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SHORT COMMUNICATION

Thanatosis in the Brazilian seahorse *Hippocampus reidi* Ginsburg, 1933 (Teleostei: Syngnathidae)

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Abstract The present study reports thanatosis behavior in *Hippocampus reidi* seahorses. We observed two different types of tonic immobility during seahorse handling, both in the laboratory and in field studies. In the former, the seahorses assumed a stretched posture, and in the latter, pointed their heads towards their bellies and curled their tails in a spiral towards their abdomen. The displays lasted 124 ± 100 s ($n = 3$) in the laboratory and 155 ± 7.07 s ($n = 5$) in the field. Camouflage is the seahorses primary defense from predators and our observations suggest that thanatosis is a secondary strategy that could be more effective than retaliation or escaping predators, due to the fact that seahorses lack teeth and have limited swimming ability. The responses caused by fear occurred after manipulation, allowing for the conclusion that the seahorse *H. reidi* may use thanatosis as a secondary defense strategy under major stress events.

Keywords Defense · Behavior · Tonic immobility · Fish

Introduction

The intense relationship between prey and predator shapes animal hunting and defensive strategies. Some animals display behavioral strategies that may inhibit possible predator attacks (Greene 1988) or be used during hunting periods. Thanatosis is a reaction exhibited by certain animals, in which they "play dead" as an answer to external stimuli, preventing predator attacks or ambush strategies during hunting (Francq 1969; Sargeant and Eberhardt 1975; Howe 1991; Gehlbach 1970). Animals that display this behavior, also known as catalepsy or tonic immobility, maintain a rigid posture (Greene 1988). This defense mechanism has been described in some fish species (Verbeek et al. 2008; Howe 1991; Vinegar and Davis 1972; Gunter and McCaughan 1959) and is very common in elasmobranchs (Brooks et al. 2011). The duration of these episodes varies from species to species and, in most cases, this behavior is displayed when other defense strategies became ineffective (Cortez and Silva 2013).

Seahorses belong to the Syngnathidae family and are common in coastal waters, occurring in several habitats, like rock and coral reefs, as well as mangroves and seagrass. These animals are threatened by human activities, such as capture for the aquarium market, bycatch and used *Hippocampus reidi* Ginsburg, 1933 as souvenirs, where they are sold dry (Vincent 1990). The seahorse *H. reidi* occurs along the entire Brazilian coast and is the most abundant seahorse species in Brazil (Lourie et al. 2004; Carpenter 2002; Rosa et al. 2002). These animals have been heavily collected for use in the aquarium and trade market for the last 30 years in Brazil, due to their charismatic and colorful appearance. They are also used in traditional medicine, sold as souvenirs, have religious purposes (Lourie et al. 1999; Rosa et al. 2002; Rosa et al. 2005), and are frequently captured in trawling nets as by catch (Foster and Vincent 2004). This species is one of the most exported Brazilian marine fish (Monteiro-Neto et al. 2003) and is considered *data deficient* by the IUCN Red List of Threatened Species of the World (IUCN 2011) and a *threatened* species by the Threatened Species of Rio de Janeiro State List (Mazzoni et al. 2000).

Seahorses have cryptic habits and show several primary defense strategies against predators. They are able to change

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color to match the substrate they use as holdfasts and may also develop dermic appendages to change their appearance to look like seaweed (Lourie et al. 1999). Their morphological ability to camouflage is improved by their sedentary behavior (Freret-Meurer et al. 2012), reducing the probability of detection (Armesto and Freret-Meurer 2012). Although they are masters of camouflage, seahorses have limited swimming ability. Their propulsion is performed by their dorsal fin (Lourie et al. 1999), so they are not as fast as other fishes, whose propulsion is performed by the caudal fin. Seahorses do not have teeth and they ingest food by suction, so they cannot retaliate predators using bites.

In this context, the present study aims to describe a secondary defense strategy used by the seahorse *Hippocampus reidi* against possible threats observed during field and laboratory studies.

Methods

Observations took place in the field and the laboratory. Field observations were conducted while snorkeling between April 2014 and December 2015 at Guaíba Island, located in Sepetiba Bay (23E 01′ S; 43° 54′ W). Sepetiba Bay has an area of 447 km^2 and is located in the state of Rio de Janeiro, southeastern Brazil. It is a highly impacted area, with several surrounding ports and industries.

