FEEDING FREQUENCY DIFFERENCES BETWEEN SIX SPECIES OF PARROTFISH IN BERMUDA: *SCARUS CROICENSIS, SCARUS COELESTINUS, SCARUS TAENIOPTERUS, SCARUS GUACAMAIA, SCARUS VETULA, AND SPARISOMA VIRIDE*

Audrey Seiz
Department of Biology, Clark University, Worcester, MA 01610 USA
(aseiz@clarku.edu)

Abstract Parrotfish graze on algae or coral through either excavator behavior, which removes underlying coral, or scraper behavior, which does not remove underlying coral. Parrotfish feeding is ecologically essential for the health of coral reefs, through reduction of macroalgae and coral maintenance. This study examined the feeding frequency of six different species of parrotfish, *Scarus croicensis, Scarus coelestinus, Scarus taeniopterus, Scarus guacamaia, Scarus vetula,* and *Sparisoma viride* in Tobacco Bay, Bermuda. The study aimed to determine if there was a difference in feeding frequency between initial and terminal phase parrotfish in general as well as to test for differences in the feeding frequency of the six different species of parrotfish. Initial phase parrotfish had an average feeding frequency that was significantly higher than the terminal phase parrotfish. In general, *S. vetula* had a significantly higher feeding frequency then *S. guacamaia* and *S. viride*. These results suggested that initial phase parrotfish feeding had a larger effect on the coral and potentially produced greater ecological benefits for the corals in Bermuda than terminal phase parrotfish.

Key Words: *feeding, parrotfish, phase differences*

Introduction

Approximately 85 species of parrotfish have been described living in tropical and subtropical coral reefs (Bonaldo et al. 2006). These herbivorous fish have a beak-like jaw of fused teeth, and an initial (juvenile) phase as well as a terminal (adult) phase (Streelman et. al 2002). These two phases are characterized by differences in both coloration and feeding frequency (Bonaldo et al. 2006). Generally, parrotfish feed on algae and live coral; however, detrital feeding species have been described recently (Mumby 2009). The feeding behavior of parrotfish has been a method for parrotfish categorization, and presently there are two recognized and distinct feeding functional groups with unique morphologies and behaviors— excavators and scrapers. Excavators take small bites; however, they have large jaw muscles that can penetrate and remove the coral beneath the algal beds. Scrapers take large bites; however, they have small jaw muscles that cannot remove underlying coral (Bellwood and Choat 1990, Bruggeman, Kuper, and Breeman 1994, Ong and Holland 2010). Mumby (2009) determined that excavator feeding behavior does not have a detrimental effect on coral growth and fecundity. Scraper feeding behavior has significant ecological effects, such as reduction in macroalgal cover, maintenance of coral cover, and bioerosion, which changes the topography of coral reef (Mumby et al. 2007).

The present study focused on two questions: (1) Is there a difference in feeding frequency between initial and terminal parrotfish in general? (2) Is there are differences in feeding frequency between the six different species of parrotfish observed in Bermuda?

Materials and Methods

Study Organisms

A list of the scientific name, common name, initial phase description, and terminal phase description of the six species of parrotfish studied in Bermuda (Table 1).

Table 1. Scientific name, common name as well as initial and terminal phase descriptions of the size species of parrotfish studied in Tobacco Bay, Bermuda.

Scientific Name	Common Name	Initial Phase Description	Terminal Phase Description
Scarus croicensis	Striped Parrotfish	Greyish body with three black stripes, two white stripes and a white belly.	Blue to green body color with a yellow spot or stripe positioned behind the pectoral fin.
Scarus coelestinus	Midnight Parrotfish	Navy blue body color with bright blue markings on the head.	Navy blue body color with bright blue markings on the head.
Scarus taeniopterus	Princess Parrotfish	Brownish body with a dark midline stripe.	Blue to green body color with two blue stripes running from the snout to eyes. Yellow or orange midline stripe.
Scarus guacamaia	Rainbow Parrotfish	Brown body color with a lighter belly.	Rust head color and a blue-green body. Greenish beak.
Scarus vetula	Queen Parrotfish	Dark body color (grey to black) with a white stripe down the midline.	Female: Gray body. Male: Blue-green body with distinct bands of orange, green and blue on the head.
Sparisoma viride	Stoplight Parrotfish	Body red- brown color with sparse white scales. Belly and tail red color.	Greenish body color with a yellow spot at the upper corner of the gill cover and a yellow band on the tail.

