FEEDING BENEFITS FOR SPOTTED GOATFISH IN MIXED SPECIES SCHOOLS WITH PARROTFISH

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Abstract: Heterogeneous schools of juvenile fish utilize turtle grass habitat at Discovery Bay, Jamaica, and commonly include parrotfish as the core fish and spotted goatfish, among other associated fish. We hypothesized that spotted goatfish feeding would be facilitated by parrotfish feeding, but that parrotfish feeding would be unaffected by the presence of spotted goatfish. We surveyed co-occurrence of these two species in 55 schools to test the prediction that goatfish would show a strong tendency to co-occur with parrotfish, but not vice versa. We also observed feeding in 18 schools with both parrotfish and goatfish to test the prediction that goatfish would feed under the parrotfish where flushing activity would increase prey availability. Data supported our hypotheses and suggested that co-feeding of these species is mutually beneficial.

Key words: bluehead wrasse, sea grass bed, spatial partitioning

INTRODUCTION

Turtle grass (*Thalassia testudinum*) beds near reefs are important habitats for the juveniles of many coral reef fish species, including parrotfish (*Scarus croicensis* and *Scarus taeniopterus*) and the spotted goatfish (*Pseudupeneus maculatus*) (Nagelkerken 2002). In the turtle grass beds inshore of the reef crest at Discovery Bay, Jamaica, juvenile parrotfish are abundant and exhibit schooling behavior, which is thought to reduce predation risk and facilitate feeding in damselfish territories. Small numbers of juveniles of several fish species, including spotted goatfish, doctor fish and slippery dicks often associate with these schools (Pouliot et al. 1995). Juvenile spotted goatfish, which use two anterior-ventral barbels to search the sediment for invertebrates, are almost always associated with the parrotfish-dominated schools (Gunderson 1992). For the goatfish, this association may facilitate feeding, reduce predation risk (Pouliot et al. 1995), or both.

We examined the nature of the relationship between juvenile spotted goatfish and juvenile parrotfish. Preliminary observations showed that spotted goatfish only occurred in parrotfish-dominated schools, while parrotfish-dominated schools did not always contain spotted goatfish. Therefore, we hypothesized that goatfish benefit from foraging with a parrotfish school, while parrotfish foraging is unaffected by goatfish. We predicted (1) that goatfish would always co-occur with parrotfish, but parrotfish would occur both with and without goatfish, and (2) that goatfish and parrotfish would spatially partition when feeding, such that parrotfish would feed on the epiphytic tips of turtle grass, while goatfish would forage below and near the sediment. In this arrangement, goatfish would not likely effect parrotfish feeding, but parrotfish biting and movements could facilitate goatfish foraging by dislodging invertebrates from the bases and blades of grass. To test these predictions, we observed schools of juvenile fish in turtle grass beds at Discovery Bay, Jamaica.

METHODS

On the afternoons of 25 and 26 February 2004, we snorkeled imprecise transects in the turtle grass beds of the backreef at Discovery Bay without sampling the same area twice. For every school seen containing juvenile parrotfish, juvenile spotted goatfish, or both, we recorded the number and composition of species. We analyzed the relative abundances of species and

ran a chi-square model to examine the tendency of co-occurrence of goatfish and parrotfish.

We followed some schools until we observed a feeding event, noting where the parrotfish and spotted goatfish were feeding. Relative feeding positions were categorized as either "bottom of turtle grass and sediment" or "top of turtle grass." We ran a chi-square model to examine the tendency of the two species to maintain separate relative feeding positions.

RESULTS

We sampled 55 schools with a mean size of 24 fish (SD = ± 15) per school. Mean proportions of species, based on all 55 schools, showed parrotfish (princess and striped, which are difficult to distinguish in the field) to be the core species. Spotted goatfish, doctor fish, bluehead wrasse, stoplight parrotfish, slippery dick and french grunt were present in decreasing order (Table 1). The ratio of parrotfish to spotted goatfish was approximately 9 : 1.

Parrotfish occurred without spotted goatfish in 18 schools, and both species occurred together in 37 schools. Frequencies of co-occurence were significantly greater than those expected by chance for the goatfish ($P < 0.0001$) but not for the parrotfish ($P = 0.08$; Table 2). In one case, one stoplight parrotfish and one spotted goatfish were seen foraging together.

