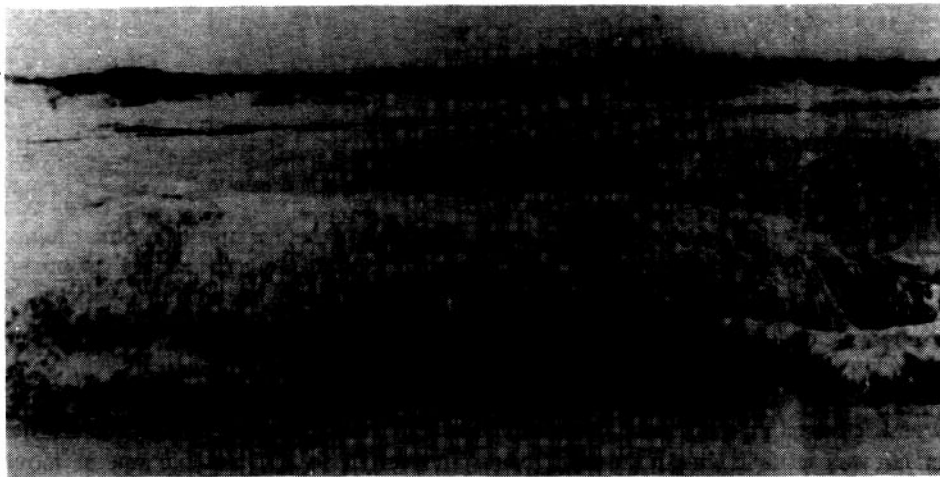


Figure 1. From the first December photographic session, this is the only known example of an actual photograph of the beach carcass that has never before been published.



Figure 2. Sketch from one of the photographs taken on December first, showing end view of the beached carcass. Taken from American Naturalist, April 1897.

given by Wilson and Webb regarding dimensions of the supposed tentacles. The eyes and the alleged tail, which appear for the first time in Dr. Grant's description are probably incorrect. It is apparent that Figure 5 is a newspaper artist's interpretation based upon Grant's description - surviving sketches and photographs definitely indicate that the carcass did not look remotely like this!

During a severe storm, soon after this examination, the carcass was adrift at sea and washed ashore again two miles further south - but now minus its arms.

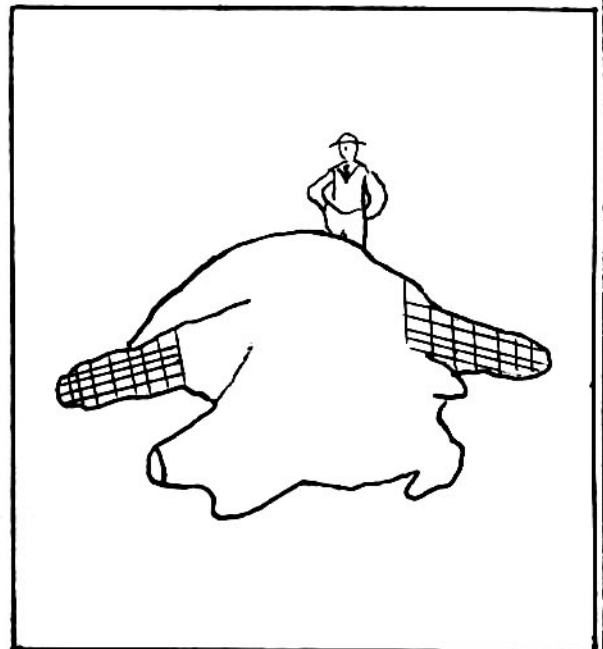


Figure A. Black outline of Fig. 2, with the checkerboard areas indicating possible lateral fins. Verrill (1897) commented upon this: "It is possible that it may be related to Cirrotauthis, and in that case the two posterior stumps, looking like arms, may be the remains of the lateral fin, for they seem to be too far back for the arms, unless pulled out of position. On the other hand, they seem to be too far forward for fins."

