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CASSIS IN CAPTIVITY: AN ONGOING RESEARCH PROJECT

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ABSTRACT

A study of the food preferences of the Queen helmet, *Cassis madagascarensis*, and the king helmet, *Cassis tuberosa*, among the regular and irregular sea urchins found around San Salvador Island, Bahamas is presented. Food preferences were studies in captivity, but some observations of *C. tuberosa* in the wild are included. *C. madagascarensis* laid egg masses June 8-10 1991. These are briefly described.

INTRODUCTION

The Emperor Conch or Emperor Helmetshell (also called Queen Helmet-shell by Bahamians), *Cassis madagascarensis* Lamarck, is the species of large marine gastropod preferred for cameo cutting because of dark layers between white layers of shell, and is much sought after for it's economic importance.

Mr. Lee, a Bahamian fisherman and exporter of *C. madagascarensis*, came to the authors in 1985 with the problem that he was finding a reduced number of this species available, and was interested in the plausibility of it's mariculture. This fact is not supported by the export data from the Bahamas Department of Fisheries (Table I). However, the increased export of this species may reflect the fact that the value of these shells has increased tremendously over the past decade, from an average of $15.00 per shell in 1979, to a present value of over $50.00 each, with the very best going for over $100.00.

In our study we interviewed many fishermen from throughout the Bahamas and found they agree with Mr. Lee that *C. madagascarensis* is more difficult to locate, and they must travel further to find them. The value of these shells, however, does continue to make it economically worthwhile for the fishermen to continue to search for them, and thus increases the risk that they will become an endangered species. Given this scenario, the need exists for its mariculture.

To undertake the mariculture of any species, however, it is necessary to have a complete understanding of that specie's habitat, niche, reproduction, growth rate, and entire life cycle.

Year	Product	Quantity	Value
1979	Queen Helmet Shells	6,958	B$ 104,910.
1980	Queen Helmet Shells	15,495	B$ 366,400.
1981	Queen Helmet Shells	no data.	-
1982	Queen Helmet Shells	11,350	B$ 373,675.
1983	Queen Helmet Shells	2,000	B$ 77,700.
1984	Queen Helmet Shells	2,500	B$ 79,100.
1988	Queen Helmet Shells	14,445	
1989	Queen Helmet Shells	13,647	
1990	Queen Helmet Shells	15,456	

Table I Export data from the Bahamas on *Cassis madagascarensis* from 1979 to 1990.

The Queen Helmet (sometimes called the Emperor Conch or Emperor Helmet-shell), *Cassis madagascarensis* Lamarck, is a solid, strong shell reaching a length of up to 14 inches. It is characterized by a pale cream-colored back shell and an apertural face which is salmon with dark brown clouding. The middle knob on the shoulder is the largest and those on either side are smaller, varying in number and size (see Fig. 1). The outline of the lip is oval, not triangular, (see Fig. 2) with the parietal shield brown between 10 to 12 teeth.

The King Helmet, *Cassis tuberosa*, is somewhat similar in appearance, except the outline of the parietal shield is triangular and the inside of the outer lip has seven to eight brown strips (see Fig. 2)

Cassis madagascarensis ranges from Bermuda and North Carolina, south through the Bahamas to the Greater Antilles. It resides in sandy areas protected by reefs, at a depth of 10 to 20 feet (Warmke and Abbott, 1961; Abbott, 1954). In the Bahamas it has been collected for the cameo trade for numerous years, but recently has become more scarce.

Based on interviews with local fishermen and observations by the scientists at the Bahamian Field Station, it is strongly suspected that *Cassis madagascarensis* has been fished out and has not existed on San Salvador for at least the past thirty years. Therefore, it seems that they have not been able to reintroduce themselves from populations on other islands. This is probably due to the distance San Salvador lies from the other Bahama islands, and because the veliger larval stage of this species is very short. However, the specifics of the life cycle are not truly known.

