SCHOOLING BEHAVIOR OF *HAEMULON SPP.* IN BERMUDA REEFS AND SEAGRASS BEDS

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Abstract Schooling behavior is common among many different species of fish. Schools usually lack a clear leader and are thought to be a predator defense. Schooling behavior of three grunt species, *Haemulon flavolineatum, Haemulon sciurus,* and *Haemulon. Carbonarium,* were observed in a reef and seagrass bed at Tobacco Bay and Shelly Beach in St. Georges, Bermuda using underwater visual transects. A school was defined as a group of three or more individuals swimming together. There was a greater number *Haemulon spp.* sightings as well as species diversity in the reef at Tobacco Bay than the seagrass beds at Shelly Beach. However, there were more school sightings at Shelly Beach than Tobacco Bay. This is possibly due to the life cycle stage of the individuals, the time of day, or the type of habitat substrate.

Key Words: *habitat,* Haemulon spp., *juvenile stage, schooling behavior*

Introduction

Many families of fish exhibit schooling behavioral patterns throughout their lives. Schooling could be a co-evolved predator defense mechanism (Ogden and Ehrlich 1977). By swimming together, individuals are more protected from predators. *Haemulon* is a genus that exhibits these schooling traits. *Haemulon spp.* spend their juvenile stage in seagrass beds, and adult stage in coral reefs (Ogden and Erlich 1977). Juveniles display diurnal behavioral patterns, resting on reefs by day and travelling to seagrass beds at nightfall to feed (Ogden and Ehrlich 1977).

The purpose of this study was to observe the schooling behavior of three *Haemulon spp.* on a coral reef and in a seagrass habitat to determine if one species exhibits schooling behavior more than others, and which habitat is more conducive to schooling.

Materials and Methods

Study Organisms

Three species of *Haemulon* were studied: French Grunts (*Haemulon flavolineatum),* Blue Stripped Grunts (*Haemulon sciurus),* and Caesar Grunts (*Haemulon carbonarium)*. These fish are found in warm, tropical waters and exhibit schooling behaviors associated with patch or fringe reefs (Ogden and Ehrlich 1977; McFarland and Hillis 1982). Characteristics of *Haemulon spp.* schools are the display of social attraction to one another, polarization, retreating for refuge, and organization according to size (McFarland and Hillis 1982). During the day, inactive fish in the reefs swim actively when threatened or jostled by currents (McFarland and Hillis 1982). Polarization refers to the diurnal migration between seagrass and coral reefs.

Study Site

The study was done at two sites in St. Georges, Bermuda. The first site was Tobacco Bay (32.38°N -64.67°E), a rocky reef inhabited with sand and hard corals. This site was a protected inlet on the eastern shore of the island, susceptible to strong currents The second site was Shelly Bay (32.33°N -64.74°W), a seagrass bed habitat in a calm inlet on the north shore of the island, protected from heavy wave action.

Observational Methods

Data collection took place in October 2012. Visual transects were used to observe fish schooling behaviors and patterns. Data from eight 30 x 3 meter transects were collected at each site. Once the transect was laid, five minutes passed before collecting data to allow individuals to settle back into their normal behavior and habitat after the disturbance. The species was identified (Table 1) and number of fish was recorded for each grunt sighting along the transect. An aggregation including more than one species was considered one sighting. The total number of individuals in the entire group was recorded as well as the number of individuals for each species represented in the aggregation. Contingency testes were performed on the data using JMP software version 6.0 to determine significant differences in schooling behavior.

Table 1 Distinguishing characteristics used to identify *Haemulon spp.* (Humann and DeLoach 1995)

Species	Distinguishing Characteristics
H. sciurus	Blue stripes on yellow background, black caudal and dorsal fins
H. flavolineatum	Yellow stripes on a bluish background
H. carbonarium	Yellow stripes over white/silver background, pale stripe on black caudal fin

Results and Discussion

Differences in schooling behavior of three different *Haemulon spp.* were observed in different habitats. There were 68 *Haemulon spp.* sightings along the reefs of Tobacco Bay, and 32 sightings in the seagrass beds at Shelly Bay. Seagrass beds are nursery and feeding grounds for juvenile *Haemulon spp.* (Verweij et al. 2006). Juveniles settle into sand and seagrass habitats and begin to migrate to reefs within the first month of their lives (Shulman and Ogden 1987). During the day, grunts rest over coral colonies and migrate at night to feed in solitude in seagrass beds (Ogden and Ehrlich 1977; McFarland and Hillis 1982; Meyer and Shultz 1985; Verweij et al. 2006). Data collection took place during the afternoon, when *Haemulon spp.* may have migrated out of the seagrass beds and into the reefs, explaining the high number of sightings at Tobacco Bay compared to Shelly Bay.

