Cyphoma gibbosum L. and Gorgonians: evidence of a chemical relationship

Kathryn N. Hoy
Biology FSP
Tropical Marine Ecology
John Gilbert
3-8-83

Abstract

The relationships between several species of gorgonian soft coral and the mollusc Cyphoma gibbosum was investigated on the fore reef at Discovery Bay, Jamaica. A common, though widely dispersed predator on Gorgonians, the Flamingo Tongue, Cyphoma has been suggested to display aggressive and territorial behavior. This study attempts to clarify these observations by assessing competitive forces between molluscs and resource carrying capacity of gorgonians. Evaluation of results is done in consideration of possible allelochemicals/chemicals in the Gorgonian. These chemicals are hypothesized to be detectable by Cyphoma, influencing orientation, choice, and preference activities. Cyphoma is found to orient chemically and demonstrate substrate preferences. Further study is suggested, and possible adaptive strategies of Cyphoma morphology and physiology are discussed.

Introduction

One of the most colorful relationships on the coral reef exists between the often-purple species of Gorgonian soft coral and the Cyphoma gibbosum, an orange and black spotted marine mollusc. The toxicity of two species of gorgonian (Bakus 1981) suggest the possibility of a chemically-controlled coevolved predatory relationship between the snail and the gorgonian -- a relationship where aposematism may reflect mutual distaste.

The Flamingo Tongue, *Cyphoma gibbosum* Linné (Kyphoma- Greek: hump; gibbus- Latin: hump) is a prosobranch gastropod found from the North Carolina shores to throughout the West Indies. Its shell is compact and robust, with a strong cross-wise rib for which it was named. The shell is white rimmed with light orange where the mantle of the living mollusk spreads its spotted cloak across the dorsal part of the shell. *Cyphoma* is in the family Ovulidae, in which the other common genus *Neo Simnia* also feeds on Gorgonians. (not found in this study)

The Octocorallia, or gorgonians, is a group of soft corals including such major organisms dominating the reef landscape as sea whips and sea fans. Caribbean diversity in the Octocorallia is greatest on the Windward side of the Lesser Antilles, with 59 species represented. In the most depauperate areas, still eight species exist. Jamaica has a total of twenty-three different species and forms of soft coral. Aspects of gorgonian morphology and physiology which have a bearing on ecological interaction include perpendicular orientation to the prevalent current, planar form, flexible skeleton (Wainwrite and Koel 1976), and low nematocyst densities (Lasker 1981). Velimirov (1975) found gorgonian architecture to allow for a maximum size peak at 10-15 years. This high upper age limit, coupled with very low predation pressure (Kenzie 1973) points strongly toward a chemical explanation.

Methods and Materials

Field and laboratory studies were conducted at the Discovery Bay Marine Laboratory in Discovery Bay, Jamaica, West Indies. The study site was located at Mooring #1, on the west fore reef, at a depth of 30-40'. Coral and coral rubble areas are separated by sand channels, with a great number and variety of octocorals arising from firm attachments. *Cyphoma gibbosum* was found as an infrequent preditor.

1st experiment

This study involved four sets of experiments: field surveys, field release experiments, lab orientation experiments, and preference tests. Field survey consisted of recording all gorgonians found with *Cyphoma*, measuring *Cyphoma* size, area eaten, and distance parameters as well as gorgonian species. (A total survey of all area gorgonians was not made because of time constraints. Lasker (1981) did conduct general Gorgonian surveys and found negligble snail occurence. Therefore, a larger area was scanned to find *Cyphoma*.)

The second group of experiments involved the release of groups (3 to 6) of *Cyphoma* at the base of gorgonians. A dispersed array of *Cyphoma* territories was expected to appear by the end of a twenty four hour period. Tests were done using unknown and * known edible individuals. All distances were measured.

The third set of experiments consisted of ten in-lab orientation tests. These tests were carried out in a controled flow salt water table, with five to eight *Cyphoma* placed in the tank to react to various stimulii (i.e. current changes, different

* because a *Cyphoma* was found already feeding there

gorgonian species.) Cyphoma density experiments were also done to observe the affects of experimental crowding. In all these tests, time and distance moved were recorded to come up with movement rates.

A fourth set of tests was designed to assess the importance of preference in movement and substrate choice. In the lab, snails originally feeding on four different gorgonian species were carefully watched when placed on two different gorgonian substrates. Qualitative remarks on feeding microbehavior, "tasting", and selection of feeding surface were recorded. This array allowed for two control feedings. Field preference tests were planned, but problems with boat availability made it impossible to execute them.