During December Webb wrote numerous letters introducing others to the importance of this discovery. One letter, published in The Nautilus (Webb, 1897) told:

"I have been greatly interested in an immense Cephalopod which came ashore about five miles south of Jack Mound, Anastasia island. Only the stumps of the tentacles were left, and it had been dead for, perhaps, days. The body



Figure 3. Another sketch based upon the December first photographs, giving a side view of the carcass. Drawing credited to A.H. Verrill. Source: Hartford Courant, February 18, 1897.

proper measured 18 feet in length, 11 feet in breadth and  $3\frac{1}{2}$  feet thick above the sand as it lay soft and flattened on the beach. Of course there is no way of knowing how long the tentacles were, but, judging from the size of the body, the arms must have been of enormous length."

Similar letters were forwarded to others. One was sent to Mr. J. A. Allen, who sent it on to Mr. R. P. Whitehead, then forwarded to Prof. Addison Emmerly Verrill of Yale. Verrill, less than two decades earlier, confirmed the existence of the giant squids, and was considered the foremost expert in this field. But his position, based upon the letter's contents, was this Florida specimen was an *Architeuthis* - though larger than any of the previous Newfoundland stranded specimens of this species.

Among the recipients of Webb's correspondence was Prof. William Healey Dall, Curator of Mollusks of the Smithsonian Institution. Webb's earliest letter, undated, referred to his first attempt at moving this beached octopus:

"... I spent the greater part of two days with a corps of photographers, that is one professional and several amateur, with a lot of help but found ... that all of us with the aid of strong tackle could no even turn the monster over. We could, with a dozen men pulling at the ropes, only partly raise it as you will see. I have another scheme which I hope to accomplish if I can raise the funds and that is to draw it by means of horses and a windlass fater up the bank entirely out of the pit so that the hood can be spread out and then I hope to be able to get men to cut through the enormously thick hide



Figure 4. Second earliest surviving photograph and the only one established to have been taken on the second photographic session on December 7, 1897. Possession of the original is credited to th Division of Mollusks of the National Museum of Natural History, Washington, D.C.





Figure 5. Artists interpretation of the beach carcass based upon Dr. Grant's description as given in The Grit, December 13, 1896.

which measure in some places  $3\frac{1}{2}$  inches in thickness and so open the whole thing up. The hood is so tough that when it is exposed to the air an axe makes very little impression upon it. Judging from the difficulty of moving it must weigh 6 or 7 tons for 12 men with a block and tackle ought to move anything less."

The information contained in this letter offers clues as to when the third series of photographs were taken. And conversely, these dated photographs reveal, in turn, that this letter was written in December.

The historical significance of the third series of photographs is that they were literally "lost" for nearly a century - during this time their existence was not even suspected. The late Ms. Marjorie Blaskoner of California possessed a photo album inscribed with the words "Photographs by Van Lockwood". This album was given to the St. Augustine Historical Society after her death (Barrett, 1993a). Among the many photographs of this city Lockwood had taken during 1885-1899 were three original  $2\frac{1}{2} \times 3\frac{1}{2}$  inch size prints showing the giant octopus on Anastasia island with captions and dates for them (GEH/BIO; Barrett, 1993b).

Figure 6 is inscribed in the album with the caption "Crowd on Anastasia Island Beach where giant Octopus washed ashore, December, 1896." This panorama shows about 50 people who had come to view the beached giant octopus. No discernable image of the carcass can be seen.

The second Lockwood photograph (Figure 7) is a distance shot showing a horse and carriage with men and women in it to the left of a dome-shaped mass that is in the center of the photograph. On the far right are two men - the one second to the right, looking towards

the camera, is Dr. Webb. This overexposed print shows a barely distinct, dome-shaped mass with a rope around its middle; there is a pole to the left.

A close-up of this same set-up (Figure 8) shows, in detail, the dome-shaped mass. This photograph has been reproduced a number of times, usually cropped, but wrongly credited as being taken in January of 1897, whereas the correct date is December of 1896.

Each series of dated photographs shows the gradual physical mutilation and deterioration of the carcass, leaving by this date only a huge sack-like mass of tissue.

