

## NOTE

## Fish predation on the scleractinian coral *Madracis mirabilis* controls its depth distribution in the Florida Keys, USA

A. G. Grottoli-Everett\*, G. M. Wellington

Department of Biology and Biochemistry, University of Houston, Houston, Texas, 77204-5513, USA

**ABSTRACT:** We evaluated the role of fish predation as the mechanism controlling the local distribution of the scleractinian coral *Madracis mirabilis* on Conch Reef in the Florida Keys, USA. At many Caribbean sites, *M. mirabilis* is found at depths ranging from 1 to 63 m. However, at Conch Reef this coral is rarely found shallower than 20 m. *M. mirabilis* fragments transplanted from 26 to 13 m depth suffered significantly higher levels of fish predation than fragments transplanted from 26 to 20 m. These results indicate that fish predation potentially limits the vertical distribution of *M. mirabilis* on Caribbean reefs.

**KEY WORDS:** Fish predation · Coral distribution · *Madracis mirabilis*

Competition for space, habitat type, food availability, environmental conditions and natural disturbances have often been emphasized as important factors controlling coral distribution (Loya 1972, Porter 1972, 1974, 1976, Fishelson 1973, Lang 1973, Glynn 1976, 1988, Sammarco 1980, 1982, Wellington 1982a, Huston 1985, Glynn & Colgan 1988). Increasing evidence from field studies shows that predation by invertebrates (Robertson 1970, Glynn et al. 1972, 1979, Glynn 1976, McClanahan & Shafir 1990, McClanahan et al. 1996) and corallivorous reef fish (Glynn et al. 1972, Kaufman 1977, Brock 1979, Neudecker 1979, Wellington 1982b, Harmelin-Vivien & Bouchon-Navaro 1983, Littler et al. 1989) can play a direct role in shaping coral distribution and community structure (reviewed by Glynn 1990, Hixon 1997). Here, we present evidence that fish predation limits vertical distribution of the pocilloporid coral *Madracis mirabilis* on the Florida, USA reef tract.

*Madracis mirabilis* is commonly found throughout the Caribbean, South Florida and the Bahamas (Hu-

mann 1993). It forms densely packed clumps of small pencil-sized branches with blunt tips, small polyps which are light brown to yellow in appearance. *M. mirabilis* is found nearshore at a depth of 3 m at the Channel Two pass (24° 50' 05" N, 81° 41' 05" W) which links Florida Bay and the Florida reef track between Lower Matacumbe Key and Long Key (pers. obs.). At Conch Reef, Florida (24° 57' 05" N, 80° 28' 00" W), it is rarely found shallower than 20 m. In the course of experimentally assessing the source of carbon in the skeletal matrix of *M. mirabilis*, we observed evidence of heavy fish grazing on colonies transplanted from 26 to 13 m depth.

In this experiment, 8 distinct *Madracis mirabilis* coral colonies were collected at 26 m and each was divided into 8 fragments. Each individual fragment was cemented to an individual plexiglass disk. Four fragments from each coral head were transplanted to 13 m and 4 to 20 m (4 fragments colony<sup>-1</sup> × 2 depths × 8 colonies = 64 total sample size). All fragments were manipulated in an identical fashion at both depths. Coral fragments were collected approximately 6 wk later and treated in 5% sodium hypochlorite solution for 24 h. Because the number of branches per fragment was unequal, predation is reported here as a percentage, as follows:

$$\frac{\text{total number of fish bites}}{\text{(total number of branches/fragment)}} \times 100\%$$

In cases where the total number of bites exceeded the total number of branches (due to more than 1 bite/branch<sup>-1</sup>) the percent predation value exceeded 100.