More information concerning the niche and life cycle of this species is greatly needed in order to set up a mariculture system suitable for raising large adult specimens for reproduction of eggs which then could be introduced in a larva stage or as young adults into their natural habitat. Given this mission, the authors began a study of the feeding habits of this species in both captivity and at large. Since the closely related species *Cassis tuberosa* is found locally, it has been included in the study.

CAPTURING *CASSIS MADAGASCARENSIS*

This mollusc is usually very difficult to see during the day since they are almost completely buried in the sand, except for the tip knob of their shell and the end of their siphon.

To expose the helmets to the surface, local fishermen use a five gallon plastic or metal paint pail with several holes in it. Into this pail they place either fresh cow hide or pieces of a ray's wing, and then anchor the pail into an appropriate sandy area. After a day or two the fisherman returns and picks up the helmets which have been attracted by olfactory means to the pail.

RESULTS

During the majority of this study a total of eight *C. madagascarensis* specimens were maintained. Four of these were medium to large in size, measuring on the average of 30 mm in circumference from one edge of the lip, around the largest part of the first whorl, back to the other edge of the lip. The other four were small to medium in size, measuring on the average of 23 mm in circumference.

Food preferences of *C. madagascarensis*

It is known that *Cassis madagascarensis* feeds exclusively on echinoids, and has a strong preference for the giant heart urchin, *Plagiobrissus grandis*. Because of the scarcity of this species in the natural environment, a number of species of echinoids available on San Salvador were offered to *C. madagascarensis* in the laboratory to see if there was a more reasonable, alternative food source. Of these, the red rock urchins, *Echinometra lucunter*, and *Echinometra viridis* were attacked and eaten by the captive helmets. The captive *C. madagascarensis* have been kept alive for three years on a diet of *Echinometra lucunter*, which was selected as the major food source because of the ease in procuring this species. It was also found that if it was extremely hungry the notched sand dollar, *Encope emarginata*, would also be eaten.

Cassis madagascarensis has been referred to by several authors (Schroeder, 1962) as feeding

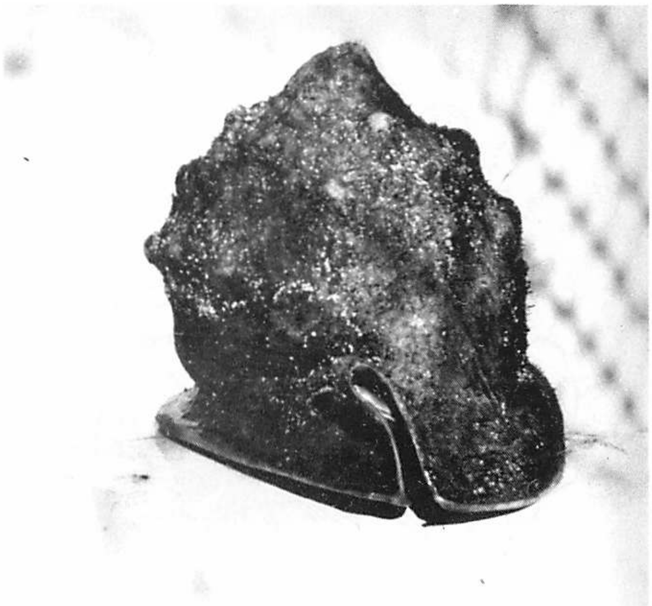


Fig. 1. The middle knob on the shoulder of *Cassis madagascarensis* is the largest, and those on either side are smaller.

