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OBSERVATIONS OF THE REEF FISH *Alphestes afer* (ACTINOPTERYGII, EPINEPHELIDAE) FOLLOWING THE *Octopus insularis* (CEPHALOPODA, OCTOPODIDAE) IN A TROPICAL REEF SYSTEM

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Abstract: We report an interaction between *Octopus insularis* (Octopoda, Octopodidae) and the reef fish *Alphestes afer* (Perciformes, Epinephelidae) and provide evidence of mimicry, camouflage and following behaviors. We observed three instances of this interaction during dives at the Pirangi reefs, Northeastern Brazil. The octopus's body color patterns indicated the type of behavior that developed while it was followed by the reef fish. These data are the first records of following behavior in *A. afer* and the first observation of such interaction with *O. insularis* in coastal reefs.

Keywords: Brazil; camouflage; coastal reef; following behavior; mimicry.

Reef fish ecological interactions are frequently reported and mainly relate to foraging activities, protection and cleaning symbiosis (Dubin 1982, DeLoach 1999, Karplus 2014, Cantor *et al.* 2018). These associations occur among the fish themselves or involve other animals, such as marine invertebrates like cephalopods, especially octopuses (Karplus 2014). Several studies around the world report ecological interactions between octopuses and fish in reef environments and describe their behaviors (Strand 1988). These interactions include cleaning symbioses (Johnson & Chase 1982, Sazima *et al.* 2004) and a "transport association" between an octopus and ray (Souza *et al.* 2007). However, most studies that focus on reef fish and octopuses refer to "nuclear-follower" behavior, which is associated with foraging (Karplus 2014).

Several species use this strategy to catch prey as they follow individuals of other species (Sazima *et al.* 2007), mainly those that exploit the substratum (Strand 1988, Gibran 2002). In a survey conducted by Strand (1988), seventeen of thirty-five specimens of reef fish studied (Gulf of California) spent part of their time following other species. According to Kayes (1974), reef fish that follow octopuses are often observed by divers, and this knowledge is useful for capturing these molluscs. Most fish that interact with octopuses belong to the families Mullidae, Labridae and especially Epinephelidae (Diamant & Shpingel 1985, Forysthe & Hanlon 1997, Gasparini & Floeter 2001, Sazima *et al.* 2007, Machado & Barreiros 2008). The Epinephelidae family has the highest number of registered species developing following behavior (Karplus 2014). According to Strand (1988), this interaction functions as an opportunistic strategy that allows the follower species to capture preys exposed by the "nuclear species".

Mimicry developed by octopuses is well known and acts as a defense mechanism against predators (Hanlon 2007, Hanlon & Messenger 2018). 'Social mimicry' in octopuses presumably increases

protection against visually oriented predators, because when an organism is camouflaged it becomes imperceptible in the presence of several similar organisms (Krajewski *et al.* 2009). In this study, we recorded the interaction between *Octopus insularis* Leite & Haimovici, 2008 (Octopoda, Octopodidae) and the reef fish *Alphestes afer* (Bloch, 1793) (Perciformes, Epinephelidae). Our record suggests that the following behavior may be motivated by the foraging of the nuclear species, which behavior was indicated by the change on body color pattern of the octopus.

This interaction was observed in two field samples (with photographic records) during diving at the Pirangi reefs (5°59'24" S, 35°06'39" W), municipality of Parnamirim, off the southern coast of Rio Grande do Norte state, Northeastern Brazil, in December 2017 (Figure 1). These reefs origin are of sandstone and are composed of corals and calcareous algae. Recreational diving and fishing are frequent activities in this area (Batista & Leite 2016). The studied reef site is located between Pirangi and Búzios beaches, approximately 200 m from the coastline, with an average depth of 1.3 m. We observed three events by applying the animal focal methodology (Altmann 1974). Each observation was 10 min long, and we remained approximately 2 m from the observation point.

