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Moorish idol, *Zanclus cornutus*, distribution among coral reef habitats in the Republic of Maldives

Robert D. Sluka

5116 Bissonnet #358, Bellaire, TX 77401 USA

bsluka@mrds.org

http://www.mrds.org/Regions/southasia/india/INDIA.HTM

Abstract

Moorish idol (Pisces: Zanclidae *Zanclus cornutus*) density was quantified among four coral reef habitats in the Maldives: outer atoll rim reef slopes, inner atoll rim reef slopes, faro reef slopes, and faro reef flats. Density was quantified using visual transects at several sites (n=3-6) within each habitat. Moorish idol were significantly more abundant in outer atoll rim reef slopes than other habitats. There were also density differences, though barely non-significant (p=0.056), among sites within habitats. Density had no discernable relationship with water depth (range = 1-23 m). Observed density patterns among habitats follow the general model of many coral reef fish species studied to date. Habitat was an important influence on Moorish idol distribution. However, density patterns were relative and not absolute. This means that relative differences in a species' abundance can be predicted with prior knowledge of available habitats, but the absolute density will vary among sites.

Introduction

Coral reef fish assemblage structure has been shown to vary among habitats (Williams 1982; Russ 1984a,b). Patterns among habitats appear to be species-specific. Several studies have also shown that the strength of the relationship between fish abundance and their habitat is scale dependent (Russ 1984b; Meeken et al. 1995; Syms 1995; Sluka et al. 2001). These studies show that while there is significant inter-site variability within a particular habitat, these differences are much less than among habitats themselves. At micro-scales, many fish species use very specific habitats (e.g. anenome fish). Thus, while factors such as recruitment variability, predation, and disturbance are important in influencing fish abundance and diversity, habitat remains an important consideration in examining the distribution of many coral reef fish.

The Moorish idol (*Zanclus cornutus*) is a common coral reef fish distributed throughout the Indo-Pacific and eastern Pacific. It is the only species in the family Zanclidae. This species is omnivorous, but feeds more on animal material, especially sponges, than algae (Randall 1992). Moorish idol inhabit turbid inner lagoons, reef flats, and clear seaward rocky and coral reefs (Myers 1999). There appears to be little information on the role habitat plays in influencing this species' abundance (Williams 1982; Galzin 1987; Chabanet et al. 1995). The purpose of this study was to test the influence of habitat on Moorish idol distribution in an area where this species had not been studied previously, the Republic of Maldives, and examine whether or not this data supports current theories regarding coral reef fish-habitat relationships.

Materials and Methods

Laamu Atoll lies in the southern third of the north/south atoll chain comprising the Republic of Maldives (Figure 1). The atoll rim has fringing reefs on the inner, lagoon side and the outer, oceanic side. Fringing reefs on both sides have similar zonation with a shallow sandy lagoon, reef flat, reef crest, and reef slope. The reef outside the atoll rim drops precipitously to 30-50 m, slopes gently for about one half km, and then drops off to abyssal depths (Anderson et al. 1992). The reef inside the atoll rim slopes gently to approximately 20 m depth and grades into a sandy bottom. In the central portion of the lagoon, pillar reefs called faros reach from the sandy lagoon floor to within a few meters of the surface. Faros have similar zonation with reef flats, reef crest, and reef slope habitats.

During May -June 1997, nineteen sites were surveyed for Moorish idol density among four habitat types: faro reef flats (n=3), faro reef slopes (n=5), and reef slopes both inside (n=6) and outside (n=5) the atoll rim (Figure 1). At each site, eight 100 m^2 transects (20 m x 5 m, width by visual estimation) were completed. Transect depths ranged from 1-23 m. Observers were trained to estimate transect width by placing construction flags at a distance estimated to be 2.5 m from each side of the length of a transect line. The actual distance was then measured and biases made known to observers. This process was repeated until observers could accurately estimate transect width.

A nested ANOVA was used to assess differences in mean species density among habitats and among sites nested within each habitat. Tukey tests were used to make pairwise comparisons for significant factors. Data were log (x+1) transformed due to heterogeneous variances. Density

was also analyzed with relation to transect depth by inspection as well as using a Pearson correlation coefficient.

Results

Moorish idol were significantly more abundant on reef slopes outside the atoll rim than in other habitats ($F_{3,133}$=6.475, p<0.001). Tukey tests revealed that there were no significant differences in Moorish idol abundance among faro reef flats, faro reef slopes and reef slopes inside the atoll rim (Figure 2). Density was marginally non-significantly different between outside and inside atoll rim slopes (p=0.057). There was also a marginally non-significant density difference among sites nested within habitats ($F_{15,133}$=1.711, p=0.056) (Figure 3).

