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Scientific Note

Feeding behavior and follower fishes of *Myrichthys ocellatus* (Anguilliformes: Ophichthidae) in the western Atlantic

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This paper described aspects of feeding behavior of *Myrichthys ocellatus* in the Western Atlantic, using diving observations and additional data from literature. The feeding behavior of *M. ocellatus* was characterized by scanning the sand surface and searching for buried preys, using its head and tail as a searching tool. Twelve species of reef fish were detected as followers of *M. ocellatus*, including three new records of follower species. The food overlap index between *M. ocellatus* and most follower species was low.

O presente estudo descreveu aspectos do comportamento alimentar de *Myrichthys ocellatus* no Atlântico ocidental, através de observações subaquáticas, complementadas com dados compilados da literatura. *Myrichthys ocellatus* caracteriza-se por buscar presas entocadas ou enterradas no substrato não consolidados e por usar a cauda e a cabeça como ferramentas de busca. Doze espécies de peixes recifais foram observadas como seguidoras de *M. ocellatus*, incluindo três novas ocorrências. O índice de sobreposição alimentar entre *M. ocellatus* e a maioria das espécies seguidoras foi baixo.

Key words: Interspecific associations, Goldspotted eel, Food overlap.

Snake eels of the Ophichthidae family typically have a long and cylindrical body and a pointed and finless tail (McCosker, 1977). They differ from most other eels because their posterior nostrils are located within the mouth or along the upper lip (McCosker, 1977; Nelson, 2006). Ophichthidae fishes use their rigid, pointed tail for burrowing (Nelson, 2006). The Goldspotted eel *Myrichthys ocellatus* (Lesueur, 1825) is distributed throughout the Atlantic Ocean from Bermuda to southern Brazil (McCosker *et al*., 1989). This is a very common species in northeastern Brazil, occurring in depths of up to 30 m (Carvalho-Filho, 1999). *Myrichthys ocellatus* reaches a total length of about 1 m (McCosker *et al*., 1989). Its body is pale brown, with a yellow or green cast, yellow polka dots and a dark outline (McCosker & Rosenblatt, 1993), and its ventral region varies from yellowish to white (Cervigón, 1996; Randall, 1996).

Myrichthys ocellatus inhabits coastal reefs and forages on sand banks, in clumps of algae or between reef crevices, feeding mostly on crabs from the families Portunidae, Xanthidae and Majidae (Randall, 1967; Robins & Ray, 1986; Randall, 1996; Lieske & Myers, 1999). The vigorous and agitated manner in which *M. ocellatus* searches for prey, and its capacity to penetrate and explore small holes in the substrate makes it a typical nuclear species for opportunistic follower fishes, presumably to increase their foraging success. Many studies describe a nuclear-follower foraging association between Anguilliformes and other reef fishes (*e.g*. Karplus, 1978; Dubin, 1982; Diamant & Shpigel, 1985; Strand, 1988; DeLoach, 1999; Gerhardinger *et al*., 2006; Sazima *et al*.,

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2007; Maia-Nogueira *et al*., 2008).

The objectives of the present study were to describe the feeding behavior of *M. ocellatus*, specially using the tail as a hunting tool, and to characterize qualitatively feeding associations between these nuclear species and its follower reef fishes.

Underwater observations were made off the northeastern coast and oceanic islands of Brazil: Pecém and Iparana (Ceará State), Rocas Atoll and Maracajaú (Rio Grande do Norte State), Fernando de Noronha, Porto de Galinhas, Serrambi and Tamandaré (Pernambuco State), Barra Grande and Maragogi (Alagoas State). Results were complemented with the compiled information from previous studies: Puerto Rico (Randall, 1967), and Brazil: Cairu - Bahia State (Maia-Nogueira *et al*., 2008), São Sebastião - São Paulo State (Gibran, 2007) and Arvoredo - Santa Catarina State (Gerhardinger *et al*., 2006). The total area studied encompass the latitudes 18º11'N 27º16'S and the longitudes 32°25'W 67°10'W.