Overall mean percent predation was found to be significantly greater at 13 m than at 20 m (Table 1). With the exception of colony 2, the mean percent predation was consistently higher in shallow water. In some shallow water fragments, all branch tips were bitten off, yet none of the fragments in deeper water were in such

\*E-mail: bioldr@jetson.uh.edu

Table 1. *Madracis mirabilis*. Mean percent predation per colony at each depth (n = 3 for colony 2 at 13 m and n = 4 for all other colonies at both depths). Mean percent predation was significantly higher at 13 m than at 20 m (Wilcoxon's signed-ranks test  $T_s = 2$ , n = 8,  $p < 0.0117$ )

Colony	Mean percent predation at 13 m	Mean percent predation at 20 m
1	61	0
2	7	28
3	125	21
4	108	26
5	102	29
6	75	17
7	37	32
8	83	10
Mean of means	74.75	20.38
SE	12.90	3.61

condition (Fig. 1). These results indicate that at Conch Reef predation by corallivorous fish plays a critical role in restricting the distribution of *Madracis mirabilis* to depths below 13 m. Although we did not directly observe fish predation on *M. mirabilis* since caged controls were not employed in this experimental design, the cusp-like bite marks revealed that parrotfish and/or pufferfish are likely to be responsible. No other evidence of damage due to handling or predation by other organisms was observed.

Situations where fish predation limits the zonation patterns of corals have also been reported in the branching coral *Pocillopora damicornis* (Neudecker 1979, Wellington 1982b) and massive *Pavona* spp. (Wellington 1982b) in the Pacific, for *Montastraea annularis* and *Acropora cervicornis* in Jamaica (Kaufman 1977) and for *Porites astreoides* and *Porites*

*furcata* in Belize (Littler et al. 1989). The pattern of predation observed in this study was also reported by Neudecker (1979) for *P. damicornis*. Further, Littler et al. (1989) suggested that the degree of fish predation is influenced by proximity to refugia for the corallivores and coral palatability. However, these factors do not appear to be applicable to Conch Reef where topographic complexity and refugia increase with depth (pers. obs.) in opposition to the observed increase in predation across the experimental depth, and where deep water *M. mirabilis* is susceptible to predation when transplanted to shallower depths.

Field studies examining the direct role of corallivorous fishes on coral zonation are limited (Kaufman 1977, Neudecker 1979, Wellington 1982b, Littler et al. 1989, reviewed by Glynn 1990, Hixon 1997). Our observations provide further evidence that fish predation can be an important factor limiting the vertical distribution of reef corals.

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#### LITERATURE CITED

- Brock RE (1979) An experimental study of the effects of grazing by parrotfishes and role of refuges in benthic community structure. *Mar Biol* 51:381–388
- Fishelson L (1973) Ecological and biological phenomena influencing coral-species composition on the reef tables at Eilat (Gulf of Aqaba, Red Sea). *Mar Biol* 19:183–196

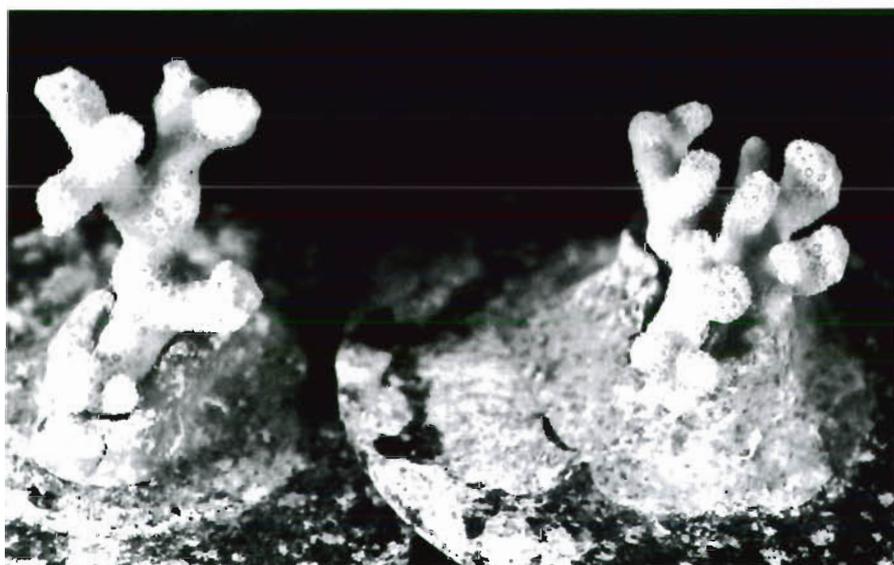


Fig. 1. *Madracis mirabilis* fragments: from 13 m with branch tips bitten off (on left) and from 20 m with intact branch tips (on right)

