# TERRITORIALITY OF THE YELLOWLINE GOBY (*GOBIOSOMA HORSTI*) IN YELLOW TUBE SPONGES (*APLYSINA FISTULARIS*)

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*Abstract.* Several species in the goby family (Gobiidae) are known to inhabit sponges, yet little is known about the nature and extent of these interactions. It is believed that the sponge provides protection and food for its resident goby. There is an apparent species specific association between yellowline gobies, *Gobiosoma horsti*, and yellow tube sponges, *Aplysina fistularis*, on the forereef at Discovery Bay, Jamaica. We predicted and found that the yellow tube sponge is an important resource for the goby, causing the goby to be territorial in defense of its sponge. More specifically, we supported our four hypotheses that 1) there is no more than one goby per sponge; 2) goby size is positively correlated with sponge size; 3) a goby's residence in a sponge is relatively permanent; and 4) when two gobies are placed in the same sponge the larger goby will win occupancy regardless of which goby was the original sponge resident. The species specific relationship between yellowline gobies and yellow tube sponges may be indicative of niche partitioning among gobies, allowing Gobiidae to be a species rich family.

## INTRODUCTION

The goby family (Gobiidae) is the largest fish family in tropical waters (Stokes 1980). These fish are commonly found on coral reefs, on or in sponges, or cleaning other fish (Thresher 1980). The nature and extent of goby-sponge interactions, however, are not well documented. Tyler and Böhlke (1972) state that the sponge probably protects its inhabitants and provides food. In addition to the physical protection a sponge provides, Gobies are apparently distasteful to predators because they pick up noxious toxins present in the sponge walls (Thresher 1980). Thresher also believes that the most important food source for sponge-dwelling gobies is a polychaete worm (*Syllis spongicola*) that parasitizes sponges.

We noticed that the yellowline goby (white phase), *Gobiosoma horsti*, was the only goby species found in the yellow tube sponge, *Aplysina fistularis*. However, no information was available about this apparent species specific goby-sponge relationship. We predicted that the yellow tube sponge is an important resource to the yellowline goby, causing the goby to be territorial in defense of its sponge. In order to test this prediction, we developed four hypotheses: (1) no more than one goby will inhabit a sponge; (2) since large sponges potentially offer better protection and/or a greater food source, they should be inhabited by large gobies, which are presumably competitively dominant, whereas small sponges will be inhabited by small gobies; (3) a goby's residence in a particular sponge is relatively permanent; and (4) a goby will try to defend its sponge against an invading conspecific, with the larger goby winning occupancy of the sponge, regardless of which goby was the original resident.

## METHODS

We examined yellow tube sponges at Discovery Bay, Jamaica. All data were collected on the forereef at the LTS mooring at a depth of 35-55'. We identified all the gobies inhabiting the yellow tube sponge as the white phase of the yellowline goby.

The first half of our study was a survey of the sponge and goby populations, where we randomly chose and labeled 45 sponges across four buttresses near LTS. For each sponge, we recorded the depth, diameter of the osculum opening, length of the atrium, and if it occurred in a clump (three or more yellow tube sponges together). In addition, we recorded the presence or absence of brittlestars, gobies, and the length of the goby. Goby length was measured from the tip of the snout to the tip of the caudal fin. Within 48 hours of the initial survey, we resurveyed the sponges, recorded the presence or absence of gobies and brittlestars and measured the length of each goby occupant.

The second part of our study consisted of a transplant experiment. We introduced a goby removed from the atrium of one sponge into a sponge inhabited by another goby. We used Quinaldine to anesthetize and capture each goby and waited until the goby regained normal activity level (determined by swimming vigor in the collection bag) before introducing it into another sponge. The introduced goby was larger than the resident goby for five replicates, smaller than the resident goby for another five replicates, and the same size for one replicate, for a total of eleven transplant experiments. Different gobies were used for each experiment and there was always at least a one cm difference in length between the small and large gobies. After introducing a goby, we recorded interactions between the two gobies and which goby was forced out of the sponge. Lastly, we observed if sponges that had gobies removed were inhabited by gobies the following day.

## RESULTS

### *Quantitative*

All sponges surveyed never contained more than one goby. Larger gobies were found in sponges with a higher atrium volume. This was a significant correlation ($F=37.5898$, $df=1,25$, $P<0.0001$, $R^2=0.601$, Fig. 1). Taller sponges were significantly more likely to be inhabited than shorter sponges ($t=-2.2971$, $df=43$, $p=0.0265$, Fig. 2). Neither atrium volume or osculum diameter were significantly associated with presence or absence of a goby. A sponge in a clump of sponges was also no more likely to contain a goby than a single sponge ($G=2.2894$, $df=1$, $p=0.1303$). We found no significant association between sponge height, osculum diameter, atrium volume, or goby length and depth.

There was no significant difference between the size of a goby inhabiting a given sponge on one day versus 48 hours later ($t=-0.1581$, $df=38$, $p=0.8752$).

Larger gobies displaced smaller gobies when the two were placed in the same sponge, regardless of which individual was the initial resident ($G=8.4562$, $df=1$, $p=0.0036$).

