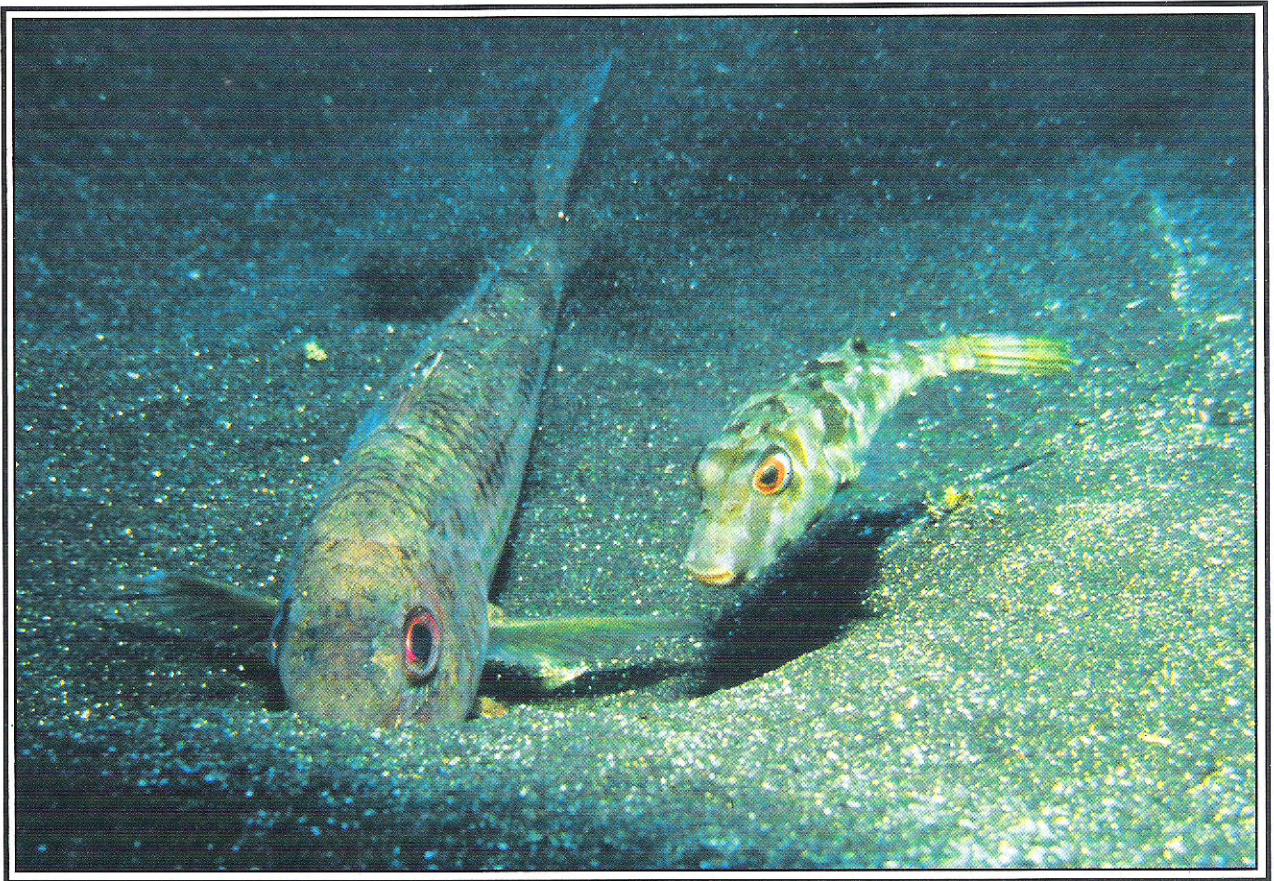


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## Following associations with the striped red mullet *Mullus surmuletus* Linnaeus, 1758 (Perciformes: Mullidae) from the Azores

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### Keywords

*Mullus surmuletus*, red mullet, NE Atlantic, intra – and interspecific interactions, following behaviour, cleaning behaviour, symbiosis