Results

The results from the field survey give an idea of the diversity of gorgonians commonly fed upon by Cyphoma gibbosum. In Table 1. the species are

Code	Gorgonian species	brief description	# Gorgs.	tot # Cyph.
B	Plexaura homomalla	dark brown w/ light polyps	3	5
P	O.T.U.	purple w/ beige polyps	5	7
BP	(Deadman's Fingers) Briareum asbestinum	thick purple w/ brown furry	4	6
KP	Eunicea sp.	knobby grey-purple	2	2
F	(Common West Indian Sea Fan) Gorgonia ventilata	purple fan	1	1

Table 1. Survey species and numbers encountered.

listed, showing also the number of snails found. The average number of Cyphoma / gorgonian = 1.3, a number sligtly over one mainly because of a tendency to live in male-female pairs. Though reported in groups even of five and ten snails, no more than three Cyphoma were observed on the same gorgonian. It is unclear whether this average number is due to resource limitation or due to competitive exclusion and/or aggressive territorial exclusion, or even due to random dispersion throughout an over-abundant array of resources. While the average Cyphoma was 2.8 cm in length (varying from 2.15-3.25 mainly), one 1.75 cm juvenile was found in close proximity to an adult. The juvenile's shell was thin and purplish. Finally, an average of 36.2 cm^2/Cyphoma was consumed, this probably being underestimate depending on the extremity of descernable damage incurred (i.e. to the coenenchyme and axis). ~ Unfortunately, field limitations did not allow for documentation of a field feeding rate.

tot		distance cm.		distance cm.	
① Purple Unknown (3)	♂♀	15	③ Purple Known (6)	38	on KP
	♂♀	15		36	on KP
	North	70		17	on designated
② Brown Known (5)	N	40		—	lost
	N 20	75		—	lost
	near Purple 5	85	④ Preference Brown (Control)	3.5 m	→ on P
	N 30	90	⑤ Preference Brown (P Cyphoma)	—	lost
	SW	270		—	lost

Table 2. Field Release Data showing distance traveled in 24 hrs.

The results of the field release experiments are summarized in Table 2. In all experiments, only one snail climbed onto the designated gorgonian. This may be due to unnatural crowding, as snails were placed side by side at the base of the selected gorgonian. To test whether crowding influences movement and direction, in-lab tests were performed.

The laboratory orientation experiments were the third aspect of this research. The results of this work ~~is~~ are interesting in that some preferences/differences have become apparent, possibly illuminating the results of the previously reported field release study. (1) A Comparison of movement rates in <u>Crowded and uncrowded situations</u> is diagrammed in Figure 1. Movement rates compared over three ten-minute periods were found significantly different ($P < .1, .05$) using the Mann-Whitney U-Test -- water flow and other distance parameters were controled. Rates were significantly higher when snails were crowded. (2) Orientation to Brown Gorgonian (*Plexaura homomalla*) Compared with Orientation w/o gorgonian found no significant difference in rate or distance traveled (See Figure 2 for sample arrangement of an Orientation test).

Isn't presence of gorgonian also a variable here?

(of interest: Young *Cyphoma* climbed up onto small stones into currents, esp. in tests of Gorgonian saturated water currents)

