Neotropical Ichthyology, 3(3):445-448, 2005


**Scientific note**

# A non-digging zoobenthivorous fish attracts two opportunistic predatory fish associates

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Following behaviour among reef fishes involves mostly a digging nuclear species while foraging, which attracts opportunistic followers preying on the exposed organisms. The flying gurnard *Dactylopterus volitans* preys on benthic animals, mostly crustaceans and small fishes, scratching and probing the bottom with the inner rays of its pectoral fins. We recorded the flying gurnard being followed by two opportunistic predators, the yellow jack *Caranx bartholomaei* and the coney *Cephalopholis fulva* at Fernando de Noronha, off northeast Brazil. Albeit not actually digging the substrate, the flying gurnard acts as a nuclear species by exploring algae tufts and by its wandering near the boulders and ledges, disturbing and flushing out hidden animals which thus become available to predation.

Entre os peixes recifais, uma espécie fossadora nuclear em atividade de forrageamento pode atrair seguidores oportunistas que se alimentam de organismos expostos pela atividade do nuclear. O coió-voador *Dactylopterus volitans* alimenta-se de animais bentônicos, principalmente crustáceos e pequenos peixes, explorando o substrato com os primeiros raios externos de suas nadadeiras peitorais. Registramos o coió sendo seguido por dois predadores oportunistas, a guarajuba *Caranx bartholomaei* e a piraúna *Cephalopholis fulva*, em Fernando de Noronha, ao largo da costa Nordeste do Brasil. Apesar de não agir como uma espécie fossadora do substrato, o coió atua como uma espécie nuclear por explorar os tufos de algas e também pela sua passagem próxima às rochas e lajes, espantando e desentocando animais escondidos que, assim, tornam-se vulneráveis aos predadores.

**Key words:** Nuclear forager, following behaviour, foraging association, reef fishes, Equatorial West Atlantic.

Reef fishes may form temporary feeding associations with other vertebrates as diverse as dolphins and turtles (Sazima *et al.*, 2003; Sazima *et al.*, 2004), but mostly associate with other fishes (Hobson, 1974; Fricke, 1975; Fishelson, 1977). Foraging associations are widespread among reef fishes and include examples as diverse as cleaning symbiosis, foraging groups of browsers, aggressive mimicry and following (Fishelson, 1977; Losey, 1978; Ormond, 1980; Lukoschek & McCormick, 2000).

Following behaviour comprises mostly a 'nuclear' predator stirring the bottom during its foraging, and opportunistic 'follower' fishes that are attracted by this activity (Fricke, 1975; Strand, 1988; Soares & Barreiros, 2003; Sazima *et al.*, 2005a). The digging movements of a nuclear species usually attract these opportunistic fishes that feed on the exposed items (Fishelson, 1977; Ormond, 1980). The "clouds" of stirred sediment and the specific features of the nuclear fish are visual signals that seem to influence the followers' behaviour (Fricke, 1975; Fishelson, 1977; Diamant & Shpigel, 1985).

Albeit not actually digging in the substrate, the flying gurnard *Dactylopterus volitans* (Dactylopteridae) scratches and probes the bottom with the inner rays of its pectoral fins (Randall, 1968; Nelson, 1994). Herein we report on the association of the flying gurnard, and its opportunistic followers, the yellow jack, *Caranx bartholomaei* (Carangidae) and the coney, *Cephalopholis fulva* (Serranidae) at the Fernando de

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Noronha Archipelago, off North-eastern Brazil.

The associations were recorded at the Fernando de Noronha Archipelago (03°50'S, 32°25'W), about 345 km off NE Brazil (see Maida & Ferreira, 1997 for map and description). Behavioural interactions between *D. volitans* and its followers were recorded at the Baía do Sueste (for *C. bartholomaei*) and Praia da Conceição (for *C. fulva*), in August 2002 and June 2003 respectively. The first site has a sandy and gravel bottom interspersed with rocky ledges that are sparsely to thickly covered by brown foliose algae, red coralline algae and stony corals (see description and illustrations in Maida *et al.*, 1995; Maida & Ferreira, 1997; Sanches & Bellini, 1999). The second site is a rocky shore with an adjacent sand flat, boulders and ledges covered mostly by green, brown and red algae, stony corals and fine sediment (I. Sazima, pers. comm.).

We recorded the associations while snorkelling, in two observation sessions, totalling 50 min of direct observation. We used focal animal samplings, in which all occurrences of specified actions were recorded (Altmann, 1974; Lehner, 1979). Besides records pencilled on plastic slates, behavioural events were photographed. During our observations we followed the wandering *D. volitans* individuals (N=2) and recorded the fish species that were associated with this nuclear. We tried not to disturb the foraging *D. volitans* or its followers, keeping a distance of 1.5 to 2.5 m from the observed individuals (see also Soares & Barreiros, 2003). Observation sessions were concentrated in the daytime.

We recorded two instances of following behaviour involving foraging individuals of *D. volitans*. In one record a *Caranx bartholomaei* (25 cm total length, TL) escorted the flying gurnard (20 cm TL) for about 20 seconds as it moved over a gravel substrate (Fig. 1). The second and more complete record on the flying gurnard foraging behaviour lasted about 20 minutes. Three individuals of *Cephalopholis fulva* (about 20 cm TL) followed the foraging *D. volitans* (30 cm TL) as it swam close to the bottom, inspecting algae tufts attached to the rocks. One *C. fulva* individual followed the flying gurnard for about 40 seconds, whereas the others left it after about 10 seconds.