By January of 1897 Prof. Verrill had agreed with Webb's original conclusion that the carcass was that of an eight-armed true octopus of colossal size. He published a series of articles in scientific journals and in newspapers. He even named this discovery *Octopus giganteus*.

Meanwhile Webb continued his examination and wrote again to Dall on January 16th:

"... I took four horses, six men, 3 sets of tackle, a lot of heavy planking and a rigger to superintend the work and succeeded in rolling the invertebrate out of the pit and placing it about 40 feet higher up the beach where it now rests on the flooring of heavy plank."

The fourth - and final - series of photographs taken of the giant octopus occurred on this date. Two of the photographs have been previously published in these pages (OS&S, Spring 1975), but the third (Figure 9) is Lockwood's and the album caption reads "In this scene are members of the St. Augustine Historical Society". In the photograph's near background are six men, thus



Figure 8. Slightly flawed close-up December 1896 view of the dome-shaped carcass with the tackle rope around its middle and a pole behind it. Dr. DeWitt Webb stands next to it, giving scale to its actual size. Credit: Division of Mollusks of the National Museum of Natural History, Washington, D.C.

giving scale to the size of the buried octopus which is positioned with ropes around it that were used to drag it onto the planks; in the far left background are the four horses used by the riggers.

A minimum of 10 images (G.S.M. note: an additional two photographs have been established to exist, but copies have not been acquired as of this date [Packett, 1994]) of this giant octopus have survived after a century of time, making this beached "sea monster" the best photo-documented. These photographs are of themselves insufficient to positively determine the zoological nature of this carcass.

Since these photographs were taken, many others have been produced, purporting to show other beached "sea monsters" only to be later correctly identified as the remains of basking sharks, whales or other known marine life.

The ultimate fate of this Florida carcass should have quickly faded into history, forgotten and neglected. But in this instance there was a factor that prevented this. Webb had sent tissue samples to Dall and Verrill, but neither scientist was able to verify the octopus identification. Verrill proposed that the sack-like mass may have originated from the upper part of the head of a sperm whale. This identification was accepted - that this giant octopus was, in fact, simply a common sperm whale.

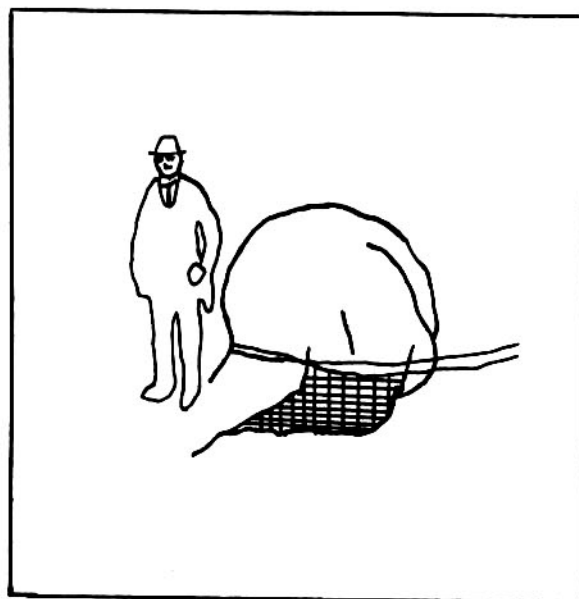


Figure B. Black outline of Figure 8, with the checkerboard sketch area - may be the presence of a lateral fin.

Verrill's tissue samples were lost during the following decades, but were acknowledged in a brief paragraph in the Smithsonian's Annual Report (1899):

"Dr. DeWitt Webb, St. Augustine, Florida, presented negatives of photographs of a sea monster stranded near that place, named *Octopus giganteus* by Professor Verrill. Portions of the remains, preserved in formalin, were also transmitted."

And it was these preserved remains that, a century later and subjected to scientific tests undreamed of in Webb and Verrill's time, began to offer clues towards the identification of the remains as being that of a genuine "sea monster"!

Captions for Figures 6, 7 & 9 on opposite page.

Figure 6. Photographer Van Norden Lockwood's panorama view of the crowd that came to see the beached giant octopus in December of 1896.

