

# Competition between corals and sponges and diversity in the coral reef.

## Abstract

Coral-sponge interactions were observed in situ. Competitive outcome and tissue damage were recorded. A network including complete and incomplete dominance relationships was described. Allelopathy and mesenterial filament attack are suggested as aggressive mechanisms. The existence of a dominance network and its relation to diversity is discussed.

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## Introduction

Substrate space has been widely suggested as the limiting resource for sessile organisms on the coral reef (Jackson & Buss, 1975) (Connell). Indeed, the literature provides a substantial record of species competition for position on substrate. Coral-coral (Lang, 1973), sponge-ectoproct (Jackson & Palumbi, 1982), <sup>and</sup> sponge-coral (Jackson & Buss 1979) aggressions have been well documented. Allelopathy, rapid growth rate, and mesenterial attack are believed to be the chief mechanisms for these aggressive interactions.

The overall scheme of these competitive interactions has important implications for the community structure of the coral reef. Lang's study (1973) on scleractinian corals definitively organized competitive relationships into a hierarchy. Her hierarchical explanation of coral aggression has been criticized, however, not for being inaccurate, but for having oversimplified the system. Buss and Jackson (1979) argue that competitive

outcomes between sessile inhabitants of the reef are not strictly transitive. Rather, they propose a network of competitive interactions for the reef community. Jackson and Buss suggest that negative feedback loops within this network system contribute to the maintenance of diversity in the coral reef.

It seems reasonable that other sessile invertebrates, such as sponges, should be incorporated into this competitive network. The abundances and competitive positions of corals may be influenced by the differential pressure of demosponge aggression. Bak and Keys (1977) observed variation between several coral species in their ability to compete with sponges. *Montastrea annularis*, for example, appeared to be more successful than *Agaricia agaricites* in confronting *Cliona* sp.

Ultimately, the species-specific nature of coral-sponge competition may profoundly influence the structure of the reef community.

The goal of this study was to outline the competitive relationships between sponges and

corals at the species level. Such information may allow for the formulation of a more complete competitive network describing the community structure of coral reef invertebrates.

It is hoped that the organization of this model will more fully reveal the mechanism for maintaining diversity within the reef system.

### Methods

This study was conducted at Mooring 1 on the fore reef of Discovery Bay, Jamaica. The north coast of Jamaica was highly disturbed in August of 1980 by Hurricane Allen. The turbulence associated with this storm razed the less massive corals in Discovery Bay. The reef is still in the early stages of succession and regeneration. SCUBA was used for all observations and manipulations at Discovery Bay.

Coral-sponge interactions were studied in two manners. First, coral-sponge confrontations were censused in situ. Second, artificial coral-sponge contacts were created and monitored in situ.

The census considered six adjacent reef butthesses. Each butthess survey was made on a separate dive. Thus, the topographic boundaries between butthesses prevented sampling overlap.

The butthesses were examined for coral-sponge interactions from a depth of 60-feet to 40-feet.

Damage and competitive outcome were described for each coral-sponge confrontation. Sponge

damage was defined as tissue disintegration along zone of contact with the coral. Coral damage was defined as the occurrence of a bare, dead zone at the point of contact. Presence or absence of damage as described above was recorded for each confrontation.

Competitive outcome of coral sponge interactions was concluded from pattern of overgrowth. The winner in each confrontation was defined as the individual which was overgrowing its competitor to the greater extent. Each coral-sponge interface was separated to verify that one individual was in fact covering the other.

The following manipulative study was also performed in situ. Individuals

of a variety of sponge genera, including Hemectyon spp., Aciria spp., and Haliclona spp., were tied to Diploria labyrinthiformis. Several replicates were arranged for each sponge. Dead Acropora cunicornis fragments were attached to D. labyrinthiformis as a control.

It was originally planned that coral recruits would be transplanted onto sponge individuals. This approach would have minimized disturbance of the sensitive poriferans. Unfortunately, sufficient numbers of the D. labyrinthiformis coral recruits were not available. Thus it was necessary to move the sponges to the coral. Some sponges were seriously damaged by this experimental manipulation.