Study Area

The study was conducted at Tobacco Bay, Bermuda (32˚17’ N, 64˚40’ W). It is a bay in the northern part of Bermuda with limestone formations.

Experimental Methods

Snorkeling surveys were conducted from 10/10/12 to 10/12/12 in Tobacco Bay to measure the frequency of parrotfish feeding. Once a parrotfish was encountered, I started a timer and recorded the phase of the fish (initial or terminal) and the number of times the fish took a bite of coral or algae until I could no longer see the fish. At that point, I stopped the timer and recorded the amount of time that the fish was followed. I determined the mean feeding frequency (bites/min) for all six species of parrotfish. I also determined the mean feeding frequency (bites/min) of initial phase parrotfish (regardless of species) and terminal phase parrotfish (regardless of species).

Statistical Analysis

A two-tailed t-test, conducted in Excel, was used to test for a difference between the mean feeding frequency (bites/min) of the initial versus terminal phase parrotfish. One-way ANOVA was used to determine if there were significant species-specific differences in mean feeding frequency of parrotfish using the software program JMP. A Tukey-Kramer HSD test, also launched in JMP, was used to identify the parrotfish species with significantly different mean feeding frequencies from one or more of the other parrotfish species.

Results and Discussion

Initial phase parrotfish had an average feeding frequency that was significantly higher than terminal phase parrotfish (Fig.1**,** $t_{df=33} = 2.24$, $p=0.03$). In general, *S. vetula* had a significantly higher feeding frequency than *S. guacamaia* and *S. viride* (Fig. 2, Tukey's HSD $p<0.05$). The feeding frequencies of *S. croicensis, S. coelestinus, S. taeniopterus, S. guacamaia* and *S. viride* were not statistically different from one another , and *S. vetula, S. coelestinus, S. taeniopterus,* and *S. croicensis* all had mean feeding frequencies did not differ significantly (Fig.2, Tukey's HSD $p>0.05$).

This research illustrates two important aspects of parrotfish feeding. First, initial phase parrotfish had a higher feeding frequency than terminal phase parrotfish. This result was also observed in Bonaldo et al. (2006), possibly because initial phase parrotfish need more energy for growth, but also because of a behavioral difference between initial phase and terminal phase parrotfish. Bonaldo et al. (2006) observed that three species of parrotfish (*Sparisoma amplum, S. axillare* and *S. frondosum)* in their terminal phase spent a great deal of time chasing away other parrotfish, either within or outside of their species, allowing for less foraging time. In the field during this study, there were several instances when terminal phase parrotfish would bolt quickly and scare off other fish. There may be a similar behavioral response for the six terminal phase parrotfish species studied in Bermuda, reducing their foraging time.

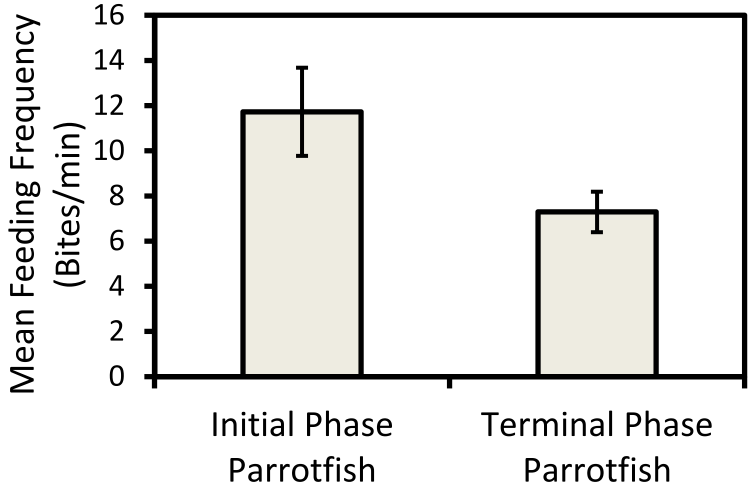

Figure 1. Mean feeding frequency (bites/min) of initial phase parrotfish versus terminal phase parrotfish in Bermuda. Error bars indicate the standard error of each mean value.