Laboratory observations were performed in a 70 × 30 × 40 cm aquarium. Seahorses were collected (SISBIO License number 25663–1) from the Guanabara Bay (22E 46′ S; 43E 09′ W) and taken to the Animal Behavior and Conservation Laboratory at the Santa Úrsula University.

Behavior was video-recorded and photographed by a Nikon Coolpix AW100 both in the laboratory and the field. The focal animal methodology by Altman (1974) was used to observe and describe seahorse behavior.

Results

This study presents the first report of thanatosis in both juvenile and adult *H. reidi* seahorses. This behavior was recorded in the field (n = 5) and the laboratory (n = 3), from a total of 342 and 66 seahorses, respectively. The frequency of occurrence of this behavior in the laboratory was of 2% and in the field was of 5%. During the field observations, seahorses were caught from their holdfasts and, after manipulation, were released alongside their original location. After release or during manipulation, the seahorses pointed their heads towards their bellies and curled their tails in a spiral towards their abdomens. They remained motionless next to the marine bottom (or the researcher's hand), led by the current (Fig. 1a, b). Their posture was rigid and no breathing or eye movements were observed. After a mean period of 155 ± 7.07 s, the animals began moving and grasped the closest holdfast.

The observations in the laboratory were different. During the first observation, the seahorse presented the same posture described in the field. During the second record, the animal stopped moving after manipulation and showed relaxed muscle tone of the dorsal fin, taking on a stretched, rigid, posture, with the head at a 45° angle to the body, with a soft laterally curved trunk and a stretched tail (Fig. 1c). During the last observation, the seahorse assumed a stretched position with the tip of the tail curled towards its abdomen (Fig. 1d). No eye

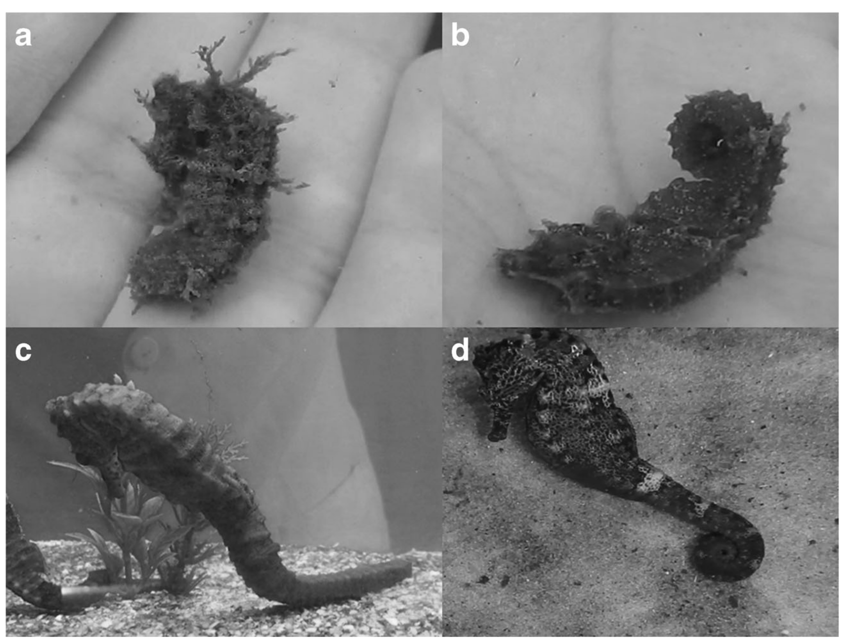

Fig. 1 Record of thanatosis behavior in the seahorse *H. reidi*. **a**, **b** field. **c**, **d** laboratory observations

movement or breathing was detected while the animals were motionless. It took 124 ± 100 s for them to start breathing and regain slow eye movements. All observations were made in different individuals.

Discussion

The results reported herein indicate that some *H. reidi* individuals can display thanatosis behavior. This behavior was displayed as a reaction to threat, in this case, handling. The responses were recorded in captivity, implying that thanatosis can occur under major stress, but were also observed in nature, suggesting adaptive behavior (Ratner 1967).