## Results

Table 1 shows the percentage of observed interactions within each pairwise grouping of corals with sponges that showed evidence of 1) coral damage, 2) sponge victories, 3) sponge damage, and 4) coral victories. Victories

were denoted by overgrowth of competitor. The total sample size was 174 sponge-coral interactions, spread over 13 coral species and 16 sponge "operational taxonomic units." The large number of species contributed to the occurrence of a  $\lambda$  population size of 1 in <sup>a few</sup> of our pair-wise groups. For analysis, the six commonest sponges and the seven commonest corals were selected as representative of the broad community structure.

Using Lang's hierarchy (1973) for coral dominance, a network among the corals and sponges was arranged (see Figures 1A & 1B). The solid arrows (Figure 1A) depict the dominant species pointing to the subordinate. Dominance was defined as overgrowth occurring in at least 75% of the pair-wise interactions. The dotted arrows (Figure 1B) denote an incomplete dominance, defined as overgrowth occurring in 25% - 75% of the pair-wise observations. Figures 1A and 1B were separated for graphical clarity.

A correlation coefficient was calculated to see if there was a relationship in the occurrence of sponge overgrowth vs. coral damage (see Fig. 4). The correlation was found to be significant to the .05 level.

Similarly, a correlation coefficient was calculated for the occurrence of coral overgrowth versus sponge damage. However, no significant correlation was found.



Table 1: Frequency (in percentages) of coral damage (white), sponge overgrowth (blue), Spongedamage, and coral overgrowth (green).  
 Sample size is shown for each pairwise group. 8

coral species	<u>Hemecton spp.</u>		<u>Iridina spp.</u>		Sponge A		Sponge B		<u>Helicidina spp.</u>		Sponge E		Other	
<u>Agaricia</u> <u>agarites</u>	25	45	41	44	50	50	33	22	60	60	50	50	83	83
	15		39		50		67		40		50		17	
	n=20		n=18		n=2		n=3		n=5		n=2		n=6	
<u>Montastrea</u> <u>annularis</u>	83	83	100	82	-	-	100	100	100	100	100	100	50	70
	17	0	18	9	-	-	0	0	0	0	0	0	0	0
	n=6		n=11		-		n=2		n=4		n=1		n=4	
<u>Diploria</u> <u>labyrinthiformis</u>	100	0	-	-	-	-	-	-	-	-	-	-	67	33
	100	100	-	-	-	-	-	-	-	-	-	-	33	33
	n=1		-		-		-		-		-		n=3	
<u>Siderastrea</u> <u>siderea</u>	100	67	100	15	100	70	100	100	100	100	100	100	67	100
	33	0	25	25	50	0	0	0	0	0	0	0	0	0
	n=3		n=4		n=2		n=1		n=1		n=1		n=3	
<u>Porites</u> spp.	33	67	67	67	-	-	100	100	33	50	17	50	15	15
	17	33	33	33	-	-	0	0	50	0	15	50	0	0
	n=6		n=3		-		n=2		n=2		n=4		n=4	
<u>Madracis</u> <u>decactis</u>	50	0	33	100	-	-	-	-	0	50	-	-	33	100
	50	50	55	0	-	-	-	-	0	50	-	-	0	0
	n=2		n=3		-		-		n=2		-		n=3	
<u>Millepora</u> spp.	25	75	0	62	-	-	-	-	-	-	-	-	0	50
	25	25	12	38	-	-	-	-	-	-	-	-	50	50
	n=4		n=8		-		-		-		-		n=2	

Figure 1A: Sponge-coral network using Lang's (1973) hierarchy. Arrows denote 75% or greater occurrence of overgrowth of "subordinate."