Figure 7. Van Lockwood's second December 1896 distance photograph of the dome-shaped carcass with tackle rope around its middle and tackle pole to the left. Person on right is Dr. DeWitt Webb.

Figure 9. Van Lockwood's January 16, 1897 photograph of the beach carcass partially excavated, but before it was pulled out onto the wood planks at the left. Original caption attested: "... members of the St. Augustine Historical Society".

NOTE: credit for these three photographs to the St. Augustine Historical Society.

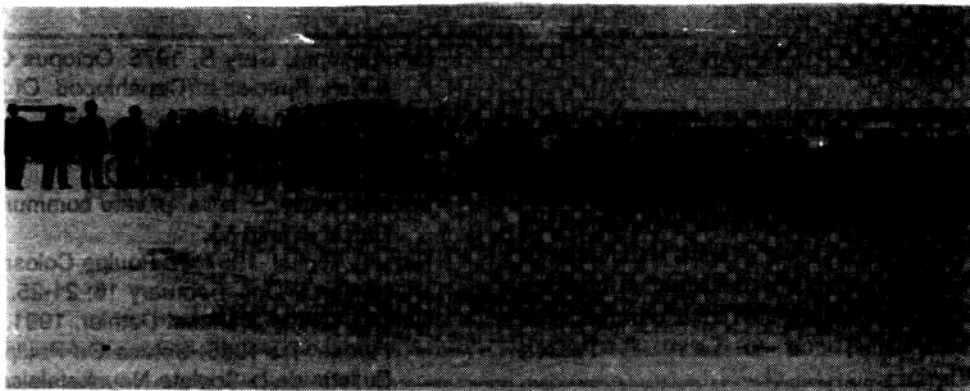


Figure 6

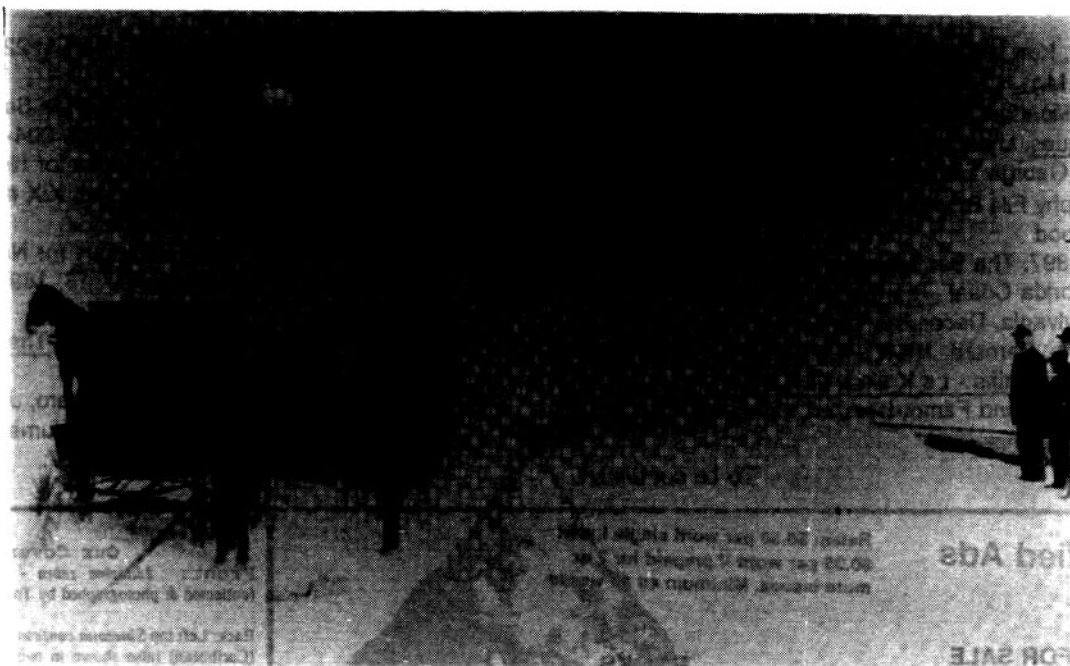


Figure 7



Figure 9



## ACKNOWLEDGEMENTS

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