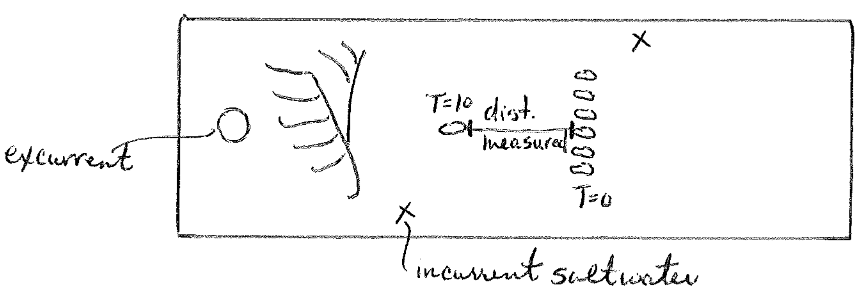

Figure 2. Sample diagram of an Orientation test

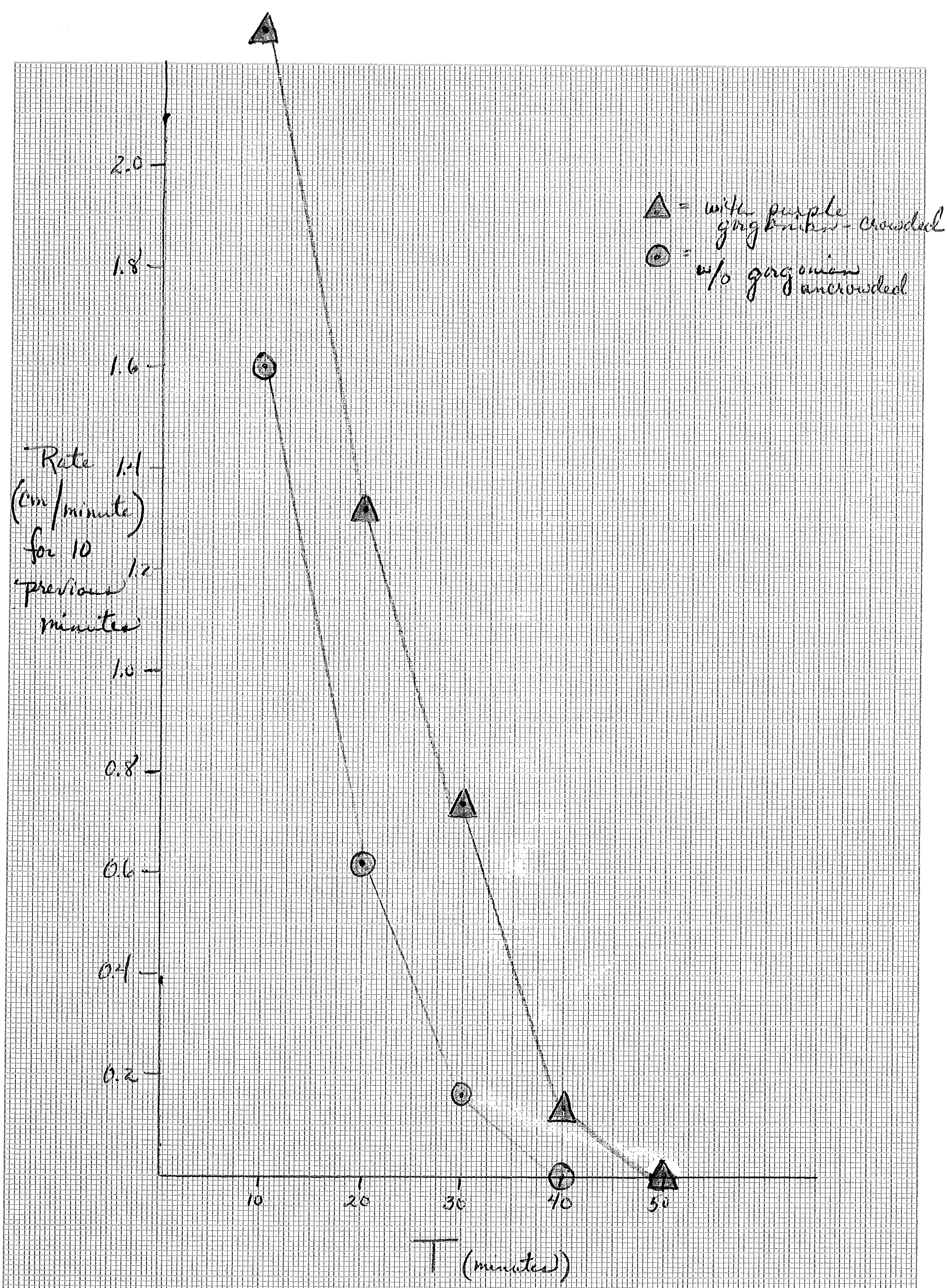

Figure 1. Comparison of Movement Rate over Time in Crowded and in Uncrowded Situation

(3) A Comparison of distance moved in the first twenty minutes with T=30→50 was not statistically testable but is very different [T=0→20 (107 cm, 36, 30, 5, 0) and T=30→50 (7 cm, 0, 0, 0, 0)] This same phenomenon of slowing rate over time was noticed in all experiments.
(4) A Comparison of orientation to Brown / Purple / and Bagged Purple is done in direction (+ = toward stimulus, − = opposite the stimulus) and average distance traveled because total observation times differed (this should still be comparable, though, because of rate slowing demonstrated in (3)). As shown in Table 3, strong positive orientation is seen toward the purple gorgonian, while perhaps even negative orientation toward the brown gorgonian, and neutral orientation to the bagged gorgonian. This neutral orientation discounts the possibility of visual orientation, and shows diffused chemicals sensed in the water serve as guides to gorgonian food sources.

Brown (40 tot mins)	Purple (90 tot mins)	Purple in Bag (150 tot. mins)
avg. dist = 25 cms	52 cms	34.3 cms
+ = 1	+ = 6	+ = 4
− = 4	− = 1	− = 3

Table 3. Visual / Chemical Orientation Test (4)

(5) Finally, some maximum distances + rates for in-lab movement were found in the orientation experiments: over 10 mins. = 54 cm or 5.4 cm/min -- the greatest field 24 hr. rate = 2.4 cm/min, showing resting time

must have taken place over the 24 hours.