9

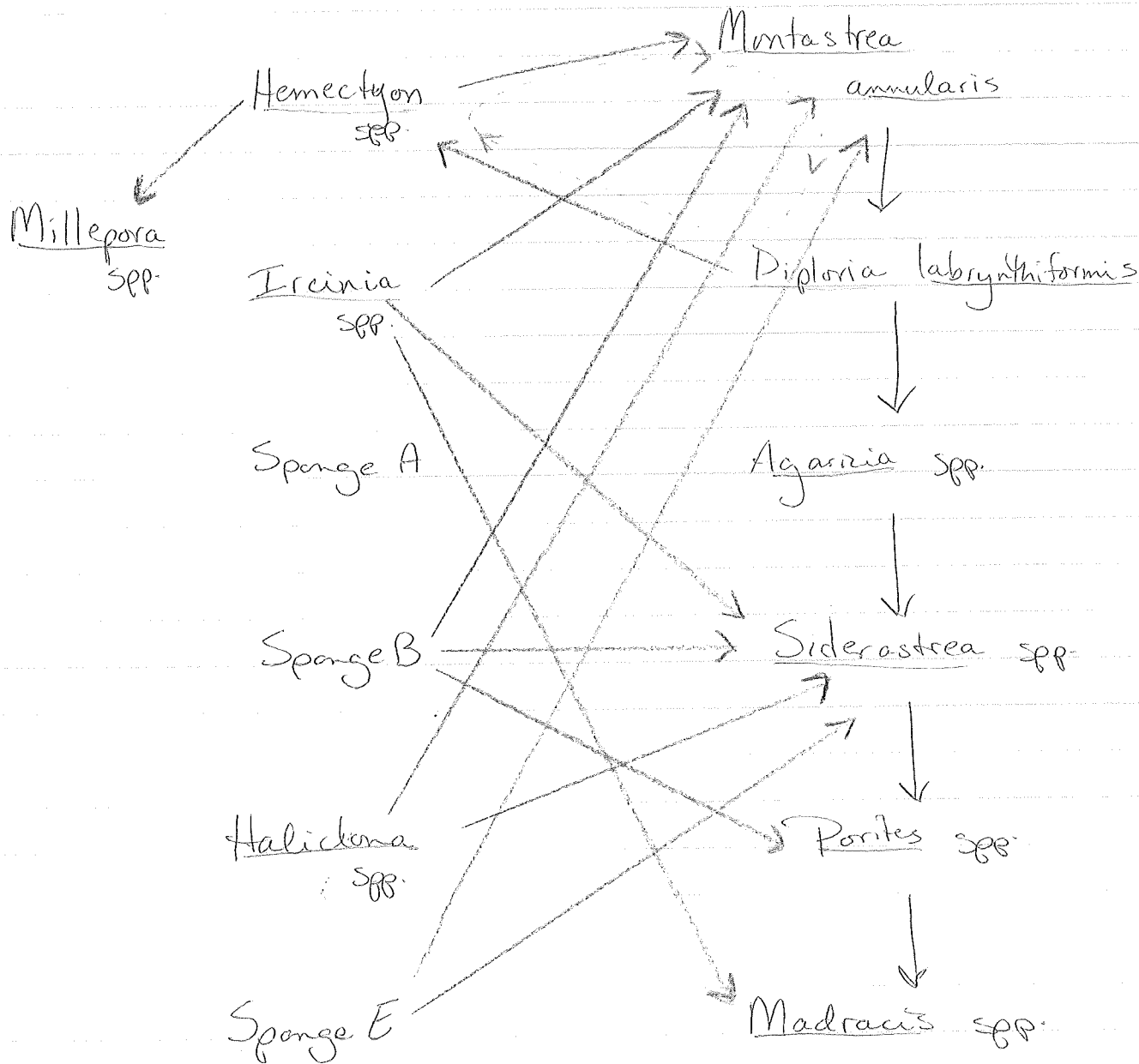


Fig 1B: Sponge-coral network using Lang's (1973) hierarchy. Arrows denote 25-75% occurrence of overgrowth of taxon pointed to. The dottedness indicates the incomplete dominance of these relationships.