There was no significant relationship between depth and Moorish idol density among habitats (r=0.08, p>0.05) nor within each of the habitats. Density was not correlated to depth within faro reef flat (r=0.04, p>0.05), faro reef slope (r=0.06, p>0.05), and outside atoll rim reef slope (r=0.05, p>0.05) sites. Density was negatively, but non-significantly, correlated with depth within the inside atoll rim reef slope habitat (r=-0.28, p=0.064).

Discussion

The distribution of Moorish idol among habitats on a coral reef atoll in the Indian Ocean has been described for the first time. Habitat was confirmed as a significant factor influencing the abundance of this coral reef fish. Moorish idol abundance appears to conform to broad

generalizations concerning the role of habitat on coral reef fish distribution world-wide. The abundance of this species differed significantly among habitats as well as among sites within a habitat. Moorish idol were more abundant in one habitat than the others, but these differences were relative and not absolute. This means that relative differences in a species' abundance can be predicted with prior knowledge of available habitats, but the absolute density will vary among sites.

Information collected on the distribution of coral reef fish within and among habitats world-wide suggests that the magnitude of impact habitat has on fish abundance varies by spatial scale (Russ 1984a,b; Meeken et al. 1995; Syms 1995; Eagle 2001; Gust 2001). There are obvious biogeographic differences in fish community structure that occur at a scale of 1000s of kilometers. Within a biogeographic province, numerous studies have shown that coral reef fish communities differ among habitat types or zones (Russ et al. 1984b; Green 1996; Sluka et al. 2001). These differences remain among reefs separated by several to 10s of kilometers. However, the differences appear to be relative, and not absolute. This study and others show that certain coral reef fish species were consistently more abundant on certain types of coral reefs than others, but the exact density could not be predicted from prior knowledge of habitat type (Williams 1982; Russ 1984b; Sluka et al. 2001). This result is reflected by significant differences in fish density among habitats as well as significant differences among sites within a habitat type.

The difference in abundance among sites within a habitat can be related to differences in one or many habitat features among the sites, as exemplified by the numerous studies showing correlations between habitat features such as coral coverage and a particular species' density (Luckhurst and Luckhurst 1978; Bell & Galzin 1984; Roberts and Ormond 1987; Sluka et al. 1996; Friedlander and Parrish 1998). Yet these correlations do not explain the distribution of all species among sites and may vary by biogeographic province. Data to examine these among-

sites habitat features were not collected in this study. It is likely that these inter-site differences in abundance that are not explained by differences in habitat features are due to factors such as recruitment variability and competition/predation pressures. There could also be local-scale disturbances, such as cyclones or fishing pressure on predators which causes second order abundance effects (Bohnsack 1982; Sluka et al. 2001).

The question then remains as to what has caused the differences in Moorish idol abundance among habitats and sites in Laamu Atoll, Republic of Maldives. Depth did not appear to be an important factor in explaining distribution within or among habitats. The Moorish idol can be found from depths of 1-180 m (Debelius 1999). Large-scale environmental differences and fish biology may provide some of the answers to this question. Williams (1982) showed that exposure to wave energy was significantly influencing the distribution of coral reef fish among his study sites in the Great Barrier Reef. The Moorish idol is omnivorous, but prefers sponges to plant material (Randall 1992). It may be that the more exposed nature of outer atoll reef rim slopes in this study allows for a greater abundance of sponges due to wave energy bringing in food for the sponges. During the southwest monsoon (June-October), sites on the eastern half of the atoll receive heavy winds and rain which increase turbidity greatly. Even during the northeast monsoon (November -May), the study sites on the outside of the atoll rim were not turbid, despite the lack of shelter from winds and waves. Unfortunately, it was not possible to examine the abundance of preferred food items among these habitat types. Clearly, this would be a logical next step towards better understanding the distribution of this species among habitat types.

Conclusion

Moorish idol populations in Laamu Atoll, Republic of Maldives exhibit an inter-habitat distribution which corresponds to known ecological patterns among coral reef fish. Management of coral reef fisheries that capture this species should take into account its habitat preferences. These records also serve as a baseline of an unfished population in an relatively undisturbed habitat.

