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SHORT COMMUNICATION

# Reef fishes foraging facilitation behavior: increasing the access to a food resource

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**Abstract** Fishes associated in schools acquire adaptive advantages by grouping together, e.g., access to a larger variety of food resources, foraging sites, and protection against potential predators. This work presents the first record of a feeding association between the bucktooth parrotfish, *Sparisoma radians* and the sailor's grunt *Haemulon parra*, on Tamandaré reefs, Southwestern Atlantic. Through this association, *S. radians* gained access to otherwise unavailable food resources to be found inside territorial damselfish domain, thus characterizing an event of foraging facilitation.

**Keywords** Foraging behavior · Grunts · Mixed schools · Southwestern Atlantic

## Introduction

Schooling behavior is a process that has already been registered for approximately 10,000 fish species at some point of their life cycles (Shaw 1978) and has attracted significant attention from behavioral ecologists (Pitcher 1992; Ward et al. 2002). This behavior enhances the range of usable resources, such as food and space (Lukoschek and McCormick 2000), providing also the opportunity for increasing foraging time (Magurran and Pitcher 1983). One example of the numerical advantages is the schooling roving herbivores, which as a group have access to algal resources within other herbivore territories not usually available (Robertson et al. 1976, 1979).

Foraging in groups can also facilitate the detection of predators, as some individuals may alert other components of the group (Wolf 1985). By numbers, they also confuse predators, preventing them from focusing on a particular target (Morse 1977). Conversely, when one individual of the group differs from the others, it could be subject to a greater predation risk (Hobson 1969; Wolf 1985).

The 'foraging facilitation' hypothesis suggests that species benefit from group foraging through locating or allowing the use of new types of food, foraging locations, or foraging tactics (Valburg 1992). This behavior has been described more thoroughly for birds (Powell 1985; King and Rappole 2000) and insects (Crist and Haefner 1994). However, foraging facilitation is also adequate to characterize joint foraging tactics in reef fishes

The advantages of social foraging are higher for multispecies groups compared to single-species groups, as individuals benefit from the skills combined in search of each species (Krebs 1973). A number of multispecies foraging associations involve members of different trophic categories; however, the effects of foraging interactions among groups in coral reefs trophodynamics have received little attention (Lukoschek and McCormick 2000).

Species from the genus *Haemulon* are known to form mixed-species schools and to display protective mimicry

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with at least 15 species of coral reef fishes on the Western Atlantic (Ehrlich and Ehrlich 1973; Krajewski et al. 2004; Pereira et al. 2011). It has been also observed to aggregate with squids at juvenile phase, which was associated to predation avoidance (Nunes et al. 2007). Herein we describe, for the first time, the use of schooling sailor's grunts *Haemulon parra* (Desmarest 1823) by the bucktooth parrotfish *Sparisoma radians* (Valenciennes 1840) precluding agonistic interactions with territorial species (e.g., *Stegastes fuscus*) and thus increasing their foraging success.

## Materials and methods

The observations occurred in the shallow reef complex of Tamandaré (8° 45′S 35° 05′W) between December 2009 and March 2010. These reefs are located in the upper limit of the Marine Protected Area "APA Costa dos Corais", Pernambuco, Northeastern Brazil, encompassing a 135 km coastline protected by federal law since 1997. Coral reef formations in Tamandaré are constructions resembling fringing reefs parallel to the coast. They have a distinctive growth form, developing as isolated columns that grow up to 5–6 m high and are expanded laterally on the top (Dominguez et al. 1990; Maida and Ferreira 1997). Where these columns are densely aggregated, their tops coalesce and create large reef flats at the surface, highly dominated by territorial damselfishes (Ferreira et al. 1995; Maida and Ferreira 1997).

Observations were made while snorkeling in maximum depths around 6 and 10 m of water visibility. Schools were photographed and video-recorded. We have used the focal animal methodology registering all occurrences (Altmann 1974) and the total length (TL) was visually estimated and recorded on plastic sheets.

## Results and discussion

Juvenile individuals of *S. radians* were observed in foraging facilitation associations with juveniles of *H. parra* on 10 different occasions. The parrotfish took advantage of the proximity of the grunt schools to actively feed on algae mats aggressively defended by the dusky damselfish, *S. fuscus* (Cuvier 1830), a territorialist damselfish that is very common along the Brazilian coast (Ferreira et al. 2004). The large numbers of individuals in the school overwhelmed the damselfish, which allowed the parrotfish to feed inside its territory (Fig. 1c). This behavior was observed on multiple occasions, and if the parrotfish were agonistically pursued, they swam toward the *H. parra* school, clustering with them. During the occurrence of the observed associations, *S. radians* individuals used both the center and edge of grunts' schools not showing preference for a particular position within the school of grunts. The great similarity in size (all observed individuals had about 5 cm TL) and body shape (Fig. 1a, b) strongly motivated this interaction.