The differences observed in posture may be related to the presence of currents and also to the level of protection needed. In all the displays observed in nature, the seahorses curled their tail towards the abdomen, reducing their size and the influence of currents, in order to become more protected. In captivity, seahorses presented different displays, both the same as observed in nature, but also a stretched and rigid tail, leaving them more exposed. Handling was similarly conducted, so the level of stress resembled in both situations. Thus, it is probable that habitat characteristics were responsible for modulating the displayed posture (Johnsson et al. 2014). In natural habitats, the seahorse gets exposed to several environmental features (e.g., fast currents, many species, predators) and becomes more vulnerable. Captivity has more stable environmental trends, such as no current and a couple of holdfasts. These limited characteristics allow the individuals to assume a more unprotected posture.

The structural complexity of the ecosystem can influence predator-prey encounter rates, and non-consumptive predator attacks are the main force of defensive behavior (Schmitz et al. 2004). Predator pressure causes prey to adapt and develop defensive strategies to discourage predator attacks (Greene 1988). Primary defense mechanisms usually limit the predator's ability to detect or recognize the prey. Background matching is a common type of primary defense among reef species, where the animals match their appearance to one or several background types (Stevens and Merilaita 2009). In a heterogeneous habitat, such as reefs, the optimal coloration should resemble a relevant background and not an average part of it (Stevens and Merilaita 2011). Seahorses have advantages regarding this issue, because they show broad potential in avoiding detection by cryptic behavior (Armesto and Freret-Meurer 2012), as well as the ability to change color and develop dermic appendages (Lourie et al. 1999). However, changing morphological features may cost a significant amount of energy and sometimes fails. Once detected, strategies to avoid approach and subjugation must be applied.

Seahorses have no teeth, so fight and retaliation may not be as efficient as in other fish species (e.g., making sounds and biting). Retaliation could be in the form of sound production, but this may be ineffective for some species, as stated by Oliveira et al. (2014). Swimming away would also be ineffective, because the seahorse dorsal fin, which is responsible for propulsion, has several properties that afford less speed, although it may deceive predator due to its structure. The seahorse dorsal fin is different than that of other fishes. Fishes use the median fin for propulsion, generating a low frequency that allows them to swim with high hydrodynamic efficiency (Blake 1980) and avoid predators. On the other hand, the dorsal fin of seahorse generates a high frequency (Breder and Edgerton 1942; Blake 1976), beating so rapidly that its movement is probably above the frequency for flicker fusion of its predator (Blake 1976), allowing it to become invisible, causing the impression that the animal is drifting on the substrate, avoiding predators. However, when seahorses do not confuse the predator, thanatosis may be an alternative strategy to avoid predation.

Thanatosis is an important mechanism that promotes the survival of many species (Zimmermann et al. 2009) and has been reported in five invertebrate classes and all vertebrate classes, except for Agnatha (Whitman 1984; Vogel and Han-Yuem 2010). Feigning death is a secondary strategy, adopted when the animal has already been captured by the predator. This can prevent sequential predator attacks, allowing for possible escape (Miyatake et al. 2004) or as an anti-stimulus for predators that only attack moving prey (Miyatake et al. 2009). Seahorses have no specific predators, but some records are found regarding predation by crabs, tuna, shark, and anglerfish (Lourie et al. 1999). Some records are also available regarding accidental biting by pufferfishes, lizardfishes, and wrasses (*N. V. Freret-Meurer*, *personal observation*), where, after the bite, seahorses were released, so this may have helped in tanathosis modulation.

In addition to these environmental pressures, the human pressures of handling and capture for use in traditional medicines, souvenir sales, live ornamental display, and commerce (Rosa et al. 2002; Costa – Neto 2000; Lourie et al. 1999; Vincent and Pajaro 1997; Vincent 1996) may also be considered major stimuli. According to Gallup (1977) and Misslin (2003), tonic immobility is apparently a response caused by fear, which may occur after manipulation or animal detention, as recorded in the present study. Although this is still infrequently observed for *H. reidi*, individuals from two different populations displayed this behavior. Thus, this allows for the conclusion that the seahorse *H. reidi* may use thanatosis as a secondary defense strategy under major stress, but that it is not a usual defense strategy.

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