Acknowledgement

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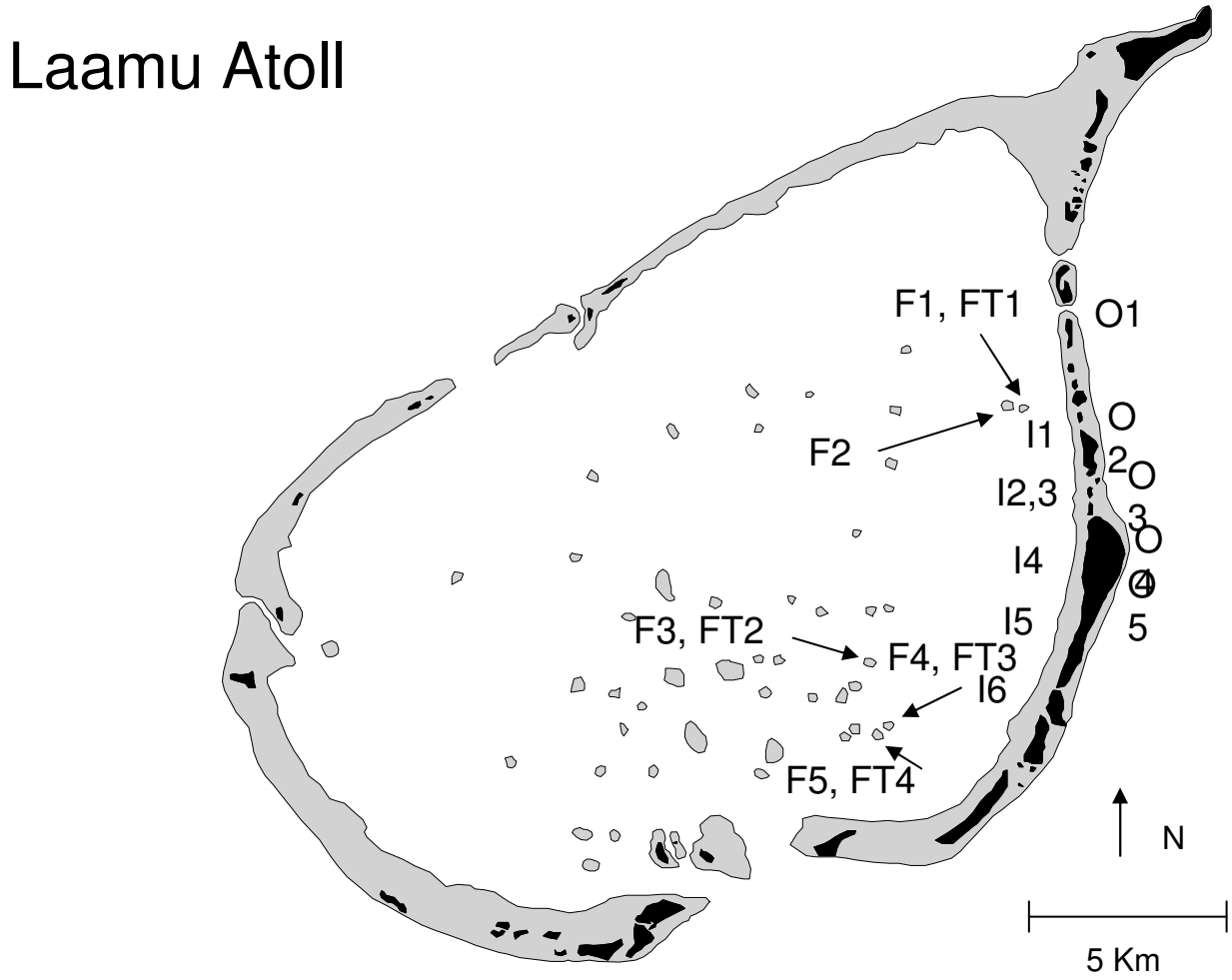

Figure 1. Map of Laamu Atoll, Republic of Maldives. Site codes indicate habitat type: F = faro reef slope, FT = faro reef flat, I = inside atoll rim reef slope, and O = outside atoll rim reef slope. For definitions of habitat types see text.