Mixed schooling involving herbivorous fish is a well-known association to avoid territoriality (Robertson et al. 1976) and thereby to increase foraging success by attaining higher feeding rates (Robertson et al. 1976; Lawson et al. 1999; Morgan and Kramer 2004). Species from the genus *Haemulon* are mobile invertebrate feeders (Ferreira et al. 2004) that do not share food items with *Sparisoma* species —thus, the stimulus for joining into heterospecific schools is not related to similar diets or feeding behaviors. It does appear to be motivated by the reduced abundance of herbivores in the area—making the grunts a prime choice for forming mixed schools, as they are the most numerous reef-associated schooling fish in the Atlantic (Rocha et al. 2008), therefore attracting individuals from various species and life stages that benefit from the protection afforded by grouping together in heterotypic schools (Pereira et al. 2011).

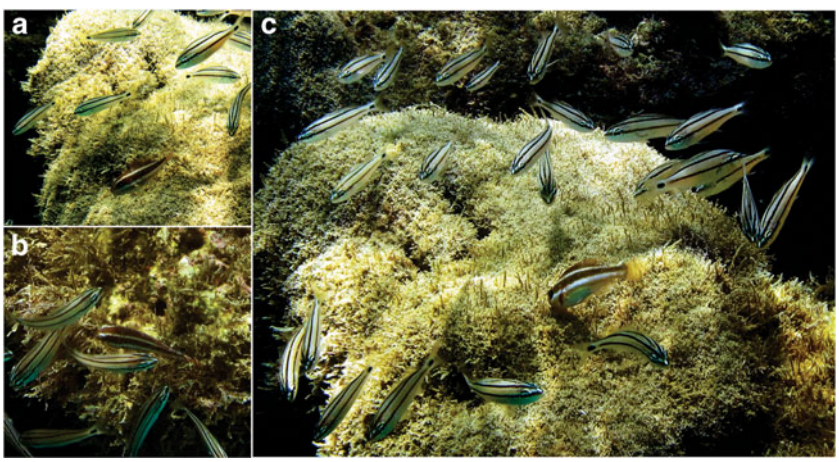


**Fig. 1** **a** Foraging facilitation involving *S. radians* and juvenile *H. parra*. **b** Detail of the species, showing similar coloration and sizes. **c** Parrotfish associated with juvenile *H. parra* while foraging on algae. *S. radians*, bucktooth parrotfish, presented a *reddish–brown* coloration and is the individual that appears only once in the photos

Heterospecific schooling was also recorded for other *Sparisoma* species, e.g., the newly described species *Sparisoma rocha* mimicking and joining schools of *Halichoeres penrosei* and *Thalassoma noronhanum* (Pinheiro et al. 2010), and *Sparisoma axillare* exhibiting a protective mimicry behavior and clustering together with *H. parra* schools (Pereira et al. 2011). Noteworthy, is the fact that these species have similar coloration and body shape and the interactions always occurred during their juvenile life, a critical phase for survivorship, when both predation risk and nutritional needs are feasible to be greater.

Regardless, the several advantages of heterotypic schooling for both involved species, it is known that this process imposes some ecological costs, such as spatial competition (see Pavlov and Kasumyan 2000 for a general review). This competition also can be maximized by the 'oddity effect' whereby distinctive coloration increases the risk of predation for relatively rare individuals (Wolf 1985). *Haemulon* spp. are known to display a certain degree of territorialism and perform agonistic behavior towards conspecific grunts and other species when solitary or in schools (McFarland and Hillis 1982; Pereira and Ferreira 2012). Therefore, such conspecific schools are likely to occur when the antipredator benefits of being aggregated outweigh the competition costs (Landeau and Terborgh 1986; Ward et al. 2002).

This work highlights the significance of feeding associations through schooling behavior for reef fish species from different trophic guilds, where apparently the benefits overcomes the costs of this interaction for both species. Given the importance these interactions may have for the life history of the associated species, it is likely that other species are using the same path to reach an alternative food resources. Individuals from the genus *Haemulon* are found in very numerous schools and have similar color patterns and body shapes, especially in their juvenile phases (Lindeman and Toxey 2002), these features together strongly encourages the formation of mixed shoals and mimicry events with other reef fish, that may still unreported.

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