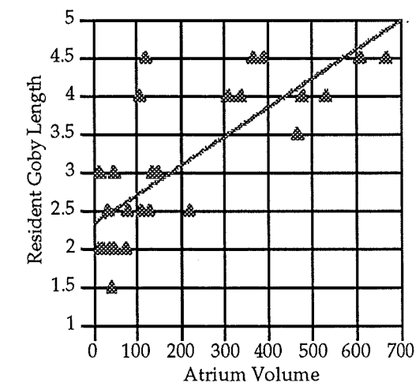


FIG. 1. Length of goby resident versus volume of the inhabited sponge atrium (n=27).

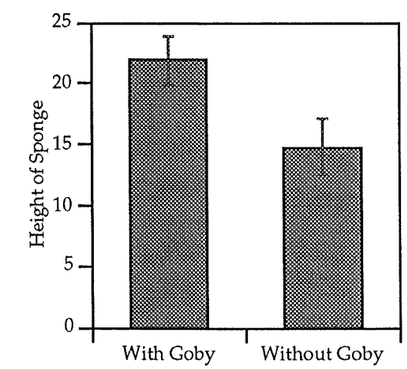


FIG. 2. Mean height of inhabited and uninhabited sponges (inhabited, n=27; uninhabited, n=18)

*Observations*

We never found another species of fish in the *A. fistularis* sponges that we examined. On the sides of inhabited sponges we observed very small (<1.5 mm) "peripheral" individuals. These were smaller than any that we observed living inside any sponge. When we removed gobies from a particular sponge, this empty sponge appeared to be recolonized within a day. Whether this was a recolonization by a peripheral or another goby in the area was not determined. Brittlestars were found in sponges both with and without gobies and did not remain there over time.

During our transplantation experiments, the small "invading" gobies were easily dominated by larger gobies, with one particular invader actually eaten by the larger resident. When larger invading gobies were introduced into smaller goby residences, immediate displacement did not always occur. However, the large invader would always swim to the bottom of the sponge, forcing the smaller goby to the sponge lip. The one transplant in which we introduced an invader of the same size as the resident still had not been resolved 24 hours later.

## DISCUSSION

Our results support our supposition that *Gobiosoma horsti* is territorial. Since there is a positive correlation between goby size and atrium volume, the larger sponge appears to be a more valuable resource and therefore is more likely to be defended by a larger (and potentially more dominant) goby. Height is the only significant factor affecting whether a sponge is inhabited. It is possible that a tall sponge is needed for predator protection, whereas a sponge with greater volume is a better food resource (given that these gobies feed on the sponge's ectoparasites). Further work could examine relative importance of sponge characteristics such as atrial volume and height and therefore elucidate key factors involved in goby sponge preference.

A *G. horsti* individual also appears to be a more or less permanent resident of a given *A. fistularis*. Our assessment of this is limited, because without marking each fish it is difficult to know if a fish of the same size is actually the same individual. Furthermore, the fact that goby size is correlated with sponge size makes it likely that a new resident would be of a similar size to the previous resident. However, given the strong territorial behavior of these fish, it seems that these sponges are a valuable resource worth defending and that each sponge would therefore have a permanent resident. Brittlestars, on the other hand, are not specific to a given sponge. Because they occur in sponges with and without gobies and we have observed no territorial interactions, we believe that brittlestars and yellowline gobies are not in direct competition.

Our transplantation experiment shows that a resident goby has no inherent advantage over an invading goby. The only important factor is size, where larger gobies are competitively dominant. This seems to support the idea that larger sponges are better resources as it is in these sponges that the larger gobies are found.

Three observations lead us to believe that sponges are a limited and limiting resource. Because gobies are not found in clumps and inhabit isolated sponges, they appear to search for preferred sponges throughout the reef. In addition, sponges are recolonized quickly after goby removal, suggesting that there is a demand for preferred sponges. If gobies were recruitment limited, this immediate recolonization of sponges would not occur. Many small gobies live on the sides of inhabited sponges, indicating they derive a benefit from living on preferred sponges, perhaps reduced predation derived from sponge toxins. However, many sponges are empty, raising the question of why some sponges are preferred over others. Is the food source or protection or another factor of a sponge most important in determining if a goby will inhabit it? If sponges are indeed a limiting resource, this may have been a factor leading to the development of territorial behavior in *G. horsti*.





More study remains to be done on goby-sponge interactions. We had no way of determining the sex of any individual goby, and yet their territoriality in yellow tube sponges may also have stemmed from possible sexual interactions. In addition, it is believed that gobies feed on the ectoparasites in sponges, thereby improving sponge condition. If that is the case, this may be a mutualistic relationship. Further work could identify other benefits an inhabiting goby may confer on a sponge as well as how sponge conditions (such as algal cover, pumping rate, growth rate) vary with goby presence or absence.

We never saw another species of Gobiidae or indeed any other fish species in the yellow tube sponge. The possibility that yellowline gobies are species specific could be tested by transplanting them into other sponge species. If the yellowline gobies are species specific to yellow tube sponges, this niche partitioning may contribute to the fact that the Gobiidae family is one of the most species rich families of fish extant.

## LITERATURE CITED

Stokes, F. Joseph. 1980. Hand guide to the Coral Reef Fishes of the Caribbean. Lippincott & Crowell, New York, USA.

Thresher, Ronald E. 1980. Reef Fish. The Palmetto Publishing Co., St. Petersburg, Florida, USA.

Tyler, James C. and James E. Böhlke. 1972. Records of Sponge-Dwelling Fishes, Primarily of the Caribbean. Bulletin of Marine Science 22i.