Octopus insularis acted as a nuclear species and was followed by *A. afer*. The following behavior occurred frequently throughout this reef environment. *Octopus insularis*, a mimetic species, clearly exhibited a common body pattern during foraging (Figure 2b, c, d), called 'mottle' (Leite *et al.* 2009), which is similar to the adult *A. afer* coloration (Figure 2a). While following the octopuses, *A. afer* eventually camouflaged itself between algae (Figure 2e).

Although *A. afer* is a cryptic species that rests in reef crevices during the day, it actively interacted with *O. insularis* at the Pirangi reefs. Dubin (1982) observed similar behavior in another Caribbean epinephelid fish that, among other interactions, followed eels, Muraenidae and Ophichthidae (Anguilliformes), with similar feeding habits. Like several reef fish, some groupers have nocturnal habits, as recorded by Gerhardinger *et al.* (2006), who noted that these fish came out of their shelters during dusk. Thus, this habit is likely a tactic to increase foraging efficiency.

Krajewski *et al.* (2009) and Pereira *et al.* (2011) recorded complex behaviors during foraging activities in Fernando de Noronha between *O. insularis* and individuals of the Epinephelidae, Lutjanidae, Carangidae, Haemulidae and Labridae families, in which follower fish are frequently observed. They also noted alterations in the octopus color pattern during these interactions.

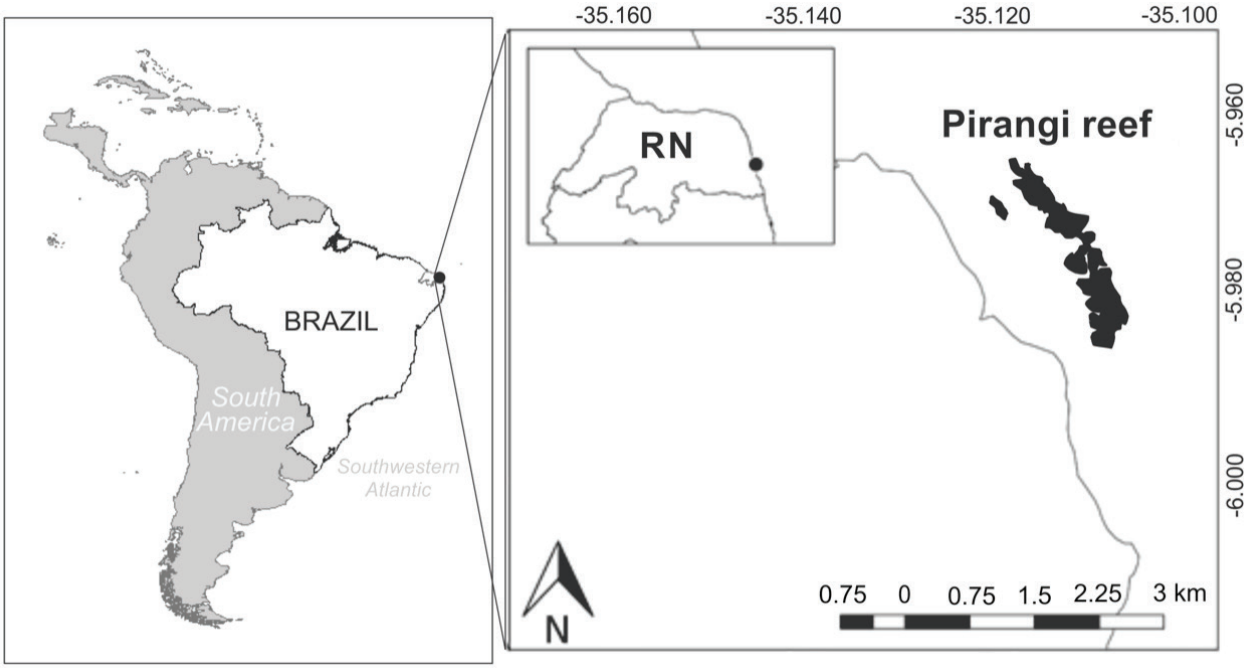

Figure 1. Study area at Pirangi reefs, municipality of Parnamirim, state of Rio Grande do Norte, Brazil.

