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Habitat selection and spatial segregation in three pipefish species

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Abstract

Habitat partitioning was investigated within a guild composed of three sympatric pipefish species, namely *Syngnathus typhle, Syngnathus abaster* and *Nerophis ophidion*. Field surveys of patterns of pipefish abundance among different seagrass habitats (each dominated by a different seagrass species) were combined with laboratory studies on habitat choice and microhabitat use in the three species. Results showed that *S. typhle* and *N. ophidion* occurred with higher abundance in the *Cymodocea nodosa* meadow, which is characterised by longer leaves and intermediate shoot density compared to the *Zostera marina* and *Nanozostera noltii* habitats. By contrast, *S. abaster* showed higher abundance in the *Z. marina* meadow than in the other meadows. Males of *N. ophidion* also showed significant habitat choice in behavioural tests, preferring long over short seagrass leaves, whereas in the other species habitat choice experiments did not show any significant results. In terms of microhabitat use, the three species tended to segregate along the vertical axis, with *S. abaster* spending significantly more time near the bottom, while *N. ophidion* and *S. typhle* preferred to use the intermediate and the top portion of the artificial seagrass. Results are discussed in the light of the current knowledge on habitat partitioning within fish guilds, especially in relation to vegetated aquatic systems.

Keywords: pipefish; seagrasses; habitat partitioning; microhabitat

1. Introduction

Habitat selection in fish species is influenced by the degree of habitat structural complexity, the level of interspecific competition and the perceived risk of predation, as shown by several field and laboratory investigations (Werner and Hall, 1977; Savino and Stein, 1989; Utne et al., 1993; Jordan et al., 1996; Munday et al., 2001; Schofield, 2003). Aquatic vegetated systems, such as seagrass beds, represent an example of habitats characterised by a high degree of both structural complexity and spatial variability, thus offering the opportunity for sympatric fish species to partition their habitat (Curtis and Vincent, 2005). Within these systems, sympatric pipefish belonging to the family Syngnathidae are an excellent example of a taxonomic and an ecological ''guild'', showing high levels of habitat partitioning both among and within seagrass habitats (Howard and Koehn, 1985; Kendrick and Hyndes, 2003; Curtis and Vincent, 2005).

Syngnathids are cryptic fish, which occupy either the seagrass canopy or reside at the sediment-water interface, with different species often co-existing on the same seagrass beds (Howard and Koehn, 1985; Teixeira and Musick, 1995; Vincent et al., 1995; Kendrick and Hyndes, 2003; Curtis and Vincent, 2005). In the Venice lagoon, three sympatric pipefish species are abundant on the seagrass beds (Riccato et al., 2003; Malavasi et al., 2004; Franco et al., 2006a): *Syngnathus typhle, Syngnathus abaster* and *Nerophis ophidion*. Although information on life history, reproductive behaviour and trophic ecology of these three species are relatively abundant in the literature (Berglund et al., 1988; Tomasini et al., 1991; Franzoi et al., 1993; Campolmi et al., 1996; Riccato et al., 2003; Franzoi et al., 2004), little is known about the distribution of these species in different seagrass habitats and the mechanisms of habitat choice and partitioning. As reviewed by Tokeshi

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(1999), habitat represents one of the three main ecological axes, along which resource partitioning among closely related species should be analysed. According with this author, habitat axis should be analysed at different scales, from the largest scale of landscape to the smallest scale of microhabitat.

In this paper, habitat partitioning among these three pipefish species was investigated in the Venice lagoon at two different scales: (1) by comparing abundance of pipefish species in three different seagrass meadows within the Northern basin of the Venice lagoon; (2) by testing for habitat preference and microhabitat use in laboratory experiments. To achieve this goal, we combined a field survey conducted during Summer and Autumn 2005 in the Northern basin of the lagoon, with laboratory experiments carried out in an aquarium under controlled conditions. Abundance of the three species were obtained and compared across seagrass habitats dominated by different seagrass species, *Zostera marina, Nanozostera noltii* Honermann and *Cymodocea nodosa*, after controlling for the differences among these habitats in terms of structural complexity (leaf height, leaf density and shoot density). Habitat preference was investigated by testing for fish choice between artificial seagrasses characterised by different structural complexity (such as leaf length and density) and by comparing the microhabitat utilisation in terms of the relative position held along the leaf by each species.

