Temporal fluctuations and settlement patterns of native and Lessepsian herbivorous fishes on the Lebanese coast (eastern Mediterranean)

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Synopsis

We provide here the first information on the abundance, settlement patterns and microhabitat use of settlers of two Lessepsian siganid species, Siganus rivulatus and S. luridus, in comparison with the two main native herbivores, Sparisoma cretense (Scaridae) and Sarpa salpa (Sparidae). S. rivulatus was the most abundant species (72%), followed by S. cretense (20%) and S. luridus (8%), whereas S. salpa was rare (<1%). A clear pattern of settlement could be established for S. rivulatus and S. cretense, with similar timing in 1999 and 2000. S. cretense settled in schools late June, while S. rivulatus settled mid-July. A few solitary settlers of S. luridus were observed in July and August, but none of S. salpa. All these herbivorous fish species settled in protected shallow areas offering hard substrates and algal communities. S. rivulatus was the most tolerant and adaptable species, able to settle on a large range of substrates and habitats, including rock pools, muddy harbours and sea grass beds. In the eastern Mediterranean Sea, S. rivulatus might have benefited from a release of competition pressure due to the low diversity and abundance of native herbivores. It has probably replaced S. salpa on the coast of Lebanon, being more competitive than the native sparid.

Introduction

Since the opening of the Suez Canal in 1869, at least 300 Indo-Pacific marine species have entered the eastern Mediterranean basin, and are known as Lessepsian migrants (Por 1978, Boudouresque 1999, Galil 2000). These introductions have produced important changes in the species composition of eastern Mediterranean communities and have resulted in mixed Red–Mediterranean sea communities (Fishelson 2000, Galil 2000). A total of 59 fish species of Indo-Pacific origin are reported from the eastern Mediterranean (Golani 2002, Golani et al. 2002, Goren & Aronov 2002). Among them, two herbivorous fish species belonging to the Siganidae family, Siganus rivulatus Forsskål 1775 and S. luridus (Rüppell 1829) have become dominant in eastern Mediterranean coastal areas. They made up 5–15% of the Israeli inshore fishery (Department of Fisheries Israel 1980–1988 in Lundberg & Golani 1995) and have similar importance in Greek (Pap conco stantinou et al. 1986) and Lebanese waters (George & Athanassiou 1967). Apart from the two Lessepsian siganids, the main herbivorous fishes present in the Lebanese landings are the two native species, Sarpa salpa (Linnaeus 1758) (Sparidae) and Sparisoma cretense (Linnaeus 1758) (Scaridae). Contrary to what is observed on coral reefs, only a few large herbivorous fish species exist in the Mediterranean, these two species being the most abundant (Verlaque 1990). S. salpa is present in the whole Mediterranean Sea, whereas S. cretense is absent from the north western basin.
Settlement and recruitment are important factors in the population dynamics of fishes (e.g. Doherty 2002). Settlement success may depend on specific requirements of early juveniles and on the availability of suitable habitats (Harmelin-Vivien et al. 1995). In the north western Mediterranean, studies on benthic fish settlement are available for various coastal rocky fish species (Garcia Rubies & Macpherson 1995, Harmelin-Vivien et al. 1995) while in the eastern Mediterranean, no data exists on the settlement of coastal marine species. More generally, there is a serious lack of biological and ecological data on most fish species in Lebanese waters. Some information exists on the reproduction (e.g. George 1972, Bariche et al. 2003) and diet (e.g. Lundberg et al. 1999) of S. rivulatus and S. luridus in the eastern Mediterranean, but none on their abundance and fluctuations. On the other hand, no data are available on the ecology of the native herbivores (S. cretense and S. salpa) in this area.

The objective of the present study was to provide the first information on the temporal fluctuations and settlement of native and Lessepsian herbivorous fish species in the Mediterranean sea in order to understand how recruitment patterns may explain their relative importances. The spatial distribution of the settlers and their temporal variation over 2 years were first analysed. Then, the structure of microhabitats preferentially used by juvenile herbivores was determined. Finally, we offer some hypotheses to explain the relative importance of the herbivorous fish species currently observed on the Lebanese coast, particularly the success of the Lessepsian migrant S. rivulatus.

**Materials and methods**

**Study sites**

We carried out the present study along the shores of Lebanon (Figure 1) and data on microhabitat use were collected at 10 sites located north of Beirut, from Daoura to Selaata (33°55′N, 35°35′E, 34°18′N, 35°40′E). These sites were chosen for their topographical characteristics to encompass the main shallow habitats present in Lebanon. Transects were laid parallel to the shore and, at each site, the surface area surveyed included all habitats available to fish. Dimensions of transects were adapted to suit the various environments investigated: open bays, harbours and rock pools. BAY (100 m × 5 m transect) was located in a small bay in the Batrun area. SEA1 and SEA2 (100 m × 5 m) were both open water sites in Bouar. PORT1 (50 m × 1.5 m), PORT2 (50 m × 1.5 m), PORT3 (50 m × 1.5 m) and PORT4 (50 m × 1.5 m) were fishing ports located respectively in Batrun, Selaata and Jounieh. POOL1 and POOL2 (25 m × 3 m) were both rock pools (Vermetus formations) in the Batrun area, which were relatively closed and only flushed by tides and large waves. SAND was a polluted sandy beach in Daoura, relatively protected from local winds and currents, where a commercial seine fishery existed. For the temporal survey, data were collected monthly at BAY, PORT1 and POOL1 in 1999, and weekly at BAY and POOL1 in 2000. As development work was being carried out in Batrun harbour (PORT1) in 2000, it was not possible to continue the survey at this site the second year.

**Visual censuses**

We performed visual counts using snorkel or SCUBA diving following the procedure recommended by Harmelin-Vivien et al. (1985). Transects were laid parallel to the shore at shallow depth (0–2 m), as all the fish species studied are known to settle in shallow waters (George 1972, Poppier & Gundermann 1975, Woodland 1983, Garcia Rubies & Macpherson 1995, Harmelin-Vivien et al. 1995). While swimming slowly along the transect, the observer (MB) recorded the number and size of the individuals of the four species studied (S. salpa, S. cretense, S. rivulatus and S. luridus). The herbivorous blenniids occurring in shallow waters were...