The fourth set of experiments were the in lab preference tests, where Cyphoma from known substrates were observed as they were offered either brown or purple gorgonians. Table 4 summarizes the results. "Side" means that the snail crossed over the gorgonian presented to it with cursory touches of the antennae + fore-edge of the foot, proceeding to climb the edge of the container. "Some feeding" means the radula were seen to rasp and some polyps were eaten, though not systematically. "Fed" signifies systematic feeding after preliminary sensing w/ chemoreceptors. (See Figure 3 for anatomical diagram) A preference for purple and a possible rejection of brown that was noted in the orientation experiments is reinforced here.

Original substrate	B	P
on which Cyphoma found	-	
KP - Eunicea	side	side
P - OTU	side	fed
BP - Briareum	some feeding	fed
B - Plexaura	Some feeding	fed (Voraciously)

Table 4. Preference Tests
extra boxed = controls

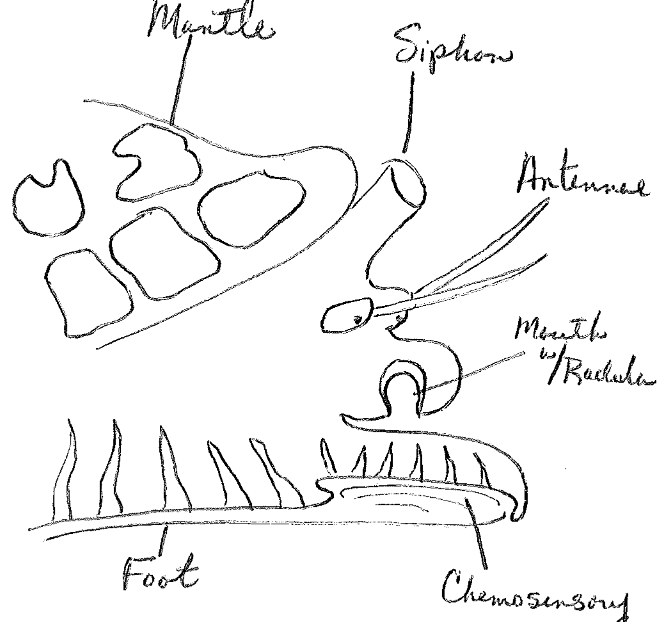

Figure 3. Anatomical Detail of Head region of Cyphoma

Discussion

The possibly competative responses observed in the field release experiments may have not been exclusion from designated gorgonian because of territoriality, but because of a crowding response. The significant change in rate of movement due to crowding, was graphed in Figure 1. The aggressive behavior observed by Ghiselin + Wilson (1966) may even have been because the five *Cyphoma* observed were unnaturally crowded in the water dish. Also, response to crowding may be confused with a chemical response, which has also been shown to influence both rate and direction of orientation. To clarify field release competition/preference tests, further study is suggested to be carried out using only 1 or 2 *Cyphoma* at a base (not exceding natural coexistance levels) to allow optimally all access to the above gorgonian that is desired.

Evidence for chemical sensing has been quite striking. Though little study has been done on Gorgonian chemistry, many factors point to the necessity for allelochemical defenses in the soft corals: long life, flexible branches, rather exposed polyps, and low nematocyst count. Veliminov and Bohm (1976) found $CaCO_3$ + $MgCO_3$ differentially located in the animals, perhaps other chemicals are as well. Wahle (1980) found that Milleporoid fire corals were able to detect Gorgonians upstream from them and actively overgrow them, *Plexaura homomalla* was the given example (Brown gorgonian in this study).

Also, in a taxonomy text it was noted that *Plexaura homomulla* was a good source of prostoglandins -- these notes might possibly explain the general dislike for Brown Gorgonians found in the Orientation and preference experiments.

The actuality of toxins in the soft Corals opens many avenues for further study -- isolate the toxins first, but more interestingly, look at the *Cyphoma's* physiological mechanism for detoxification of their food source. I suggest that the gorgonian toxins may be sequestered in the mantle of the Snail, because mantle pieces fed to the Yellow-headed Wrass were repeatedly spit out.

good idea

The feeding induced, termed "preference", is still not satisfactorally defined as true preference in *Cyphoma* or as chemical variation in Gorgonians. *Cyphoma* may be imprinted with chemical preferences because of first feeding, and perhaps this preference may be visible in shell morphology. I noticed that *cyphoma* feeding on Brown *Plexaura* tended to have shells of a deeper orange shade.

interesting observation

As for the gorgonians, chemistry should be compared intracolony, intraspecifically, and interspecifically, also with attention to changes in chemistry which may be damage-induced. In plant-herbivore systems, recent research has shown damage-induced toxicity to be an important defense mechanism for trees -- perhaps a similar coevolutionary system exists between *Cyphoma* and gorgonians.