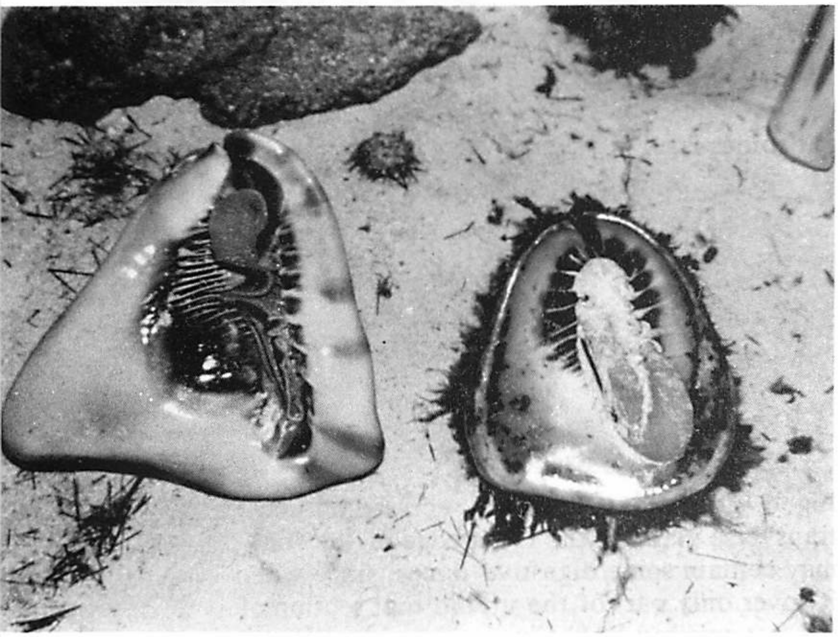
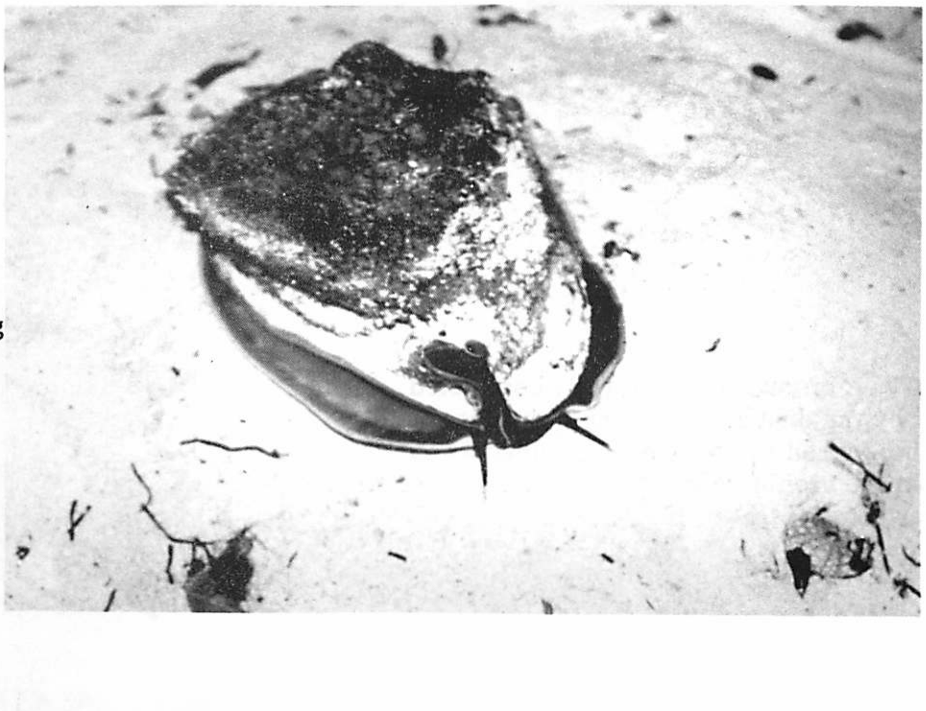


Fig. 2. *Cassis tuberosa* (on left) has a triangular outline and 7 to 8 brown bars starting from the edge of the outer lip. *Cassis madagascarensis* (on right) has a round outline of it's parietal shield.



;. 3. Almost as if on some signal after being ıentary, the Helmet extends its tentacles in ırch of prey.