Feeding events were observed for 18 schools; in 17 of these events, parrotfish fed on the top region of grass blades while spotted goatfish fed below among grass stalks or off the sediment (Fig. 1, Table 3). In one exception to this pattern, the school was swamping a damselfish territory, and spotted goatfish and parrotfish fed in the same regions.

Table 1. Composition of mixed schools (± SE) seen in the west back reef.

Species	Percent composition
Parrotfish	87.0 ± 2.0
Spotted goatfish	8.9 ± 1.7
Doctor fish	2.5 ± 0.7
Bluehead wrasse	2.5 ± 0.7
Stoplight parrotfish	0.3 ± 0.2
Slippery dick	0.3 ± 0.2
French grunt	0.3 ± 0.3

Table 2. Frequency at which spotted goatfish and parrotfish occurred alone and with the other species.

	Alone	Together
Spotted goatfish	2	36
Parrotfish	18	36

Table 3. Frequency at which spotted goatfish and parrotfish fed at the top and bottom regions of *Thalassia testudinum* beds.

	Feeding position			
	Top	Bottom	Both	χ^2 test
Spotted goatfish	0	16	2	
Parrotfish	17	0	1	$P < 0.0001$

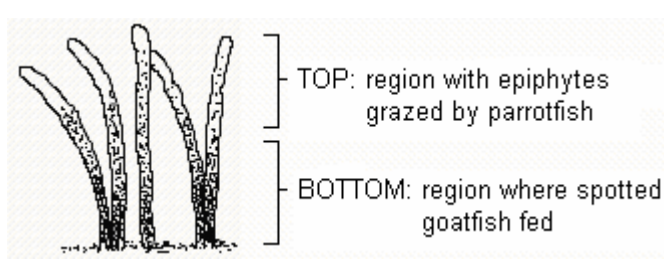

Fig 1. Feeding positions of parrotfish and spotted goatfish in *Thalassia testudinum* beds.

Discussion

Our school composition surveys showed that parrotfish often occurred without spotted goatfish, but spotted goatfish rarely occurred without parrotfish. As hypothesized, this pattern may exist because spotted goatfish benefit from co-occurring with parrotfish. However, it does not indicate whether or not parrotfish benefit from spotted goatfish. Though our data suggest that spotted goatfish have a higher tendency to occur with parrotfish than vice versa, the pattern could only be due to the different abundances of the two groups in the turtle grass habitat. If there are few spotted goatfish relative to parrotfish, and if mixed-species schools form with no particular order, it is likely that some schools would lack the relatively rare spotted goatfish, while few schools would lack the ubiquitous parrotfish.

Feeding was spatially partitioned between the two species in such a way that parrotfish could facilitate feeding for spotted goatfish, but spotted goatfish would have no affect on parrotfish feeding. Parrotfish almost always bit the upper region of grass blades with a heavy epiphyte load, a process which could flush invertebrates from the grass blades or from sediment at the base of disturbed grass stalks. Goatfish, meanwhile, fed among the grass stalks or in the sediment immediately below parrotfish, suggesting that parrotfish may in fact increase prey availability for spotted goatfish.

The relationship between these two fish may be mutualistic. By co-occurring with goatfish, parrotfish may benefit from an augmented school size and its effect on swamping damselfish territories, or deterring predators. Gunderson (1992) suggested that juvenile spotted goatfish benefit from heterospecific schooling, likely by reduced predation risk. Spotted goatfish, however, appear to also benefit from increased prey availability, which contradicts the findings of Pouliot et al. (1995), who suggested that spotted goatfish mostly feed when away from the school. Most of the schools they observed, however, were dominated by bluehead wrasse, not parrotfish. It is possible that spotted goatfish behave differently with wrasse than with parrotfish.

This study highlights the complexity of school dynamics and the range of benefits that may cause fish to form mixed-species schools. In this case, it appears that the relationship may be mutualistic, in which spotted goatfish benefit from increased feeding efficiency, and parrotfish benefit from increased school size. Further studies should investigate the change in feeding efficiency of juvenile spotted goatfish when foraging with and without parrotfish, as well as the roles of other species that occur in these schools less commonly.

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