### Abstract

In this study we report *Mullus surmuletus* being followed intraspecifically and by individual fish of the following species: *Thalassoma pavo*, *Coris julis*, *Diplodus sargus cadenati* and *Serranus atricauda*. This study was carried out over a total of some thirty-five hours between October 2001 and August 2002, in shallow water over sandy bottoms in the vicinity of the islands of Terceira and São Miguel, Azores (NE Atlantic). Red mullet search for benthic animals in the sand with their snout and barbels and feed on them. This behaviour attracts the attention of other species, which take advantage of the disturbance and capture prey themselves. Cleaning behaviour was also observed between *M. surmuletus* - "clients" and *T. pavo* and *C. julis* - "cleaners". This cleaning behaviour occurs when the "cleaners" follow the red mullet.

### Zusammenfassung

In dieser Untersuchung berichten wir wie *Mullus surmuletus* intraspezifisch sowie durch einzelne Exemplare der folgenden Fischarten verfolgt wird: *Thalassoma pavo*, *Coris julis*, *Diplodus sargus cadenati* und *Serranus atricauda*. Diese Untersuchung wurde über einen Zeitraum von insgesamt 35 Stunden von Oktober 2001 bis August 2002 in flachem Wasser über Sandboden, nahe der Inseln Terceira und São Miguel (Azoren, nordöstlicher Atlantik) ausgeführt. Die rot-gestreiften Meerbarben suchen mit ihre Schnauze und Barteln im Sand nach benthonischen Beutetieren. Dieses Verhalten wirkt anziehend auf andere Fischarten, die diese Störung des Bodens ausnutzen um selbst an den aufgewirbelten Bodentieren mit zu fressen. Putzerverhalten zwischen *M. surmuletus* als „Wirt“ und *T. pavo* und *C. julis* als

„Putzer“, wurde ebenfalls beobachtet. Dieses Putzerverhalten findet während die „Putzer“ den Meerbarben folgen, statt.

### Résumé

Dans cette étude, nous rapportons comment *Mullus surmuletus* est suivi de façon intraspécifique et par des individus des espèces suivantes: *Thalassoma pavo*, *Coris julis*, *Diplodus sargus cadenati* et *Serranus atricauda*. Cette étude s'est étalée sur un total d'environ trente-cinq heures, entre octobre 2001 et août 2002, en eau peu profonde, sur fonds de sable, près des îles de Terceira et São Miguel, Açores (NE de l'Atlantique). Les rougets cherchent des animaux benthiques dans le sable à l'aide de leur rostre et de leurs barbillons pour s'en nourrir. Ce comportement attire l'attention d'autres espèces qui profitent du dérangement et s'emparent de proies. Un comportement de nettoyage a été également observé entre *M. surmuletus* comme "clients" et *T. pavo* et *C. julis* comme "nettoyeurs". Ce nettoyage a lieu quand les "nettoyeurs" suivent le rouget.

### Sommario

In questo studio si riporta come individui di triglia di scoglio (*Mullus surmuletus*) vengano seguiti da altri della stessa specie e di specie diverse, in particolare *Thalassoma pavo*, *Coris julis*, *Diplodus sargus cadenati* e *Serranus atricauda*. Lo studio è stato eseguito tra ottobre 2001 e agosto 2002, per un periodo complessivo di circa 35 ore, lungo i bassi fondali sabbiosi delle isole Terceira e São Miguel, Azzorre (NE Atlantico). La triglia di scoglio va alla ricerca di piccoli animali bentonici nascosti nella sabbia aiutandosi con i barbigli posti sotto il mento. Questo comportamento attira altre specie, che ne traggono vantaggio catturando alcune prede disturbate dall'azione della triglia. E' stato osservato che *M. surmuletus* può comportarsi come "cliente" di pesci pulitori quali *T. pavo* e *C. julis*. Tale situazione si verifica quando le due specie seguono la triglia durante la ricerca del cibo.

## Introduction

The striped red mullet, *Mullus surmuletus* Linnaeus 1758, is a bottom-dwelling species, preferring rough bottoms and soft, sandy substrates on the continental shelf of the Mediterranean and the north-eastern Atlantic (Hureau, 1986). It is the only species of Mullidae occurring in the Azores Islands (Santos *et al.*, 1997). It feeds on benthic species with low mobility, which are either cryptic or buried in the substrate. Their highly-developed hyoid barbels are used to locate prey (Gosline, 1984; Lombarte & Aguirre, 1997). Aguirre & Lombarte (1999) mention the possibility that this species is guided to its prey by sound.