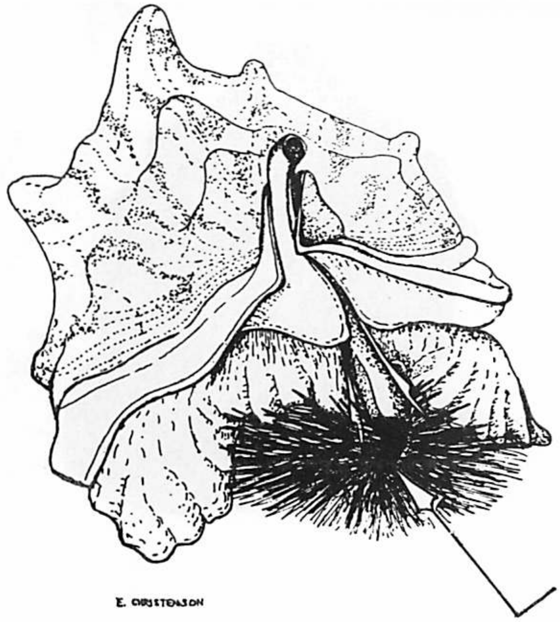


Fig. 4. When over the urchin, without the urchin's spines touching the back part of the Helmet's foot, the gastropod presses downward with the bilobal front part of it's foot. It weaves it's foot around the urchin's external spines, thus avoiding impalement. The proboscis is then extended and begins cleaning an area by ingesting spines before the boring begins.

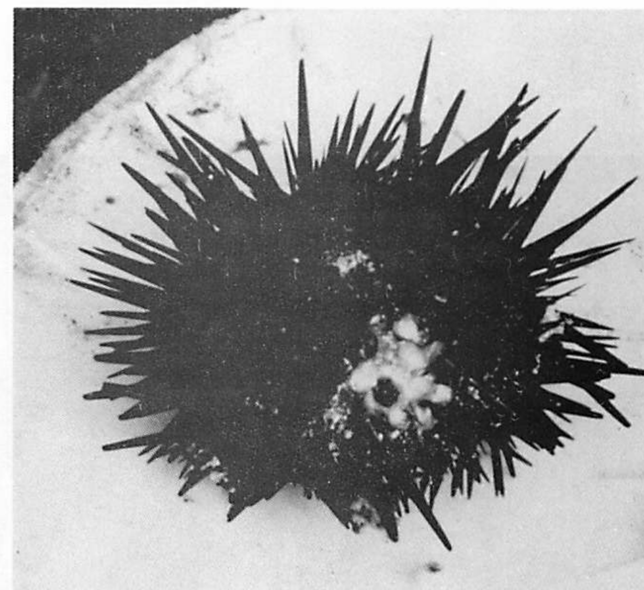


Fig. 5. An area of about five to eight spines is cleared before drilling begins.

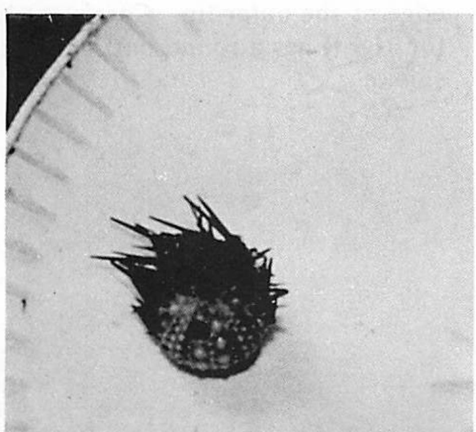


Fig. 6. The mucus substance secreted by the transverse gland at the front edge of the foot may contain some digestive juices, since when it cover only part of the urchin that section of the test covered by the mucus has it's spines removed.