The dives were conducted from July 2005 to January 2008, through 135 hours of snorkeling or scuba diving at low tide, with 54 diurnal observation sessions (150 min each). Observed specimens (n = 63) of *M. ocellatus* ranged from around 20 to 100 cm TL (average of 45 cm) that were visually estimated on field. The acquisition of ethological data obeyed the *ad libitum* and animal focal methods (Altmann, 1974). A voucher specimen from Carneiros Beach (Pernambuco State, Brazil) was deposited at Ichthyological Collection of the Universidade Federal de Pernambuco (CI-DOCEAN/UFPE # 1507).

Comparative analysis between food items of *M. ocellatus* and its followers was performed using compiled data from Randall (1967). To obtain the diet similarity between each pair of species was employed the food overlap index of Morisita (1959) modified by Horn (1966). This index ranges from 0 to 1, values equal to or greater than 0.6 are considered as high food overlap (Zaret & Rand, 1971).

Myrichthys ocellatus was often found alone, seeking prey through side movements of the head and nostrils, which were expanded. The feeding behavior was characterized by initially scanning the sand surface and searching clumps of algae and reef rock crevices, using its head and anterior region of the body as a searching tool. A variety of capture modes procedures were observed in *M. ocellatus* once prey was sighted. The most common form of capture was to cut a path to the prey by removing sand with jets of water in order to insert its head and catch the prey.

The rigid tail usually helped in searching for prey, depending on the effort required for success. It sometimes used the tip of the tail, once buried in the sand, to support vigorous movements performed, flipping the rear and/or anterior regions, and destroying the hideout where the prey was located, by widening the holes. To reach prey, *M. ocellatus* stops its head over the spot where the prey is buried and brings the tail to the head level with the substrate, forming an arc with its body and the tail takes over the head position over the prey. From this position, the animal moves vertically like a whip, both quickly and vigorously, enabling it to scatter the substrate and make enough room for the head to go deeper and catch the prey (Figs. 1-2). Besides the bury behavior on sand, *M. ocellatus*' tail can create holes in calcareous reefs. This sequence of capture tactics was first

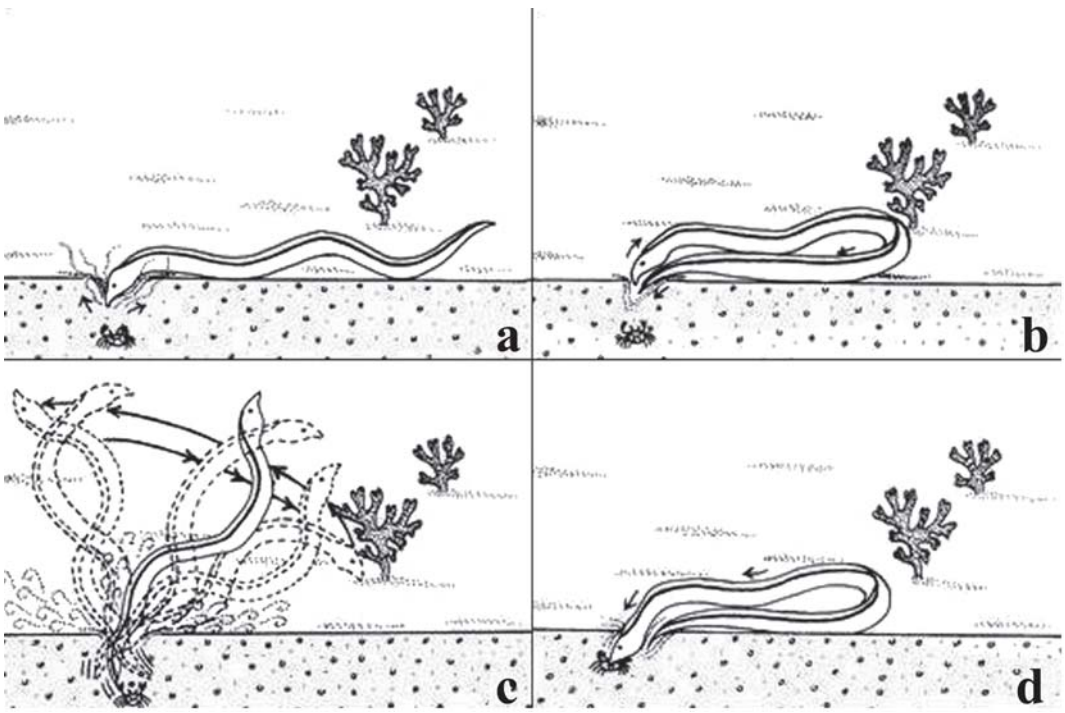

Fig. 1. Capture sequence of *Myrichthys ocellatus* involving head and tail: (a) initial scattering movements with the head; (b) tail taking over the position of the head; (c) widening hole with the tail; (d) moment of prey capture. Illustrated by Francisco Costa.