Many behavioural patterns and morphological adaptations in fish have evolved in connection with the capture of food (Labropoulou & Papadopoulou, 1999). The mechanisms employed by fish for feeding are adaptations enabling them to take advantage of particular types of prey (Alexander, 1974). The foraging activity of *Mullus surmuletus* is the basis of most of its intra- and interspecific behavioural interactions. The strategies that groups of animals use to benefit from the feeding behaviour of a nuclear species are a matter of continuing study (Labropoulou & Eleftheriou, 1997). Among these interactive activities, cleaning symbiosis and following behaviour are of particular

interest (Poulin & Gruter, 1996). In the former, the cleaner fish removes ectoparasites, tissues or mucus from the body of a co-operating fish known as the client (Arnal *et al.*, 2000). In the second, the follower species, normally a generalist, opportunistic fish, takes advantage of the disturbance by capturing prey not targeted or dispersed by the nuclear one (Strand, 1988). This behaviour is widespread and, according to the authors, benefits the followers without affecting the nuclear species (Diamant & Schpiegel, 1985).

In some cases, the nuclear species is not a fish but, for example, a sea star (see Gibran, 2002).

In this paper we describe following associations between *M. surmuletus* and *Thalassoma pavo*, *Coris julis*, *Diplodus sargus cadenati* and *Serranus atricauda*.

We also describe cleaning symbiosis between this species and the small labrids *Coris julis* and *Thalassoma pavo*.

## Methods

**Study site:** all observations were made at Terceira Island and St. Miguel Island in the Azores (Lat.: 36° to 40° N; Long.: 24° to 32° W, Fig. 1). The sites chosen were between the south-east and the north coast of Terceira Island and at Ilhéu Da Vila (S. Miguel). All of