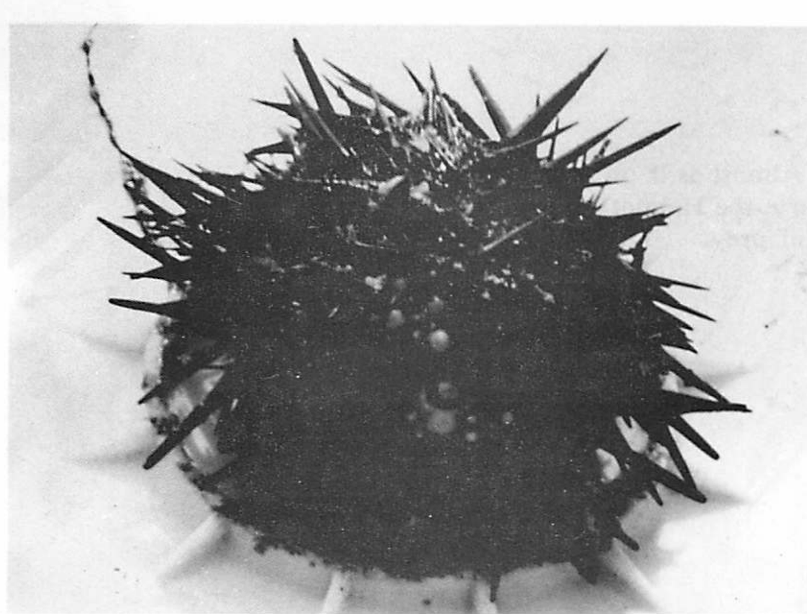


Fig. 7. A circular cut, not fully completed, was left by the dual action of the radula and acid etching when the Helmet was pulled away from the urchin before the proboscis could be inserted.

upon *Diadema antillarum*. During the past three years of captivity, however, *C. madagascarensis* has not eaten this urchin when it was placed in the aquarium. This may be due to the fact that *D. antillarum*, in its natural habitat, is often located within a rock or coral cavity on the reef, from which it cannot readily escape if attacked by *C. madagascarensis*. In the aquarium, however, *D. antillarum* can escape up the smooth sides of this structure and thus avoid attack.

It was reported that *C. madagascarensis* has been observed feeding on dead sting rays (personal communication: David Lee, Nassau, Bahamas). This potential food source was not tested in the laboratory.

The habitat of *Echinometra lucunter* (L.) is the intertidal zone, in shallow, rocky areas, and in coral reef areas. They may be found under large slabs of rock with as many as 10 or more individuals wedged in the extending crevices. They also may be found in holes with one or more individuals tucked in the cavity. The urchin travels a few centimeters from its enclave to feed on algae during the night, as long as it is not exposed at low tide. The test of *Echinometra lucunter* ranges from red on the upper surface to black beneath. It reaches a diameter of 10 cm or more, with short sharp spines. It erodes the rock surface by its movable toothed opening (Aristotle's lantern), and forms a small pit that it occupies for protection during the daylight hours.

Echinometra viridis Agassiz occurs almost exclusively in the reef area, where it feeds on algae. Its spines are thicker than *E. lucunter*'s and are lighter in color at the base, with a whitish ring where they meet the test.

Plagiobrissus grandis is one of the most beautiful and most rare of the irregular urchins, obtaining a length of more than 200 mm. It is tan to brown in color and is covered with many thin long spines. Crawling very rapidly using its bristles on the ventral side, it burrows in the sand and is considered rare, possibly because it is so difficult to see.

Lytechnius variegatus, the sea egg, is found in the *Thalassia* beds but *C. madagascarensis* would not attack it in the aquarium. It, like *Diadema antillarum*, rapidly moves up the side of the aquarium in the presence of *Cassis*.

Food preferences of *C. tuberosa*

Cassis tuberosa was also maintained in aquaria to determine if they had a food preference different then *C. madagascarensis*. *Cassis tuberosa* was successful in attacking and consuming *Diadema antillarum*, however, it did not prey on *Echinometra viridis*.

The King Helmet has been observed in the natural habitat feeding on *Meoma* and *Mellita sesquiperforata* as well as successfully attacking them in the aquaria. Drilled tests of *Lytechnius* have been found in the grass beds of San Salvador with the size hole apparently left by *C. tuberosa*, however *Lytechnius* was not attacked in the aquaria.

This gastropod hunts during the day and is often found wrapped around a *Mellita* on the sandy lagoon bottom or around a *Lytechnius* in a *Thalassia* bed.