Tobacco Bay had a greater diversity of *Haemulon spp.* than Shelly Bay (Fig. 1). Previous studies found accelerated growth of coral colonies in the presence of schools of grunts (Meyer and Schultz 1985). Excretory and fecal products of grunt individuals are rich in nutrients such as NH_4^+, which facilitates coral calcification (Meyer and Schultz 1985). Growth of the coral habitat in Tobacco Bay may be facilitated by the diversity and abundance of *Haemulon spp.* In return, coral growth benefits schools by providing resting habitats during the day. *H. flavolineatum* associate more with sandy substrate than with sea grass beds (Ogden and Zieman 1977; McFarland and Hillis 1982). As expected, more *H. flavolineatum* were found among the corals and sandy areas of Tobacco Bay than the grass and sand substrates in Shelly Bay. However, more *H. sciurus* were found in the seagrass bed of Shelly Bay than among the corals of Tobacco Bay. Due to the time of day and foraging patterns, *H. sciurus* should have been more abundant at Tobacco Bay. This result might also be due to chance, or to misidentification of species.

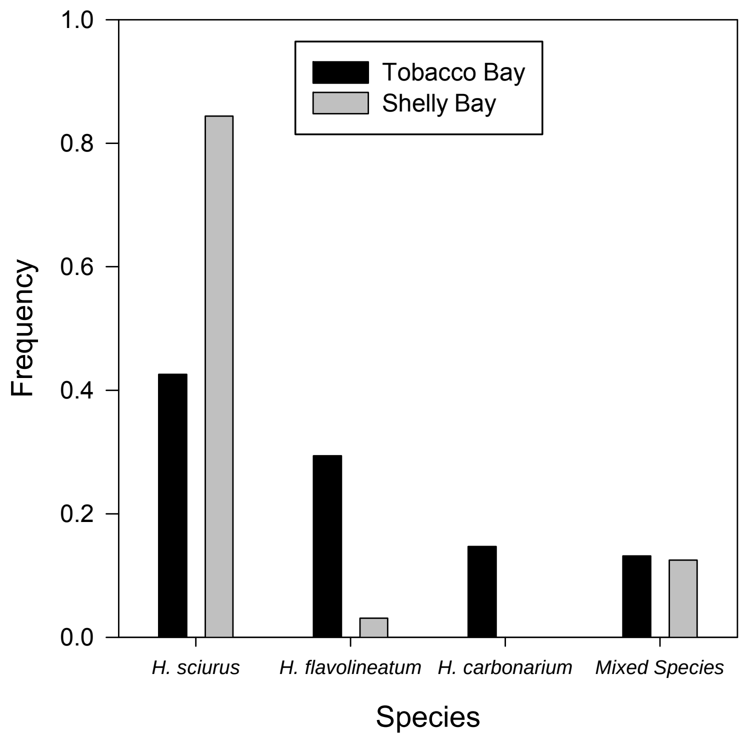

Figure 1 Frequency of *H. sciurus, H. flavolineatum, H. carbonarium,* and mixed species school sightings at Tobacco Bay and Shelly Bay.

A school was defined as a group of three or more individuals. Only 29% of sightings at Tobacco Bay were schools, while 66% of sightings at Shelly Beach were schools (Fig. 2). These are significant differences in schooling behavior and non-schooling behavior between the two bays ($X^2 = 26.249_1$, $p<0.001$). Schooling has possibly evolved in response to the need to maintain school sizes in communities (Ogden and Ehrlich 1977). Fish can gain protection by schooling on a reef if one species is represented by a specific class size (Ogden and Ehrlich 1977). The aggregations at Shelly Bay may have had a greater propensity to school for protection because of their juvenile stage and smaller size. Grunts at Tobacco Bay may have had less necessity to school if they were adults (Fig. 2).

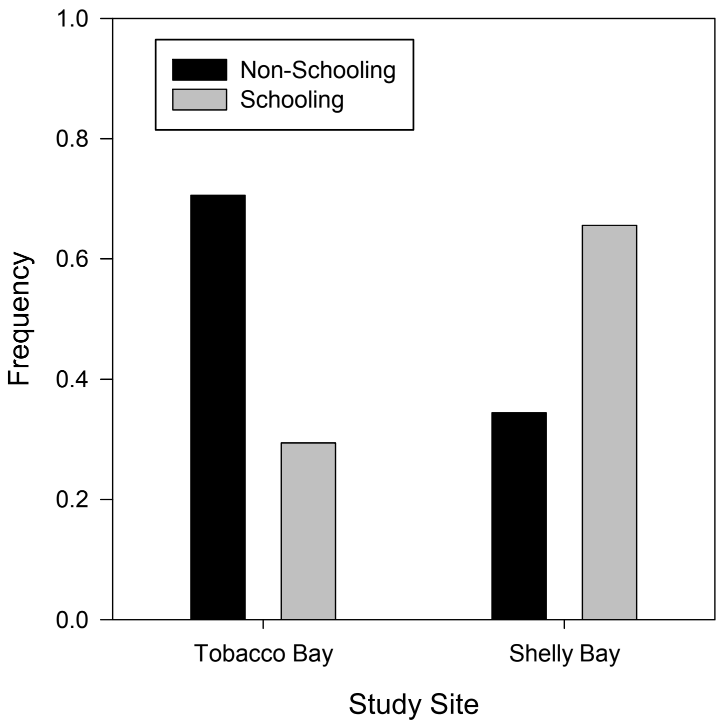

Figure 2 Frequency of non-schooling and schooling sightings at Tobacco Bay and Shelly Bay.