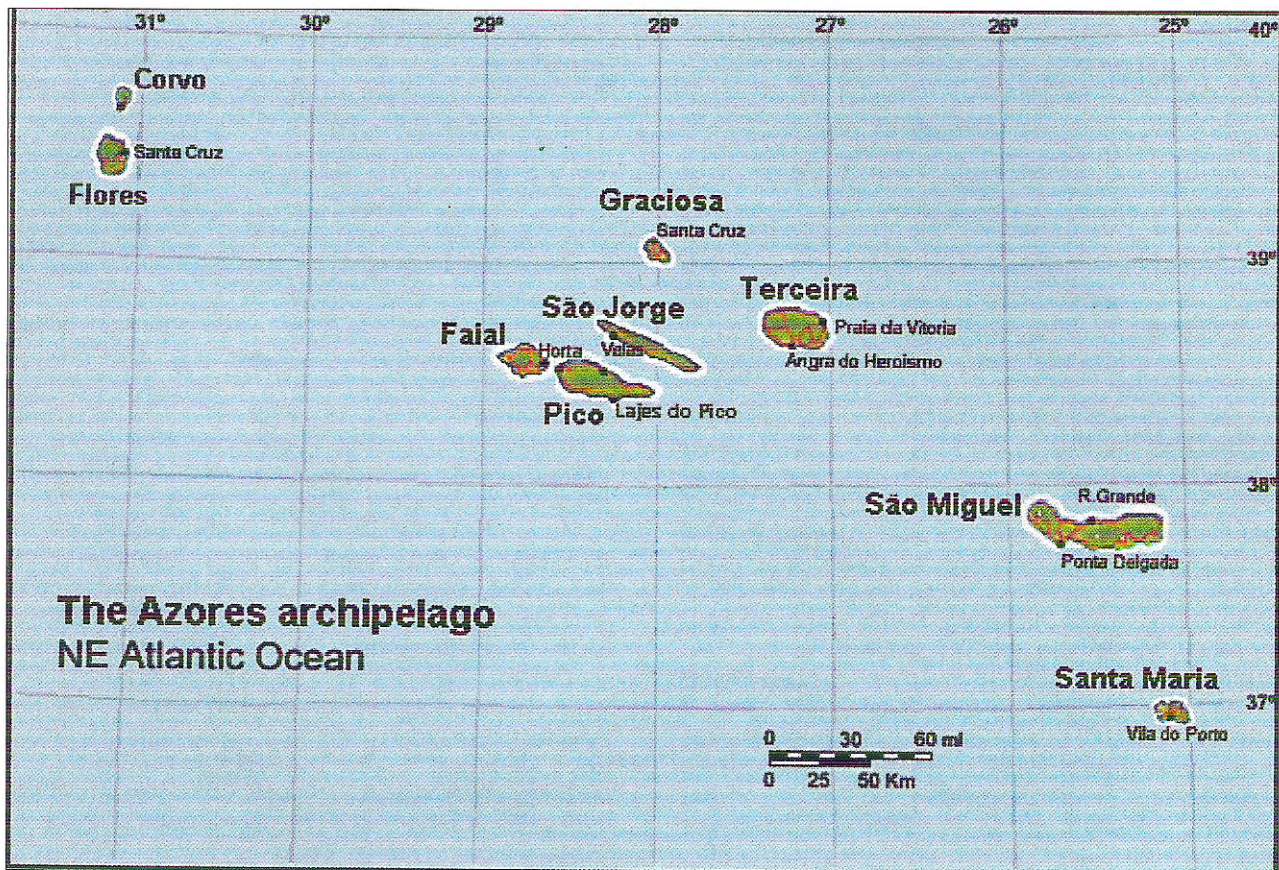


Fig. 1. The Azores Archipelago (NE Atlantic).

the sites were in shallow water (< 10 m), generally with sandy or mixed sand and rock bottoms where *M. surmuletus* is frequently found.

### Behavioural observations

Observations were carried out between October 2001 and August 2002. Observations were made during 35 hours of daytime snorkelling. Notes were made and photos taken under water.

Observations were made from far enough away (about 2 m) to avoid disturbing the fish. Once located, an individual would be followed for as long as possible. Any changes in its position were considered moves, including changes in orientation on the same spot.

### Results

***Mullus surmuletus* as a nuclear predator:** each follower species displays different behaviour when interacting with *M. surmuletus*. The following species were seen as followers: *T. pavo*, *C. julis*, *Diplodus sargus cadenati*, *Sphoeroides marmoratus*, *Serranus atricauda* and *M. surmuletus*.

**Interactions involving *Thalassoma pavo* (Labridae):** all the observed individuals of this species were either juvenile or female. They were present in large numbers at each observation. In a specific 30-minute observation, one specimen of *M. surmuletus* was followed by 24 *T. pavo*. These inhabit residential areas, where they feed and interact intra- and interspecifically. *T. pavo* follows *M. surmuletus* as the latter search for food in the vicinity of their residential and interaction areas. The time spent near the nuclear species is relatively limited (M = 5.2 minutes, SD = 1.4).

**i. Approach and foraging behaviour:** *T. pavo* individuals approach the nuclear species quickly, compared with the other follower species considered in this study. When they detect one or more *M. surmuletus* nearing their intervention area, they quickly swim towards them. The *T. pavo* surround the red mullet, adopting different stationary or moving postures. They whirl around each individual as they investigate the spot just excavated by the red mullet, moving above and around and sometimes beneath them, hovering there, as they capture their prey (obs. N = 10). Usually they flank the red mullet, facing either way, and are often in close contact. They may also remain face to face, feeding from exactly the same spot without apparent inhibition or dispute. Sometimes their behaviour is so energetic that the nuclear species is almost "expelled" from its spot, forcing it to search for a new food source elsewhere. As the red mullet finds new feeding grounds, the wrasse rush after them to take further advantage. If a spot abandoned by a red mullet is particularly interesting, the wrasse may remain there briefly. They then follow the red mullet closely, but keep their distance. In one particular

observation, three *M. surmuletus* were scooping the bottom, side by side and close to each other. A wrasse started to investigate the area around the first red mullet (whirling around it and stopping just in front of it). It then circled around the second red mullet, and then the third, moving exactly as before.