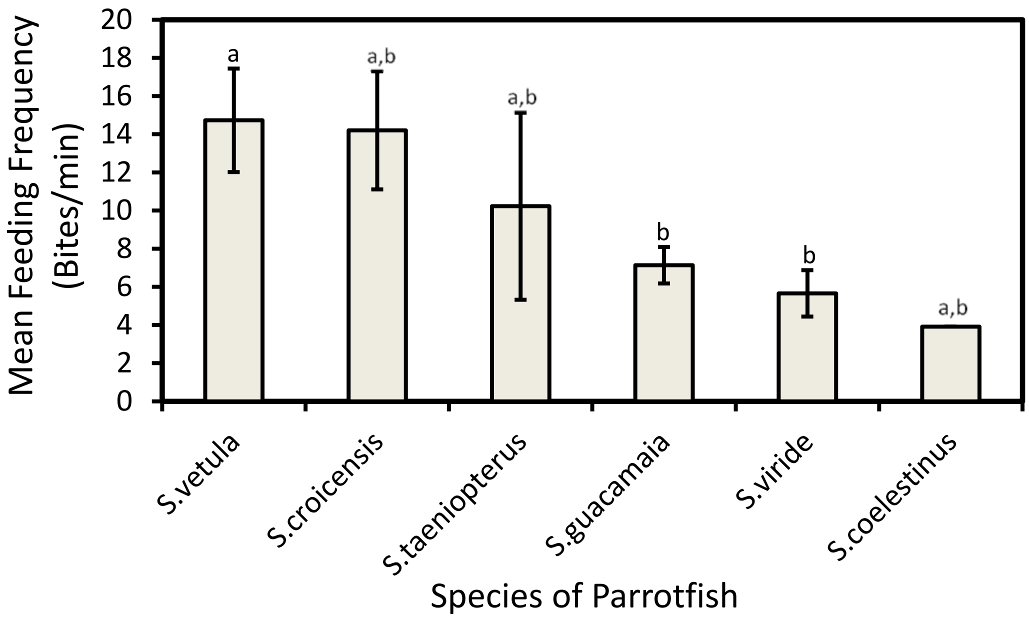

Figure 2. Mean feeding frequency (bites/min) of six species of parrotfish: *Scarus croicensis, Scarus coelestinus, Scarus taeniopterus, Scarus guacamaia, Scarus vetula,* and *Scarus viride* in Bermuda. Shared letters above a bar indicate a mean feeding frequency that were not significantly different from each other (Tukey's HSD, $p>0.05$). Errors bars indicate the standard error of each mean value.

Regardless of the reason for the increased feeding frequency of initial phase parrotfish, this finding has a broader community impact. The initial phase parrotfish, with their high feeding frequency, likely have a larger impact on the coral reef ecosystem in Bermuda than the terminal phase parrotfish. Mumby (2009) determined that parrotfish herbivory (feeding on macroalgae living on corals) facilitates coral growth, recruitment and fecundity, and coralivory (feeding on corals) is actually not detrimental to the coral. The initial phase parrotfish, therefore, aid, structure and shape the coral reef community more than the less frequently feeding terminal phase parrotfish in Bermuda.

Knowledge of the differential impact of parrotfish phase on coral reef ecosystems is beneficial for the future conservation of parrotfish species. Mumby et al. (2007) created a model for the Caribbean and found that a reduction in fishing pressure created a trophic cascade that allowed for more species of fish grazers, including damselfish and parrotfish, and increased coral health. If parrotfish were to become a heavily fished species in Bermuda, then size laws would need to be created to preserve the initial phase parrotfish. Without them, there would be a devastating impact on Bermuda's coral community.

Second, this study determined that overall *S. vetula* was the parrotfish species with the highest feeding frequency in Bermuda, and therefore has the largest impact on the coral community. *S. vetula*'s increased feeding frequency greatly contributes to maintaining the health and viability of the corals, making it an essential grazer species for the coral community.

Future research is needed to investigate more fully the interaction between feeding frequency, parrotfish phase, and parrotfish species. The research should focus on expanding the number of the initial and terminal parrotfish samples as well as comparing interspecies differences in adult or juvenile feeding frequency. Also, further research should characterize each observed parrotfish as either an excavator or a scraper (the feeding functional groups) and ask whether the difference in functional group alters feeding frequency.

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