10

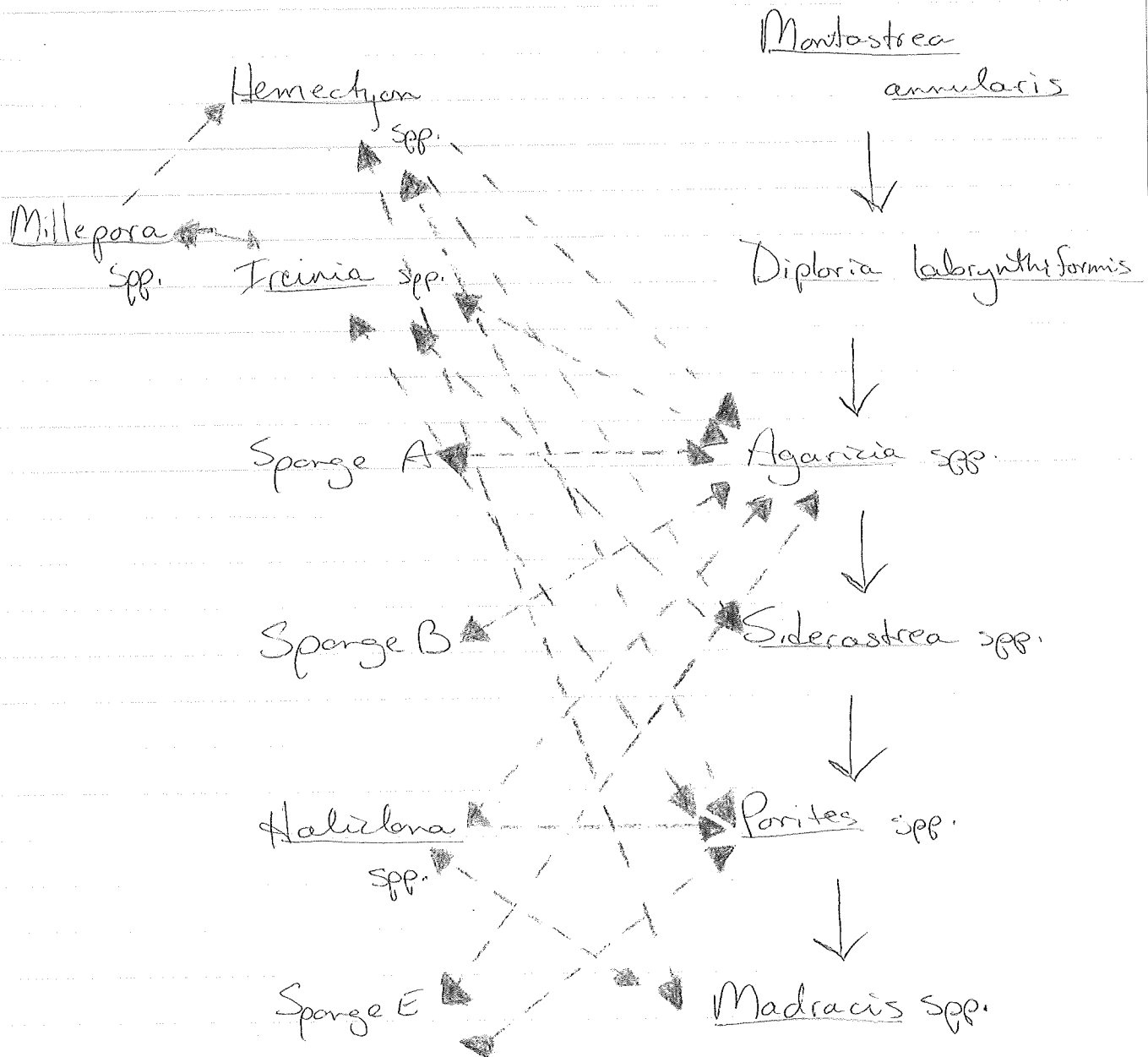


Figure 2: Schematic of the influence of spatial positioning of species on a single substratum on the determination of subsequent species distribution on that substratum. (Buss & Jackson, 1979).