**ii. Agonistic behaviour:** we observed 45 agonistic displays: 27 intraspecific and 18 interspecific. Of the latter, 10 were directed at *D. s. cadenati*, six at *C. julis* and two at *S. mediterraneus*. All these confrontations took place between followers or individuals in close proximity to the red mullets.

The confrontations may be divided into two types: i) In the first (87.5%) small wrasse make isolated attacks on conspecifics or heterospecifics that are close to the nuclear predator or its surroundings; these end in direct aggressive contact; ii) in the second, *T. pavo* individuals actively guard the area immediately surrounding the red mullet and chase every other fish that comes close. After the attack, the wrasse briefly chase the intruder away for a distance and return to near the red mullet. The wrasse keep intruders under permanent surveillance.

**iii. Cleaning behaviour:** cleaning behaviour is difficult to distinguish from straightforward searching for food. This is because the wrasse circle the red mullet and keep in close contact with them, not simply to feed on prey in suspension or on the substrate, but also to collect ectoparasites from their "clients". This behaviour was recognised and recorded 20 times.

*T. pavo* frequently touch their red mullet "clients" on their heads, eyes, mouth and lips but mostly the operculum. On one occasion, a large *T. pavo* (15 to 20 cm TL) positioned itself side by side with a red mullet, touched its right operculum, then whirled around it while attacking three specimens of *D. sargus cadenati*. In fact, as these cleaning interactions occur, the wrasse tend to become more aggressive, often attacking other fish.

**Interactions involving *Coris julis* (Labridae):** like the above species, *Coris julis* individuals also inhabit residential areas, where they feed and interact intra- and interspecifically. Observations on this species included juveniles as well as adults that showed obvious sexual dimorphism.

**i. Approaching and foraging behaviour:** compared with *T. pavo*, the *Coris julis* move more slowly, approaching the red mullet in a slower, stealthier manner. They also make contact with individual *M. surmuletus* but less frequently, and swim in circles rather than in a straight line, at a constant depth in mid-water.

On seeing one or more red mullet, the wrasse swim slowly towards them. They may circle the red mullet, stay side-by-side and face-to-face, or maintain one of these postures as the red mullet investigates the disturbed bottom. Like *T. pavo*, *C. julis* may closely approach the red mullet and position itself on top or

even beneath it. These postures between follower and followed are maintained as the red mullet searches the bottom.

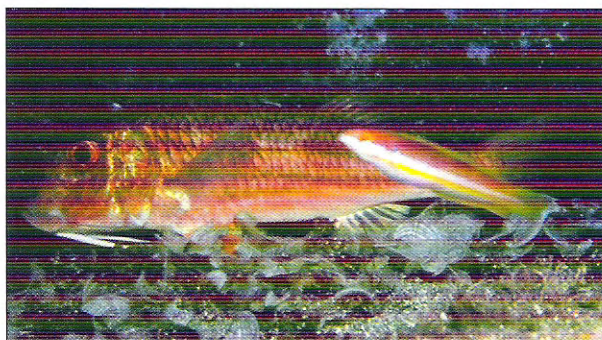
Juvenile *C. julis* seem to approach red mullet in a more agile manner than *T. pavo* (Fig. 2). However, we also noticed adult males close to *M. surmuletus* individuals, searching for and capturing food at the exact spot being dug by them. We also observed two *C. julis* feeding on some suspended organic matter close to one of the red mullet.

**ii. Agonistic behaviour:** this behaviour was recorded a total of 16 times: six towards conspecifics, seven against *T. pavo* and three against *D. s. cadenati*. All these confrontations took place between fish that were either following or surrounding *M. surmuletus*. Aggression was seen in female (60%), male (30%) and juvenile (10%) *C. julis*. 90% of these were fast, isolated, very accurate attacks on individuals passing close by, and resulted in direct contacts. In the other 10%, the confrontations were followed by pursuit of the intruder. Having expelled the potential competitor, the individual returned to the vicinity of the *M. surmuletus* it had been following and resumed interaction.