Feeding Behavior

Cassis madagascarensis remains partially buried in sand during the day. It was observed that the captive animals began feeding at varying times during the night. Initially they were rarely observed feeding during the day, however, after the location of the aquarium was changed to a covered area to avoid excessive algae growth and salt water dilution from rain, *C. madagascarensis* was observed feeding at any time. Moore (1956) observed *C. madagascarensis* feeding in their natural state in the Florida Keys during the day upon a large concentration of *Plagiobrissus grandis*. To reach this prey Moore describes *C. madagascarensis* as burrowing into the sand at a sharp angle in pursuit of an urchin. He further describes the urchin being removed from the sand by being held in the foot of *C. madagascarensis*. When the urchin test was left behind after feeding, Moore found that the urchin spines had been removed from an area of about 25 mm in diameter and a hole had been drilled into the test.

Our observation of the feeding behavior of *C. madagascarensis* in captivity revealed that when *Echinometra viridis* was dropped into the aquarium, *C. madagascarensis* detected the urchin within a few minutes. This seems to be accomplished through some olfactory means within the siphon. Almost as if on some signal after being sedentary, the helmet extends its tentacles in search of its prey (see Fig. 3). It then moves toward the urchin at a rate of 15 to 17 cm per minute. When it is one or two cm from the urchin the helmet lifts up, supporting it's shell on the anterior part of it's foot. It extends it's head in a high arch over the urchin and continues to move forward while it's tentacles hover over the tests and between the urchin's spines. The helmet does not touch the urchin in this part of the movement, but tries to cover as much of the prey as possible before the urchin's spines touch the back part of the foot. If the urchin senses the attack it can escape, but usually only temporarily, from the attacking helmet. Unlike *Diadema antillarum, Echinometra viridis* has very poor sensitivity to the presence of *C. madagascarensis* and moves very much slower then *D. antillarum*. This lack of sensitivity has been observed when *E. viridis* moves toward *C. madagascarensis* and even sometimes attaches itself to the helmet's shell.

When *C. madagascarensis* is as far over the urchin as it can get without the urchin's spines touching the back part of the helmet's foot, the gastropod presses downward with the bilobed front part of it's foot. It weaves it's foot around the urchin's extended spines (see Fig. 4), thus avoiding impalement. At this point in the attack the urchin is securely captured. The proboscis of the helmet is then extended and begins cleaning an area by ingesting spines. The area cleared is usually 5 to 8 spines and this process takes approximately 5 minutes (see Fig. 5). *Cassis madagascarensis* then secretes a thick, jelly-like substance from the transverse glands at the front edge of the foot. With this gel as a lubricant the foot can settle down on the urchin, compressing and flattening the spines without being impaled on them.

Examination of an urchin after such an attack reveals spines cleared away and a mucus coating over the basal side of the test. Hughes and Hughes (1981) felt that the mucus secretion served to cover the urchin's spines so they could not penetrate the foot of *Cassis*. However, in our research we have found that this mucus substance may contain digestive juices, since when it covers only part of the urchin (during the first twenty to sixty minutes of the attack) only that section of the test covered by the mucus has its spines removed and the test cleared of epidermal tissue. Further evidence that this mucus may contain digestive juices is that the spines themselves, when removed from the urchin, seem to have lost some of their pectin (see Fig. 6).

When the area is cleared of spines the proboscis bores a hole with its radula by cutting out a small circle. The proboscis then is inserted, taking five to ten minutes for this phase of the attack. Figure 7 shows a circular cut (not fully completed) which was left by the dual action of the radula and acid etching when the Helmet was pulled away from the urchin before the proboscis could be inserted.

Possible Echinoid food sources on San Salvador	Preference for the prey *C. madagascarensis*	*C. tuberosa*	Habitat
Diadema antillarum	0	0	reef, grass
Lytechnius sp.	0	+++	sea grass beds
Echinometra lucunter	+++	ND	rocky substrate
Echinometra viridis	+++	ND	" "
Encope emarginata	+	ND	sand
Mellita sesquiperforata	ND	++++	sand
Clypeaster rosacea	0	ND	bar bottom
Meoma ventricosa	0	++++	sand
Plagiobrissus grandis	+++	+++ IO	sand

Notes: ND = no data or observations. 0 = refuse to eat or unable to capture in aquarium.
IO = indirect observations, prey found drilled and dead or dying but not seen in grasp of predator.