11

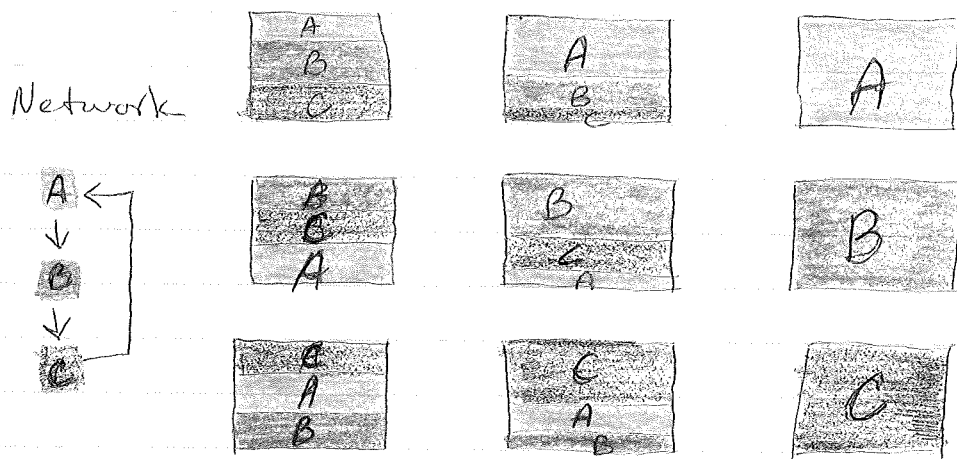
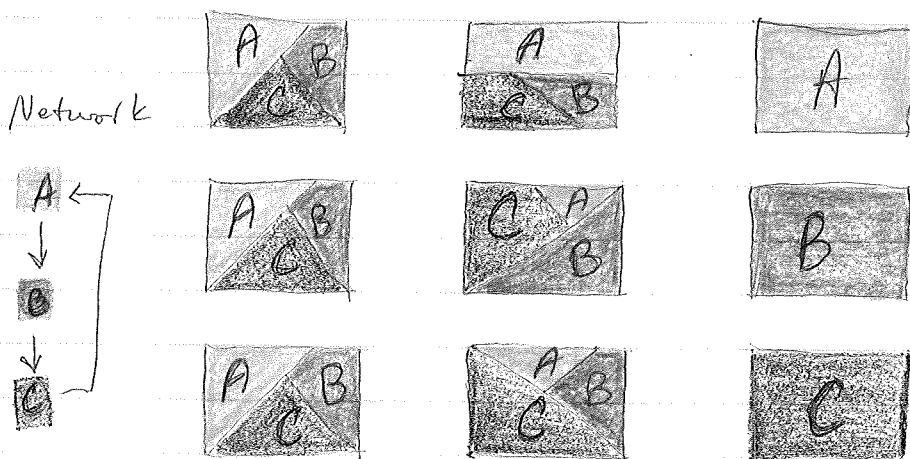
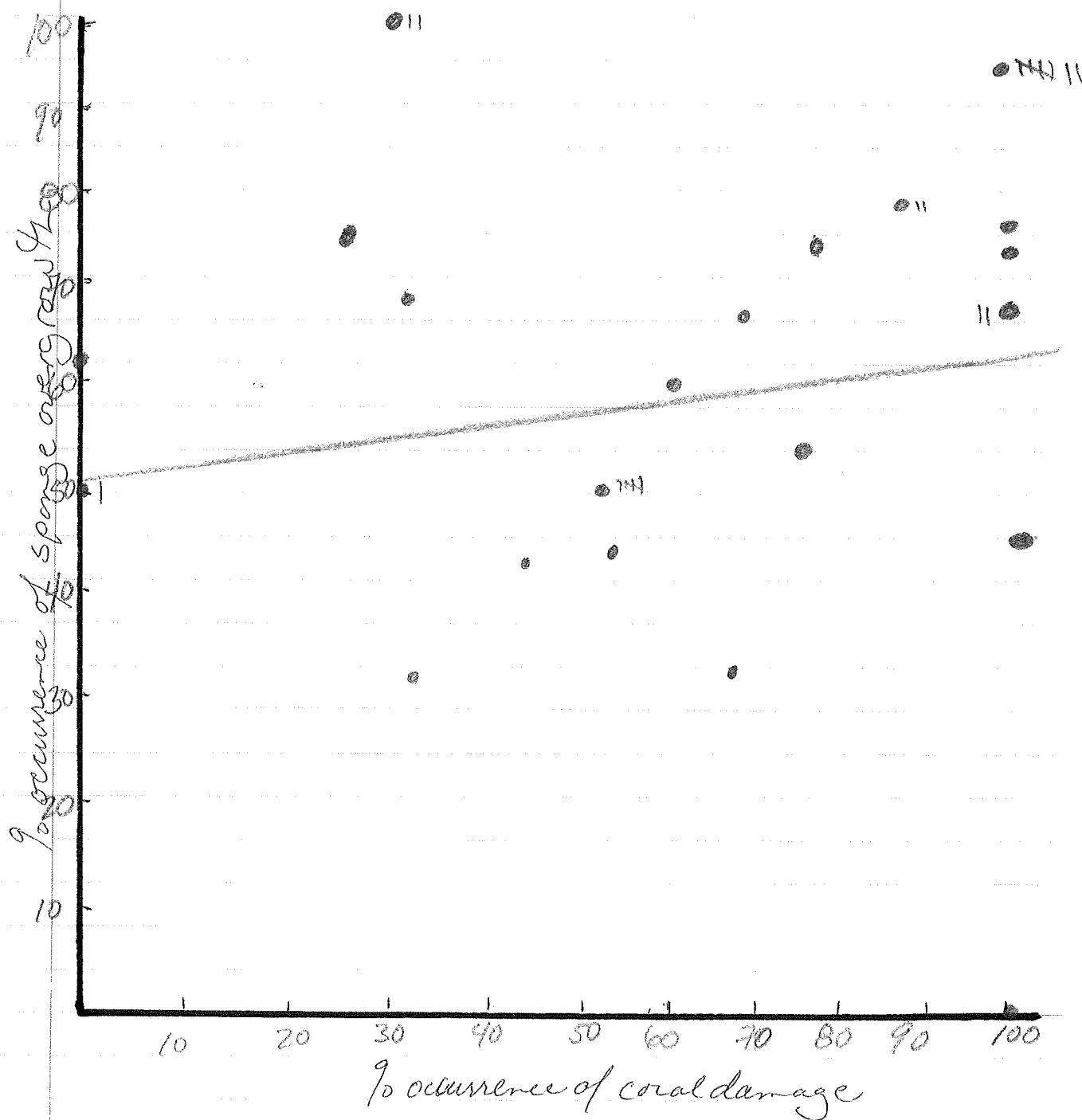