**iii. Cleaning behaviour:** cleaning behaviour was observed a total of seven times in this species. Like *T. pavo*, *C. julis* individuals swim around their "clients", encircle and touch them frequently, especially around the lips, opercula and in the dorsal region. These contacts are faster and more difficult to see than any other type of behaviour.

**Interactions involving *Diplodus sargus cadenati* (Sparidae):** the majority (95%) of sea bream observed were small juveniles (TL < 10 cm). The remaining 5% consisted of adults. They were found in the shallows (< 5 m), at high density (> 50 individuals).

**i. Approaching and foraging behaviour:** juveniles of this species maintain a certain distance (> 30 cm) from *M. surmuletus* individuals. They may follow the red mullet for up to 15 minutes but always keep about the same distance away, keeping behind them while searching the newly excavated bottom. Small shoals



**Fig. 2.** Female *Coris julis* interacting with an adult *Mullus surmuletus*. Photo by Peter Wirtz ©imagDOP.

(up to 10 individuals) of these juveniles are seen following the red mullet in this way.

Adults keep much closer to the red mullet, even digging the bottom alongside them.

**ii. Agonistic behaviour:** the bream also fight amongst themselves near and around the red mullet they are following. We observed 15 such fights between conspecifics. Five of the confrontations involved a single individual defending a spot previously excavated by a red mullet from other bream. Three other such attacks were seen in another juvenile that was following a juvenile *M. surmuletus* for more than 5 minutes. Two of the other attacks were made on an adult (> 15 cm TL) following a *M. surmuletus* (> 35 cm TL). In this case the bream was not just following the red mullet, but also driving away every conspecific in the area that came too close. It drove away 3 other sea bream, assuming a vertical posture towards its opponents and displaying its dorsal fin, then swimming back towards "its" red mullet. At one point, it stayed behind a little longer searching an area just excavated by the red mullet. On returning to near the red mullet, it discovered 3 other sea bream there. One of these was about the same size and, immediately displaying its dorsal fin, kept the first bream away.

**Interactions involving *Sphoeroides marmoratus* (Tetraodontidae):** as with the majority of the follower species described above, there are no real limits to the distance between individuals of this species and the red mullet. They also whirl around *M. surmuletus* individuals, stopping in front of them and, showing particular interest in excavated or disturbed areas (Fig. 3). They usually stay behind the red mullet they follow. The number of *S. marmoratus* individuals following a red mullet was between one and five (n = 21,



**Fig. 3.** *Sphoeroides marmoratus* observing the digging of an adult *Mullus surmuletus*. Photo by Peter Wirtz ©imagDOP.

av. = 3.3). Agonistic behaviour was not seen in this species

**Interactions involving *Serranus atricauda* (Serranidae):** this species also follows the red mullet, contact is limited and, compared with species described above, they usually keep further away from them. They follow at a distance and their interest is confined to the areas excavated by them.

**Interactions with other red mullets:** red mullet are frequently accompanied by one or more conspecifics, especially juveniles. We once found nine juveniles from 10 to 15 cm long, digging the bottom together. We observed 21 pairs (an adult with a juvenile) of red mullet followed by other individuals. Normally, both the adult and juvenile search and dig the bottom together. Whenever the adult moves off, the juvenile quickly swims after it. In one case the juvenile stayed close beside the adult, moving below it when it found an interesting spot and searching exactly the same area, without aggression (both kept on digging and investigating the same place). Moving around the two red mullet were a male *C. julis* and two *T. pavo*.

We also saw two or three adults seeking food together on the bottom. As red mullet follow each other, they keep very close together. Assuming a variety of positions, they whirl around each other, investigating exactly the same spot. New individuals constantly join the group, and others move aside to forage elsewhere.

On one occasion, close to sunset, in dim light, we observed two juveniles grubbing about on the bottom around a motionless adult. A few moments later, the adult began to search for food close to the juveniles. They then all swam together to a new sandy spot. Again the adult remained motionless, with both barbels directed at the bottom. Next, one of the juveniles stopped beside it while the other continued to excavate the bottom.