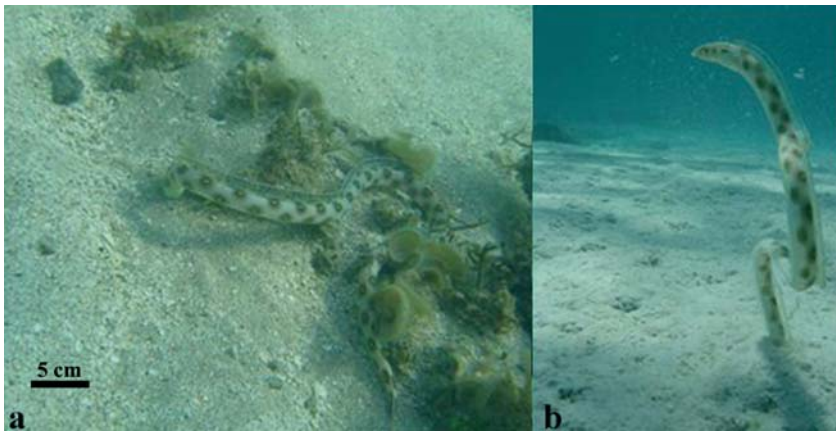

Fig. 2. *Myrichthys ocellatus* during feeding behavior: (a) beginning search behavior; (b) burying its head and opening the hole wider with its tail. Photos by S. Marques (a) and V. Marques (b).

described here and named "head and tail feeding behavior".

When foraging in rocky substrates, the digging mode is not effective, so *M. ocellatus* seeks its prey on crevices using just its head. At the Rocas Atoll and Iparana, for instance, individuals of *M. ocellatus* were found foraging in shallower depths with barely enough water to cover them. In these cases, the horizontal wave-like movements of these animals constantly exposed their bodies to the air.

The senses of smell and touch are highly involved when *M. ocellatus* is hunting for prey, since the fish extends its tube-shaped nostrils (McCosker & Rosenblatt, 1993), and moves them excitedly, directly touching the substrate. *Myrichthys ocellatus* moves by undulations of muscle contractions stemming mainly from its trunk. Greater amplitudes towards the tail create a counter-stream that pushes the Anguilliformes fishes forward (Wilson & Wilson, 1992; Moyle & Cech-Jr, 2004).

Individuals of this species commonly move under the sand as both a foraging procedure and for defensive purposes (Lieske & Myers, 1999). This behavior was recorded along study area; in Iparana calcareous reefs the Goldspotted eel's specimens were recorded using their tails to made holes on this substratum. The use of the tail as a traction tool in Anguilliformes was recorded by DeLoach (1999) in an agonistic behavior observed between *Gymnothorax moringa* (Cuvier 1829) and *Echidna catenata* (Bloch 1795).

The results of the present study, added to the bibliographic information for the western Atlantic, recorded 12 species belonging to five families as followers of *M. ocellatus* (Table 1). Among these, *Eucinostomus lefroyi* (Goode, 1874), *Halichoeres brasiliensis* (Bloch, 1791) and juveniles of *Lutjanus alexandrei* Moura & Lindeman, 2007 are recorded for the first time as followers of *M. ocellatus* during the dives made at Porto de Galinhas and Serrambi. Epinephelidae had the highest number of species acting as nuclear-followers of *M. ocellatus*, totaling five species. Despite the relatively high frequency of following behavior records, it is uncommon to sight the prey been captured by the follower species. In the present study, only in one observation, it was possible to see when *M. ocellatus* captured a crab and some pereopods detached from its body, and remained floating in the water, until being bitten by *Epinephelus adscensionis* (Osbeck, 1765) (Fig. 3).

The diurnal associative feeding behavior known as 'nuclear hunting' (Fricke, 1975; Sazima *et al*., 2007) is characterized by a nuclear individual that forages actively in the substrate, exposing organisms that may serve as prey for

Table 1. List of the follower fishes of *Myrichthys ocellatus* and food overlap index between them. Data are from present study and also from literature. *index calculated with values from the diet of species from the same genus.