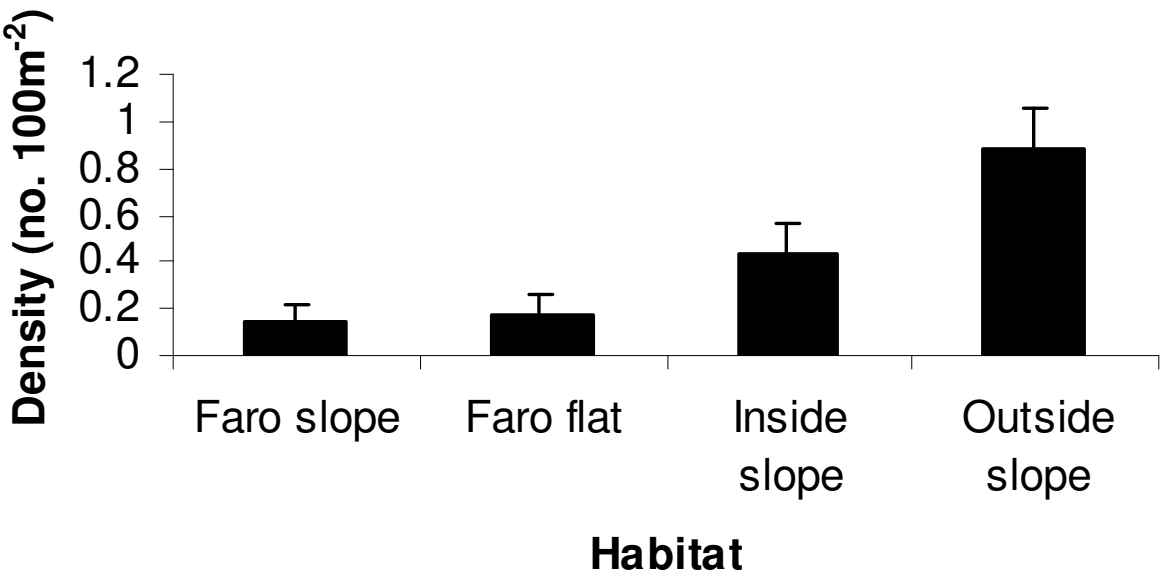

Figure 2. Moorish idol (*Zanclus cornutus*) density (no. 100 m^{-2}) by habitat type. Differences in density among habitats are significant ($p<0.001$).

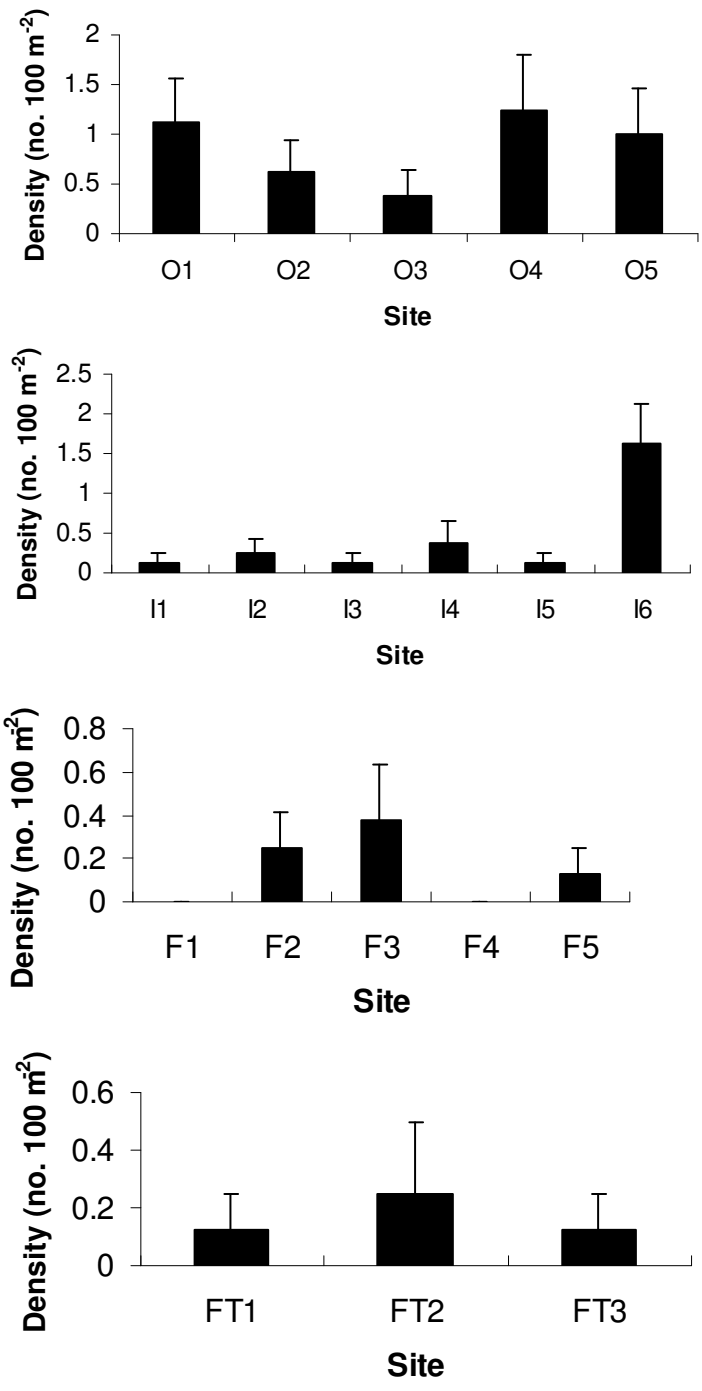

Figure 3. Moorish idol (*Zanclus cornutus*) density (no. 100 m^{-2}) among sites within a habitat type. Site codes follow map in Figure 1 and indicate habitat type: F = faro reef slope, FT = faro reef flat, I = inside atoll rim reef slope, and O = outside atoll rim reef slope. For definitions of habitat types see text.