- Glynn PW (1976) Some physical and biological determinants of coral community structure in the Eastern Pacific. *Ecol Monogr* 46:431–456
- Glynn PW (1988) El Niño-Southern Oscillation 1982–83: nearshore population, community and ecosystem responses. *Annu Rev Ecol Syst* 19:309–345
- Glynn PW (1990) Feeding ecology of selected coral-reef macroconsumers; patterns and effects on coral community structure. In: Dubinsky Z (ed) *Ecosystems of the world 25: Coral reefs*. Elsevier, Amsterdam, p 365–400
- Glynn PW, Colgan MW (1988) Sporadic disturbances in fluctuating coral reef environments: El Niño and coral reef development in the Eastern Pacific. *Am Zool* 32:707–718
- Glynn PW, Stewart RH, McCosker JE (1972) Pacific coral reefs of Panama: structure, distribution and predators. *Geol Rundsch* 61:483–519
- Glynn PW, Wellington GM, Birkeland C (1979) Coral reef growth in the Galapagos: limitation by sea urchins. *Science* 203:47–49
- Harmelin-Vivien ML, Bouchon-Navaro Y (1983) Feeding diets and significance of coral feeding among Chaetodontid fishes in Moorea (French Polynesia). *Coral Reefs* 2: 119–127
- Hixon MA (1997) Effects of reef fishes on corals and algae. In: Birkeland C (ed) *Life and death of coral reefs*. Chapman and Hall, New York, p 231–246
- Humann P (1993) Reef coral identification. New World Publications, Inc, Jacksonville
- Huston MA (1985) Patterns of species diversity on coral reefs. *Annu Rev Ecol Syst* 16:149–177
- Kaufman L (1977) The three spot damselfish: effects on benthic biota of Caribbean coral reefs. *Proc 3rd Int Coral Reef Symp* 1:559–564
- Lang J (1973) Interspecific aggression by scleractinian corals. 2. Why the race is not only to the swift. *Bull Mar Sci* 23: 260–279
- Littler MM, Taylor PR, Littler DS (1989) Complex interactions in the control of coral zonation on a Caribbean reef flat. *Oecologia* 80:331–340
- Loya Y (1972) Community structure and species diversity of hermatypic corals at Eilat, Red Sea. *Mar Biol* 13:100–123
- McClanahan TR, Kamukuru AT, Muthiga NA, Gilgaberher Yebio M, Obura D (1996) Effect of sea urchin reductions on algae, coral and fish populations. *Conserv Biol* 10: 136–154
- McClanahan TR, Shafir SH (1990) Causes and consequences of sea urchin abundance and diversity in Kenyan coral reef lagoons. *Oecologia* 83:362–370
- Neudecker S (1979) Effects of grazing and browsing fishes on the zonation of corals in Guam. *Ecology* 60:666–672
- Porter JW (1972) Patterns of species diversity in Caribbean reef corals. *Ecology* 53:745–748
- Porter JW (1974) Community structure of coral reefs on opposite sides of the Isthmus of Panama. *Science* 186:543–545
- Porter JW (1976) Autotrophy, heterotrophy, and resource partitioning in Caribbean reef-building corals. *Am Nat* 110: 731–742
- Robertson R (1970) Review of the predators and parasites of stony corals, with special reference to symbiotic prosobranch gastropods. *Pac Sci* 24:43–54
- Sammarco PW (1980) *Diadema* and its relationship to coral spat mortality: grazing, competition, and biological disturbance. *J Exp Mar Biol Ecol* 45:245–272
- Sammarco PW (1982) Echinoid grazing as a structuring force in coral communities: whole reef manipulations. *J Exp Mar Biol Ecol* 61:31–55
- Wellington GM (1982a) An experimental analysis of the effects of light and zooplankton on coral zonation. *Oecologia* 52:311–320
- Wellington GM (1982b) Depth zonation of corals in the Gulf of Panama: control and facilitation by resident reef fishes. *Ecol Monogr* 52:223–241

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