Species	Family	References	Food overlap index
Cephalopholis fulva (Linnaeus, 1758)	Epinephelidae	Feitoza B. M., pers. comm., 2000; Sazima *et al*., 2007; Maia-Nogueira *et al*., 2008; present study	0.41
Epinephelus adscencionis (Osbeck, 1765)	Epinephelidae	Maia-Nogueira *et al*., 2008; present study	0.92
Mycteroperca acutirostris (Valenciennes, 1828)	Epinephelidae	Gibran, 2007	0.04*
Mycteroperca bonaci (Poey, 1860)	Epinephelidae	Maia-Nogueira *et al*., 2008	0.04
Mycteroperca marginata (Lowe, 1834)	Epinephelidae	Gerhardinger *et al*., 2006; Gibran, 2007; Luiz-Jr. *et al*., 2008	0.04*
Rypticus bistrispinnus (Mitchill, 1818)	Serranidae	Maia-Nogueira *et al*., 2008	0.24*
Serranus flaviventris (Cuvier, 1829)	Serranidae	Maia-Nogueira *et al*., 2008	0.18*
Lutjanus alexandrei Moura & Lindeman, 2007	Lutjanidae	Present study	0.40
Eucinostomus lefroyi (Goode, 1874)	Gerreidae	Present study	0.22*
Halichoeres brasiliensis (Bloch, 1791)	Labridae	Present study	0.38*
Halichoeres radiatus (Linnaeus, 1758)	Labridae	Sazima *et al*., 2007	0.38
Thalassoma noronhanum (Boulenger, 1890)	Labridae	Sazima *et al*., 2007	0.38*

Fig. 3. Interspecific foraging association between *Myrichthys ocellatus* and *Epinephelus adscensionis*. The head of the follower fish is close to the Goldspotted eel, which is in a hole seeking for prey. Photo by M. E. Araújo.

opportunistic follower species (Strand, 1988). The followers recorded here swam near the head of *M. ocellatus*, but *E. adscencionis* and *L. alexandrei* dared to draw closer.

Cephalopholis fulva (Linnaeus, 1758) is the species with the greatest number of interaction records with *M. ocellatus* (Sazima *et al*., 2007; Maia-Nogueira *et al*., 2008) as confirmed in the present study. This may be due to the high cognitive capacity and opportunist behavior of groupers (Gerhardinger *et al*., 2006); this group of fishes have among the greatest number of species in association with *M. ocellatus*. Groupers are also known followers of other species, such as octopus (Strand, 1988; Sazima *et al*., 2007; Machado & Barreiros, 2008), moray eels (Karplus, 1978; Dubin, 1882; Diamant & Shpigel, 1985; Strand, 1988; Bshary *et al*., 2006; Sazima *et al*., 2007), sea stars (Gibran, 2002, 2007), other Actinopterygii fishes (Barreiros & Santos, 1998; Sazima *et al*., 2007), and also Elasmobranchii (Sazima *et al*., 2007).

The majority of the follower fishes have low food overlap with *M. ocellatus* (Table 1). This pattern was also found by Dubin (1982), who compared the diet of *Myrichthys breviceps* (Richardson, 1848) with that of *Cephalopholis fulva* (food overlap of 0.29) and *Hypoplectrus puella* (Cuvier 1828) (0.34). Although some followers have a low degree of similarity to the diet of the nuclear species, certain prey that remain hidden and buried are only accessible to followers through this kind of association, making it easier for the follower to catch the disturbed or mutilated prey. On the other hand, *E. adscencionis*, in the present study, showed a high value of food overlap (0.92), as their diet is composed mainly of crabs (66.70%), which is also the most common item for *M. ocellatus*, corresponding to 61.20% of its diet according to Randall (1967). The genus *Mycteroperca* was considered by this author to feed only on fish, and it was the one with the lowest food overlap value among all the species analyzed. This may be due to the fact that Randall (1967) only studied adult individuals, while interaction records involved juveniles (Gerhardinger *et al*., 2006; Maia-Nogueira *et al*., 2008; Luiz-Jr. *et al*., 2008).

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