Table II. Food preferences of *Cassis madagascarensis* and *Cassis tuberosa* as determined by both captive and free observations.

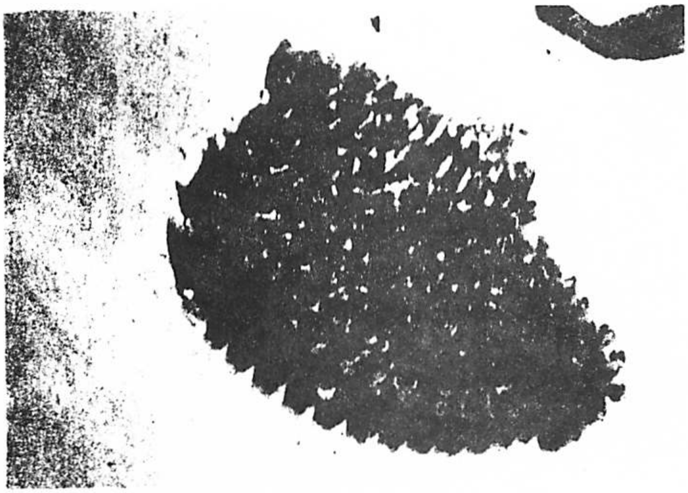


Fig.8 The egg masses were one to three inches in diameter and almost spherical, consisting of individual columns (or tall vases) 8mm tall by 2mm wide arranged side by side.

After the proboscis enters the test it takes on the average of two hours to consume the internal parts of the urchin. It has been observed that if left undisturbed the *C. madagascarensis* would consume all of the interior parts including some of the comminator muscle and peristomical membrane. What remains after the attack is a test devoid of internal and external tissue. Aristotle's lantern falls away with the individual pyramids, leaving a skeletal test with a prominent radula opening.

The speed with which the prey is consumed is remarkable. In the case of the *P. grandis* the process was completed in less than two hours.

Egg laying

Cassis madagascarensis laid eggs in the aquarium on June 8th, 9th, and 10th of 1991. They were attached to the solid substrate of the aquarium wall (fiberglass). The egg masses were one to three inches in diameter and almost spherical. The masses consisted of individual columns (or tall vases) 8 mm tall by 2 mm wide arranged side by side. Each column attached to the substrate and was free standing. There were 160 'vases', 23 'vases' and 102 'vases' in the three masses. In each 'vase' were from 170 to 300 spherical structures that were presumed to be eggs. When a 'vase' was torn open the eggs dropped to the bottom of the dish of sea water.

DISCUSSION

Cassis poses some very interesting problems to the mariculturist. The first is how to provide a diet that the post larval animal will take and one on which it will grow. It is apparent from this study that the organisms on which the *Cassis* feeds are difficult to obtain in order to provide an ample supply of food for the animals in captivity. Further, the growing of an adequate supply of echinoids poses a whole new set of problems. More is known, however, of echinoderms and their embryology, growth and life cycles. Because of the problem obtaining ample food the normal growth curves that had been originally anticipated in this study were not obtainable.

The queen conch *Strombus gigas* is a vegetarian during each of the stages in its life cycle. Is *Cassis* in the same situation in being dependent on echinoids for food during the various stages of its life cycle? If so it must spawn at about the same time as one or more of the Echinodermata. How is this controlled? In *Strombus* settling of the larva is triggered by secretions from an alga. What triggers the settling of the larva of *Cassis*?

Mr. Lee reports finding 2 to 4 of the animals in a hollow space in the sand presumably over-wintering. In our observations they have never moved deeper in the sand than the siphon. The *C. madagascarensis* shells that these experimenters have observed, both museum and live, have been pitted by boring organisms. *Cassis tuberosa* seldom shows this pitting.

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