**Interactions with rocky bottom species:** when *M. surmuletus* approaches rocky areas while foraging, it may confront other species. We observed 14 instances in which foraging red mullet came too close to territorial males of *Symphodus mediterraneus*, *Abudefduf luridus* and *Ophioblennius atlanticus*, which dominate the rocky subtidal zone and display aggressively to other benthic fishes (see Mapstone & Wood, 1975; Santos & Barreiros, 1993). When this happened, the red mullet immediately retreated and changed colour.

## Discussion

Habitat may be a key element in the foraging behaviour of *M. surmuletus*. Arcoletto *et al.* (1989) characterised *M. surmuletus* as an opportunistic user of feeding habitats, being more selective with the substrate than with prey. Sazima (1986) characterised *M. surmuletus* as "grubbers", which excavate while moving about, probing with the snout, working the barbels

in the sediment and feeding on benthic animals. In fact, these individuals are quite eclectic when choosing an area in which to search for food. This varies between sandy, mixed or rocky environments. Naturally, the choice of a particular environment may offer new arrivals a chance of following a nuclear predator and present new feeding opportunities. Mixed habitats would then prove suitable for species such as *C. julis*, *T. pavo* and *D. s. cadenati*, while sandy bottoms favour *S. marmoratus*, a major red mullet follower.

The degree of intra- and interspecific interaction is dependent on the habitat in which the fish are found.

Ehrlich (1975) noted that intra- and interspecific territoriality is increased by limitations of space. Considering that most of the underwater observations were made in a small bay (Negrito bay, at Terceira Island), and that most of the agonistic episodes were recorded in two specific places (Negrito Bay and Ilhéu da Vila - at S. Miguel Island) it is obvious that an increase of interrelations (cleaning, agonistic, etc.), while associated with feeding areas, is mostly related to the potential food source which, in this case, derives from the activity of foraging red mullet.

Interspecific foraging groups were a common feature of this study. They were composed of one or several red mullet, and specimens of *T. pavo*, *C. julis*, *D. s. cadenati*, *S. marmoratus*, and *S. atricauda*. Of the species that feed and interact with *M. surmuletus*, *S. atricauda* proved to be the least interested in and dependent on the relationship. Morato *et al.* (2000) refer to *M. surmuletus* as a prey of *S. atricauda*. If so, they not only follow *M. surmuletus* in search of new feeding opportunities, and thus confront them agonistically, but also, as opportunistic stalking predators, regard them as prey. Nevertheless, we did not observe predation of red mullet by *S. atricauda*. It may be added that any foraging species, in this case *M. surmuletus*, accepts a higher predation risk (Brick, 1998).

Cleaning interaction with *T. pavo* and *C. julis* is characterised by Arnal & Côté (1998) as typical of "facultative cleaners". The swimming patterns of these cleaners around their *M. surmuletus* clients differ from the classic display of patterns and poses. These are often species specific and typically entail a static headstand or tailstand position (Losey, 1972). In our case, the approaches were made as *M. surmuletus* foraged, limiting the possibility of posing or the soliciting of cleaning by the "clients".

All followers ("cleaners" or not) may exhibit territorial behaviour towards any other conspecific or heterospecific individuals, by approaching them or merely by staying close to the followed individual. The larger followers are more capable of staying with the red mullet and retaining exclusive use of the resource. This explains the high rate of attacks by *T. pavo* or *C. julis* on *D. s. cadenati* juveniles. The action of simply following one or more *M. surmuletus* may arouse

these competitive interactions aimed at securing and maintaining a potential food source.

This study is the first attempt to describe the ecological importance of *M. surmuletus* as a nuclear predator for a small range of follower species that, in the case of the two labrid species, may also engage in cleaning associations. Many such associations between different species occur in the Azores and have not been sufficiently studied or described. As stated by Gibran (2002), sandy and muddy bottoms are promising habitats for these associations as they harbour a wide range of bottom disturbing organisms.

Night observations may also reveal important associations and unknown or undescribed interactions.

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Cover: *Sphoeroides marmoratus* observing an adult *Mullus surmuletus* while it digs. Photo by Peter Wirtz ©imagDOP.



Córrego Divisão, where *Astyanax turmalinensis* was first collected. (See paper by Mauro L. Triques *et al.*, pp 145-150, this issue).