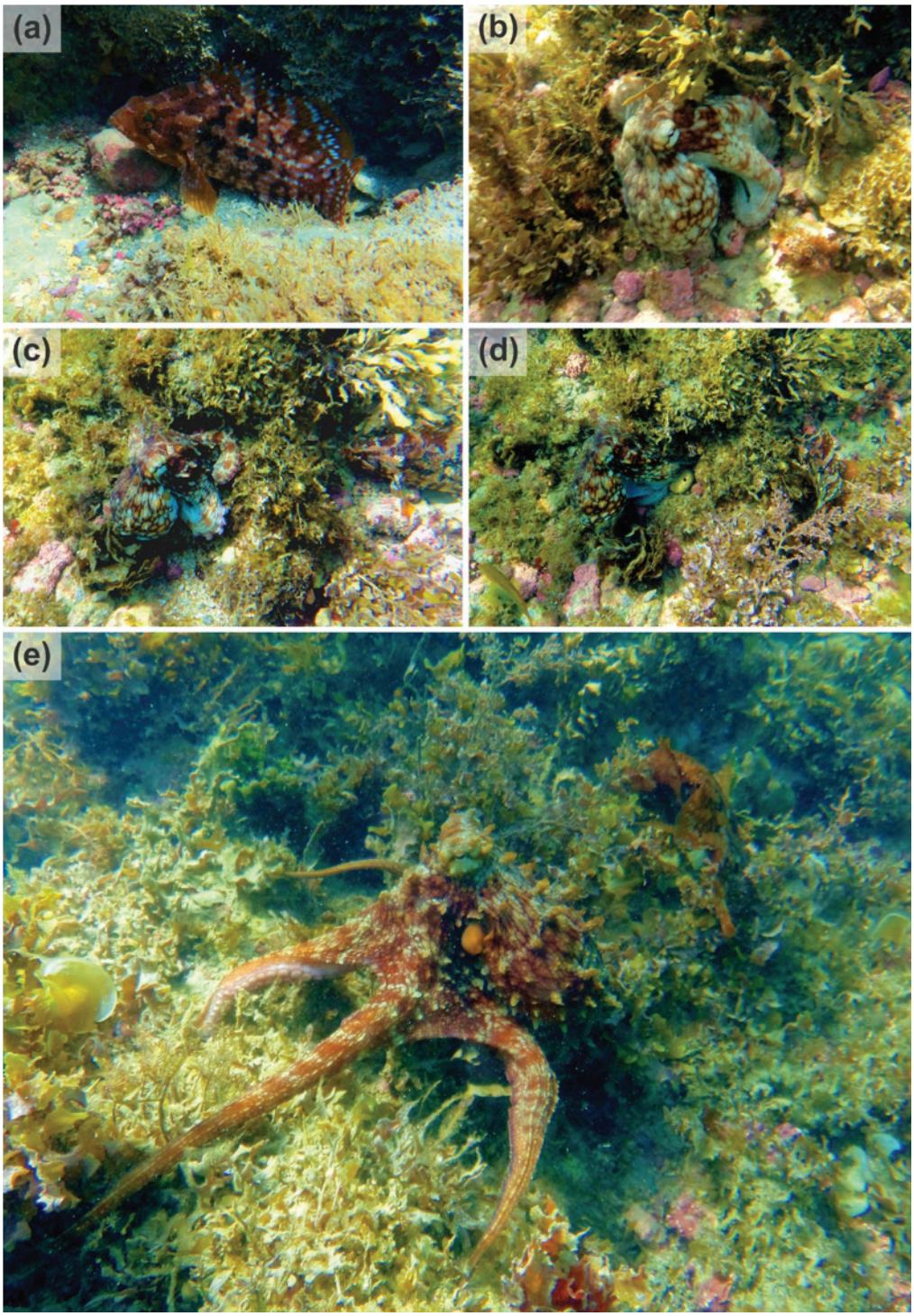

Figure 2. (a) Color pattern of the reef fish *A. afer* (Perciformes, Epinephelidae). (b) Octopus 'blotch' color pattern with a head-and-mantle-up. (c-d) An octopus changing from the 'blotch' to 'mottle' color pattern. (e) An octopus with a 'mottle' camouflage pattern typical during foraging. Photos: A. Felinto.