2. Materials and methods

2.1. Study species

The three pipefish species investigated represent a large proportion of the total fish abundance in the shallow water seagrass habitats of the Venice lagoon (Franco et al., 2006a). They constitute both an ecological guild (*sensu* Root, 1967), as they feed on small crustaceans and share the seagrass habitats (Riccato et al., 2003; Franzoi et al., 2004), and a taxonomic guild, according with Simberloff and Dayan (1991).

Syngnathus typhle (broad-nose pipefish) is a medium-size, green-brown, pipefish, with a maximum length of about 35 cm (Muus and Nielsen, 1999). *S. typhle* reaches sexual maturity at about 11 cm of total length, brooding lasts from 4 to 6 weeks depending on temperature (Vincent et al., 1995), and it is a sex role reversed species with males limiting female reproductive rate (Berglund et al., 1988).

Syngnathus abaster (black-striped pipefish) is the smallest Mediterranean pipefish, reaching a maximum of 17 cm of total length. The sexual maturity is reached after 3–4 months with a total length of about 6 cm (Tomasini et al., 1991) and the incubation period lasts about fifteen days at a temperature of 20–21 °C. The body of both species is typically slender and elongated, with males carrying eggs under their tails in a well-defined brood pouch.

Nerophis ophidion (straight-nose pipefish), is a small and slender green-brown pipefish with a vermiform shape characterised by a strong sexual dimorphism with females bigger than males. It is a very cryptic species, with a weakly prehensile tail, holding the fish aligned with the seagrass. The species is sex-role-reversed: the potential reproductive rate of females exceeds that of males, with females actively competing for access to males (Berglund et al., 1989; Rosenquist, 1990). Males bring eggs glued onto the ventral surface of their trunk, and brooding takes about 4 to 6 weeks depending on water temperature (Berglund et al., 1986).

2.2. Study area and seagrass habitats

The Venice lagoon is located in the Northern Adriatic Sea and is the largest wetland coastal area of the Mediterranean basin. The lagoon is about 50 km long and 10 km wide with a longitudinal axis in the north-south direction. The total surface area is about 550 km^2 with an average depth of about 0.5 m. The lagoon communicates with the sea through three inlets, Lido, Malamocco and Chioggia and an underlying network of navigation channels connects these inlets with the inner shallow areas. Tides are mainly semidiurnal and the mean tidal range is about 55 cm with a spring tide of 110 cm (Cappucci et al., 2004). The field surveys were conducted in three different stations in the northern part of the Venice lagoon (A, B and C, Fig. 1). In each station, some environmental variables were measured to obtain a more detailed description of the seagrass habitats investigated. In particular, water temperature and salinity were measured before sampling using a digital thermometer ($\pm$ 0.1 °C) and a temperature refractometer ($\pm$ 1), respectively. Furthermore, water depth and seagrass coverage data were collected. Seagrass coverage was assessed on the basis of five classes, as follows: 0 = 0% percentage coverage; 1 = seagrass percentage from 0% to 5%; 2 = from 5% to 50%; 3 = from 50% to 75%; 4 = from 75% to 100%.

Site A (45°25′15″ N, 12°20‘44″ E). This site is characterised by a single uniform patch of *Zostera marina*, the meadow is about 300 m long and 40 m narrow. Water depth during sampling ranged between 1 and 1.2 m. Water temperature ranged from 25.2 by summer to 20.1 °C by autumn, and salinity varied from 35 to 36. Seagrass coverage was ranked as 4 both in summer and autumn.

Site B (45°26′18″ N, 12°23′18″ E). In this station *Cymodocea nodosa* forms an homogeneous bed on gentle sloped coarse sandy bottoms. The meadow is about 500 m long and 35 m narrow, water depth during sampling ranged between 0.80 and 1.2 m. Water temperature ranged from 24.9 by summer to 20.2 °C by autumn, whereas salinity was between 35 and 36. Seagrass coverage was 4 both in summer and autumn.

Site C (45°26′33″ N, 12°23′46″ E). This site is characterised by a little patch (40 × 40 m) of *Nanozostera noltii* surrounded by a mixed meadow of *Zostera marina, Cymodocea nodosa* and *N. noltii*. Water depth during sampling ranged between 0.5 and 0.9 m. Temperature varied from 24.8 in summer to 20.4 °C in autumn, and salinity ranged from 34 to 36. Seagrass coverage was about 4 both in summer and autumn.

As shown in Fig. 1, all the sampling stations are located within a radius of approximately 5 km. This means that the three meadows are geographically close, sharing larger scale influences such as tidal factors, water currents and climatic conditions (Jackson et al., 2002).