There is a significant difference between schooling and non-schooling behavior of each species ($X^2 = 137.452_3$, $p<0.001$). At Tobacco Bay, *H. sciurus* and *H. flavolineatum* exhibited mostly non-schooling behavior (82% and 95% respectively) while *H. carbonarium* and mixed species assemblages exhibited schooling behavior (80% and 67% respectively) (Fig. 3A). A mixed species sighting can be non-schooling if it has only two individuals, each belonging to a different species. At Shelly Bay, *H. flavolineatum* exhibited 100% non-schooling, while *H. sciurus* and mixed species sightings were schooling (59% and 100% respectively) (Fig. 3B). Larger members of the school swim actively when threatened or when there is a surge of currents that displaces them (McFarland and Hillis 1982). There were high winds and heavy currents on the day data were collected from Tobacco Bay. This might explain the high number of non-schooling sightings. Individuals might have also felt threatened by the observer lying the transect and swimming along it, causing them to separate from their school. The weather and water were calmer during data collection at Shelly Bay. Because this is a primarily juvenile habitat, individuals are smaller and may be less likely to separate from their school.

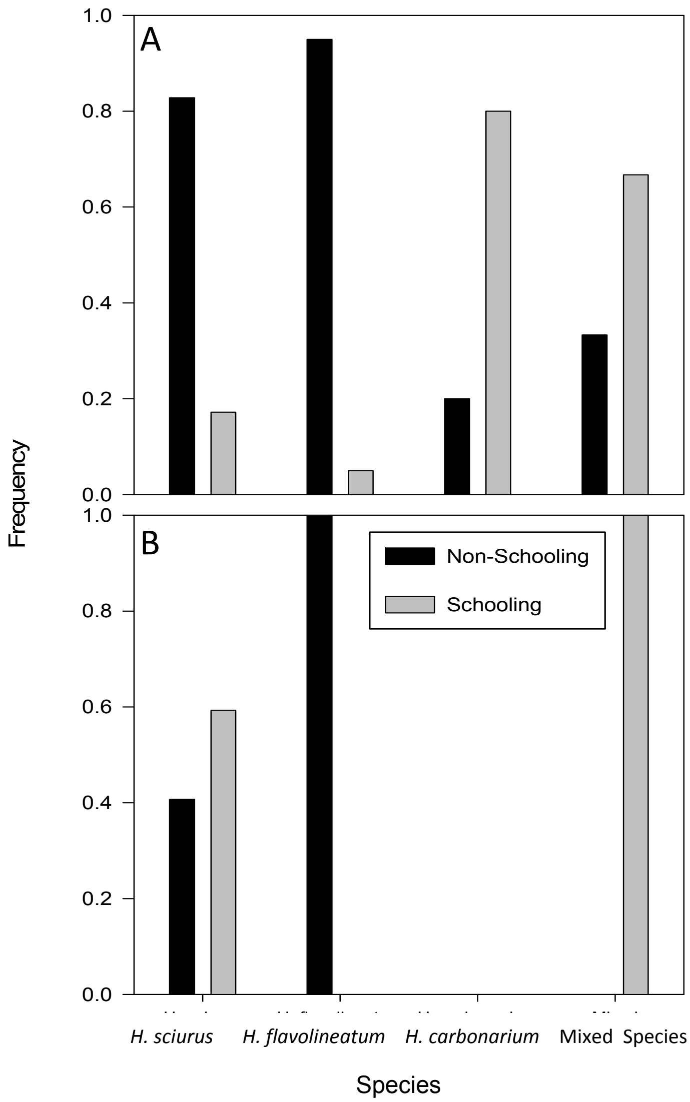

Figure 3 Frequency of schooling (n ≥ 3 individuals) and non-schooling sightings (< 3 individuals) for *H. sciurus, H. flavolineatum, H. carbonarium,* and mixed species aggregations for (A) Tobacco Bay and (B) Shelly Bay. Mixed species aggregations classified as non-schooling are two individuals from two different schools.

The presence or absence of schooling behavior for *Haemulon spp.* could be determined by different interacting factors. Foraging patterns and time of data collection could influence total numbers of grunt aggregations spotted. Resource partitioning and response to threats could influence schooling behavior. A host of characteristics and factors should be considered when determining *Haemulon spp.* schooling patterns.

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