All records of Epinephelidae following behavior are associated with foraging activities and include several nuclear species, mainly octopuses (Karplus 2014). The interaction between *A. afer* and *O. insularis* is probably related to foraging activity, since both are carnivores and have a similar diet (Randall 1994, Leite *et al.* 2009). Thus, their interaction would benefit the fish and increase the chance of catching prey. According to Gerhardinger (2006), groupers often follow other species as a feeding strategy. Craig & Erisman (2010) reported that *Alphestes immaculatus* (Perciformes,

Serranidae), a sedentary species similar to *A. afer*, follows other fish species during foraging activities. Many of these associations involve territorial fish, like groupers, which follow active species with malleable bodies, like octopuses. These mollusks can easily access the reefs and move material from the substratum and algae while searching for their prey, actions that dislodge the organisms present in these microhabitats and make them available to the follower species (Diamant & Shpigel 1985, Rahel & Stein 1988, Strand 1988). Thus, the foraging rate increases for fish associated with octopuses (Karplus 2014). Mather (1992), while studying reef fish, observed that *Labrisomus nuchipinnis* and *Halichoeres bivittatus* approached the octopuses only during foraging activities.

The foraging rate is high for follower fishes, but they expend a lot of time and energy following (Karplus 2014). We speculate that for nuclear species such as octopuses, the cost of being followed is doubled, since there is food loss and risk of predation (Machado & Barreiros 2008). In this way, these individuals use different strategies in these associations, which vary according to the habitat (Mather 1992, Leite *et al.* 2009). Krajewski *et al.* (2009) observed that *O. insularis* changes its body coloration due to followers, and it remains camouflaged with the reef substratum when the fish are absent. Mather (1992) recorded the same observations for other octopus species that changed body coloration patterns during fish encounters. Thus, a positive relationship is beneficial for both species, since during following behavior, *A. afer* benefits from the octopus disturbing food, and the octopus can imitate the fish to appear similar to *A. afer* aggregation, what would confuse potential predators. As mentioned by Messenger (1974), the fish exert selective pressure and represent "designers of the octopus skin".

It may be difficult to characterize a single staining pattern for Octopodidae cephalopod species due to the high camouflage potential exerted by these species during different behaviors (Leite & Mather 2008). Reef fish camouflage and mimicry are common during interactions with other species (Moland *et al.* 2005). In this study, the reef fish *A. afer* was visualized camouflaging between algae during interaction with *O. insularis*, which probably represents a defense strategy due to exposure during follower behavior. Diamant & Shpigel (1985) reported a similar behavior for other Epinephelidae fish, specifically ambush coloration, during associations of these species with octopuses. The body pattern of *O. insularis* varies from yellow to reddish brown; it is usually light brown (Leite *et al.* 2008). Once it is followed by the fish while foraging, *O. insularis* presents a 'mottled' body pattern during hunting, as observed by Leite & Mather (2008), with an *A. afer*-like color pattern that is densely spotted with orange or light brown with scattered white spots, small scattered black spots or dark halftones (see redescription by Craig *et al.* 2006). Since the 'mottled' body pattern is common during hunting, our results confirm that the following behavior observed in this study is motivated by feeding strategies.

This study is the first record of follower behavior in *A. afer*, and the first observation of its interaction with *O. insularis* in coastal reefs. Previous studies (Krajewski *et al.* 2009, Pereira *et al.* 2011) were only performed on oceanic islands. Here, we expanded the knowledge about interactions between invertebrates and reef fish. However, more detailed investigations related to *A. afer* following behavior, as well as its interactions with *O. insularis*, are necessary.

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