Figure 3: Schematic of the influence of organisms overgrowth on a single substratum on determination of subsequent species distribution on that substratum. Overgrowth rates are, in the first series of substrata, sp. A > sp. B > sp. C; the second, sp. B > sp. C > sp. A; and the third, sp. C > sp. B > sp. A. (Buss & Jackson, 1979).



12



## Discussion

In situ observations of coral-sponge interactions produced competitive network at the species level. Coral-sponge dominance relationships were revealed when competitive outcomes were summed for each species pairing. Judith Lang's coral dominance hierarchy (1973) was adjusted to produce a sponge-coral network.

The inclusion of sponge coral interactions complicated model. Various loops were formed due to the differential pressure of sponge species on various corals. For example, Monastrea annularis outcompetes Diploria labyrinthiformes, D. labyrinthiformes outcompetes Hemectyon sp, which in turn outcompetes M. annularis (Figure 1A). Thus, the presence of sponge stabilizes the coral-coral relationship, through network feedback. Moreover, the inclusion of relationships involving frequent reversals in competitive outcomes increases the potential for feedback looping (Figure 1B). The work of Jackson and Buss (1979) seem to corroborate the type of competitive loops suggested here. These works (OVER)

(Jackson and Buss, 1979).

Having described and organized the competitive relationship between reef invertebrates, attention was focused on the aggressive mechanism of the interactions. What makes certain coral and sponge species so competitively dominant? This study sought to correlate competitive success to ① ability to inflict damage through allelopathic or mesenteric attack, and ② intrinsic rate of growth.

Correlation coefficient analysis suggests that occurrence of coral damage is positively associated with sponge dominance. The correlation proved significant to the  $\alpha < 0.05$  level. Thus, sponge ability to damage its coral competitors seems to be correlated with success at overgrowing that coral. Allelopathy is suggested as the causal link which produces the correlation between bare zone and overgrowth by sponge. Bare zones are assumed to be produced by allelopathic attack by sponges.