On both records the flying gurnard wandered on the edge of the rocky reef inspecting mostly the rocky substrate as well as the sandy bottom. It displayed its characteristic dotted pattern of coloration while swimming or walking over rocky or gravel substrate (Fig. 1) but turned whitish while over sandy areas.

Some serranids are considered territorialist at some extent, or even aggressive (Froese & Pauly, 2005). However, the *C. fulva* individuals which simultaneously followed the flying gurnard displayed none aggressive interactions. Although *C. bartholomaei* could also be expected to display agonistic behaviour towards conspecifics, no other individual attempted to approach the flying gurnard during our record. The foraging nuclear could be considered as a 'moving feeding territory' and encourage aggressive behaviour among followers, as recorded for *C. bartholomaei* while following the stingray *Dasyatis americana* (Dasyatidae) at Fernando de Noronha (CS, pers. obs.).

**Fig. 1.** The flying gurnard (*Dactylopterus volitans*; 20 cm TL) wandering close to the gravel substrate with its characteristic dotted coloration, escorted by a yellow jack (*Caranx bartholomaei*; 25 cm TL).

*Dactylopterus volitans* is regarded as a bottom dweller inhabiting coral reefs and able to "walk" over the substrate using its thoracic-placed pelvic fins (Randall, 1968; Nelson, 1994). With the specialised inner rays of its huge fan-like pectoral fins, the flying gurnard scratches and probes in the sand and/or turn over small rock pieces or rubble while foraging (Randall, 1967, 1968; Smith, 1997). Albeit not actually digging in the substrate while foraging, the flying gurnard plays the role of a nuclear predator and attracts attendant associates (see Lukoschek & McCormick, 2000 for a classification of following associations). The flying gurnard's role as a nuclear species resembles that of some large parrotfishes (Scaridae) and triggerfishes (Balistidae) which break up coral, lift and turn over stones and rubble, and thus attract mainly small wrasses (Labridae) that prey on the disturbed small benthic organisms, stirred particles and even faeces (Ormond, 1980; Sazima *et al*., 2005a).

The flying gurnard feeds primarily on benthic crustaceans and small fishes (Randall, 1967; Froese & Pauly, 2005), and we observed benthic animals disturbed by the wandering *D. volitans*, especially juvenile and/or small fishes, that withdrew upon its approach. Therefore, several prey become potentially available to opportunistic followers by the mere wandering of a flying gurnard. Therefore, *D. volitans* plays the role of a nuclear species not only while exploring algae tufts, pieces of rocks and rubble, but also while simply wandering on the reef, as in both situations it may disturb potential prey for its followers.

Species of *Caranx* may be considered as highly piscivorous predators (Randall, 1967), but some of these also display opportunistic feeding, with variable foraging tactics (Potts, 1980; Baird, 1993; Silvano, 2001). Moreover, *Caranx latus*, *C. melampygus* and *C. ruber*, were recorded acting as followers of nuclear predators (e.g., Potts, 1980; Baird, 1993; Silvano, 2001). Thus, *C. bartholomaei*, which additionally forages mostly near the bottom (Randall, 1967; CS, pers. obs.),

would be expected to behave as a follower of nuclear species, in accordance with the opportunistic foraging known for several Carangidae species (Potts, 1980; Sazima, 1998).

Jacks are rovers, whereas groupers (Serranidae) are mostly sedentary and sit-and-wait predators (Randall, 1967). However, groupers are also versatile followers, which associate with diverse species of reef fishes including eels, and also octopuses and sea stars (Karplus, 1978; Diamant & Shpigel, 1985; Gibran, 2002). *Cephalopholis fulva*, already recorded as a follower (Francini-Filho *et al.*, 2000; Gibran, 2002; Froese & Pauly, 2005), inhabits reef areas where it hides under ledges or inside caves, feeding on small fishes and crustaceans (Randall, 1967; Francini-Filho *et al.*, 2000; Froese & Pauly, 2005). Being an inquisitive, alert and opportunistic predator, as other epinepheline groupers (Karplus, 1978; Diamant & Shpigel, 1985; Sazima *et al*., 2005b), the coney would be expected to inspect almost every moving animal, the more so a foraging flying gurnard.

Foraging associations in fishes can be highly diverse and complex, involving interactions between members of different trophic groups (Lukoschek & McCormick, 2000; Sazima *et al*., 2004, 2005a). The searobin *Prionotus punctatus* (Triglidae) is also a carnivorous species, with foraging behaviour similar to that displayed by *D. volitans* (Carvalho-Filho, 1999; Froese & Pauly, 2005), thus herein suggested as a potential nuclear species. Also, we suggest that additional reef fish species might associate with foraging *D. volitans*. Wrasses (Labridae), such as *Halichoeres dimidiatus*, *H. poeyi* and *H. radiatus*, highly versatile species and opportunistic foragers (Sazima *et al*., 1998; Jones, 2002; CS, pers. obs.), are likely such candidates.

**Acknowledgements**

We thank the Projeto Tamar and the Centro Golfinho Rotador (through J. M. Silva-Jr.) for logistical support at Fernando de Noronha Archipelago; the Ibama for issuing study permits at the Fernando de Noronha Archipelago; FAPESP and Fundação Pró-Tamar for financial support. CS is recipient of scholarship from the CNPq – Brasil.

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Received May 2005
Accepted August 2005