Does a coevolved chemical system go hand in hand with an evolved morphological system? It is tempting to suggest that the black and orange ring pattern on the Cyphoma mantle is aposematic -- displaying its own toxicity. (a distastefulness even borne out in Yellow headed Wrass experimental feedings of Cyphoma). Also, the robust shell of Cyphoma offers a great deal of protection. Contrasting this morphological form is that of the Genus Neosimnia, Cyphomas' closest relative. The Simnias have shells very much like those of the Cyphoma, except they are thin + lightweight for hanging onto the sea whips in the surface. Also, since they feed on mucus and sloughed spicules, they are able to incorporate Gorgonian pigment into their shells, taking on the color of the Gorgonian on which they feed (Patton 1972) -- yellow or orangish or purple. So this closely related group is cryptically colored and doesn't ingest polyp or other tissue or axis structure -- I suspect that the Simnias may not be toxic either. The evolutionary pressures that lead to the formation of such disparate morphologies and probably physiologies might be studied across the Pleistocene glaciation periods when habitat and carbonate restrictions may have induced such changes. (Gould 1970). Increased cephalization, the development of an assymetric spiral, and shell torsion (aiding in hiding) are aspects of gross development in mesogastropod evolution. Chemical evolution and adaptation are just as likely to occur with time, and the sensitivity/selectivity of this relationship in Gorgonians and Cyphoma would prove an interesting subject for further study.

A good attempt to get at a number of questions concerning this little-known snail-gorgonian system.

References

Bakus, Gerald J. 1981. Chemical defense mechanisms on the Great Barrier Reef, Australia. Science 211: 497-498.

Barnes, Robert D. 1980. Invertebrate Zoology. Fourth edition. Saunders College, Philadelphia, PA.

Bayer, Frederick M. 1961. The Shallow-water octocorallia of the West Indian region: a manual for marine biologists. Martinus, Nijhoff, The Hague.

Emerson, W.K. and Morris K. Jacobson. 1976. The American Museum of Natural History Guide to Shells. Alfred Knopf, New York.

Ghiselin, Michael T., and Barry R. Wilson. 1966. On the anatomy, natural history, and reproduction of Cyphoma, a marine prosobranch gastropod. Bull. Mar. Sci. 66(1): 132-141.

Gould, S.J. 1970. Coincidence of Climatic and Faunal Fluctuations in Pleistocene Bermuda. Science 168: 572-573.

Gould, S.J. Phenotypic Reversion to Ancestral Form and Habit in A Marine Snail. Nature Vol 220 No. 5169: 804.

Kinzie, R.A. III. 1973. The zonation of West Indian gorgonians. Bull. Mar. Sci. 23(1): 93-153.

Kohn, Alan J. 1961. Chemoreception in gastropod mollusks. Amer. Zoologist 1: 291-308.

Lasker, Howard R.. 1981. A comparison of the particulate feeding abilities of three gorgonian sp gorgonian soft coral. Marine Ecology - Progress Series Vol 5: 61-67.

Morris, Percy A. 1973. A Field Guide to the Shells of the Atlantic and Gulf Coasts and the West Indies. ed, William J. Clench. Houghton Mifflin Company. Boston pp. 178

*

Preston, Eric M. and J. Lynn Preston. 1975. Ecological Structure in a West Indian Gorgonian Fauna. Bull. Mar. Sci. 25(2): 248-258.

Wahle, C.M. 1980. Detection, pursuit, and overgrowth of tropical gorgonians by Milleporoid hydrocorals: Perseus and Medusa revisited. Science Vol. 209: 689-691.

West, D.A. 1976. Aposomatic coloration and mutualism in a sponge-dwelling tropical zoanthids. From: G.O. Mackie (ed.) Coelenterate Ecology and Behavior, Plenum Press. 443-452

Velimirov, B. and E.L. Bohm. 1976. Calcium and Magnesium carbonate concentrations in different growth regions of gorgonians. Marine Biology 35: 269-275.

*Patton, Wendell K. 1972. Studies on the animal symbionts of the Gorgonian coral, <u>Leptogorgia virgulata</u> (Lamark). Bull. Mar. Sci. 22(2): 419-431.