A correlation coefficient was also calculated for percent overgrowth by coral individuals versus percent sponge individuals.

damaged. No significant correlation was found between the two variables. Therefore, corals probably employ some aggressive strategy different from that used by sponges. Corals have been observed to attack competitors with mesenterial filaments (De Klamer, FSP 1978). In a large coral hierarchy was based on mesenterial aggression. The few observations from one manipulation support this speculation. Sponges were affixed to *D. labyrinthiformis* at 0930; mesenterial filaments were observed later at 1600. No filaments were seen on the following day. Sponges were then apparently washed away by turbulence. No further observations were possible.

Next, it was hoped that coral growth rates might similarly be tested for correlation with their specific competitive success against sponges. Unfortunately, published growth rates for sponges were not available for sufficient numbers of corals. Jackson and Boss (1975) describe the growth rate of *M. murchisii*: .33 cm/yr and *A. agrionites*: .77 cm/yr. High growth rates for these corals



did not correlate with high success against sponges. A greater record of coral growth rates could allow for data analysis of a greater diversity of competitive pairings.

It is clear that a competitive network exists between reef invertebrates. This study has more completely described the coral-sponge interactions within this greater network. Interaction loops were observed between coral and sponge competitors. Competitive interactions were intransitive.

The network which this study documents may contribute to species diversity on the reef. As Buss and Jackson (1979) have outlined, the intransitivity of a competitive network produce variation in competitive outcomes, and therefore increase species diversity.

Competitive network theory has profound implications for population dynamics within the reef. Sessile invertebrates are the primary producers and shapers of the reef environment. Any interaction which affects the invertebrate community ultimately influences all levels of

Reef species. Accordingly, Further research on the sponge-coral ~~within~~ interactions within this network is essential to our understanding of the reef.

The chief problem with our investigation was its overambitious scope. It is impossible to survey sufficient coral-sponge interactions within the allotted time. Our small sampling size prevented a more comprehensive description of the network system. Further research ought to focus on a smaller range of competitive pairings. Manipulative studies are desirable, though difficult logistically. Sponges are difficult to maintain in a hb situation.

## Literature Cited

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A good pilot study. I hope more on this subject will follow.

Discussion on networks is a bit repetitive. Also, the discussion section is barely readable.

## REFERENCES

- BAK, R.P.M., and ES, Y.S. 1980. REGENERATION OF SUPERFICIAL DAMAGE IN THE SCLERACTINIAN CORALS Agaricia agaricites AND PORITES ASTEORIDES. Bull. Mar. Sci., 30(4): 883-887.
- BAK, R.P.M. et al. 1977. REGENERATION AND ASPECTS OF SPATIAL COMPETITION IN THE SCLERACTINIAN CORALS Agaricia agaricites AND MONTASTREA ANNULARIS. Proc. Third INT. CORAL REEF Symp.
- BUSS, L.W. 1980. COMPETITIVE INTRANSITIVITY AND SIZE-FREQUENCY DISTRIBUTIONS OF INTERACTING POPULATIONS. Proc. Natl. Acad. Sci. USA, 77(9): 5355-5359.
- BUSS, L.W. AND JACKSON, J.B.C. 1979. COMPETITIVE NETWORKS: Nontransitive Competitive Relationships in CRYPTIC CORAL REEF ENVIRONMENTS. Am. Nat., 113(2): 223-234.
- GLADFELTER, E.H. et al. 1978. GROWTH RATES OF FIVE REEF-BUILDING CORALS IN THE NORTHEASTERN CARIBBEAN. Bull. Mar. Sci., 28(4): 728-734.
- HUOSON, J.H. 1981. GROWTH RATES IN MONTASTREA ANNULARIS: A RECORD OF ENVIRONMENTAL CHANGE IN KEY LARGO CORAL REEF MARINE SANCTUARY, FLORIDA. Bull. Mar. Sci., 31(2): 444-459.
- JACKSON, J.B.C. AND BUSS, L. 1975. ALLELOPATHY AND SPATIAL COMPETITION AMONG CORAL REEF INVERTEBRATES. Proc. Natl. Acad. Sci. USA, 72(12): 5160-5163.
- LANG, JUDITH. 1973. INTERSPECIFIC AGGRESSION BY SCLERACTINIAN CORALS. 2. Why the tree Is Not Only to the SWIFT. Bull. Mar. Sci., 23(2): 260-279.