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Marine Biogeography of the Mediterranean Sea: patterns and dynamics of biodiversity

Observations on the recruitment of *Musculista senhousia* (Mollusca, Bivalvia) in the Taranto seas (Eastern-Central Mediterranean Sea)

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SUMMARY

Juveniles and adults of *Musculista senhousia* were collected during four monthly benthic surveys carried out from September to December 2002 in the Mar Piccolo of Taranto (Southern Italy).

Two recruitment pulses were observed in September and December and a growth rate of about 2 mm/month was observed for the juveniles. In September and October two cohorts were shown in the sampled population.

The present study confirms the settlement of *M. senhousia* in the Mar Piccolo of Taranto. Considering the ephemeral nature of the mussel mats and the seasonal changes in some environmental factors in the study area, further studies are required in order to define the dynamics of such a settlement.

INTRODUCTION

The presence of non indigenous species in the Mediterranean basin has increased in the recent years. The spreading of these species is often due to adult or larval transport by fouling on the hulls of ships and in ballast waters, respectively (Occhipinti Ambrogi, 2001). Furthermore, the transfer of exotic species into the Mediterranean for aquaculture purposes often causes the entrance of other non indigenous species (Rossi, 1992).

When a non indigenous species reaches a new habitat it may die immediately because it cannot withstand the new climatic conditions or it may survive

without reproducing. On the other hand, it may take advantage of the new climatic conditions and settle. The introduction of non indigenous species, with an invasive behaviour, and their settlement in Mediterranean basins represent a difficult management problem. In fact, for those species, it is difficult to predict their dynamics and their interactions with indigenous species. The species with a wide ecological niche often become dominant due to the lack of natural predators (Mistri, 2002a).

The Asian date mussel *Musculista senhousia* (Benson in Cantor, 1842) is a small mussel widespread in several regions, from the Asian continent (*locus tipicus*) to the western coast of the USA, to the New Zealand and Australian coasts, along the Israel coast as far as the Red Sea, in the islands of Zanzibar and Madagascar as well as in Indo-China and Japan (Lazzari and Rinaldi, 1994). This small mussel was recorded for the first time in the Mediterranean along the Israel coast as a misidentification of *Modiolarca arcuata* (Hanley, 1844) (Barash and Danin, 1972). Successively, it was recorded in the western Mediterranean along the French coast (Hoenselaar and Hoenselaar, 1989). The first record of this species in Italy was from the brackish lagoons of Ravenna (Lazzari and Rinaldi, 1994) and later it was found in the Sacca di Goro, in Comacchio Bay (Turolla, 1999, Mistri et al., 2001), in Venice Lagoon (Russo and Mel, 2002) and in the Tyrrhenian Sea in the Gulf of Olbia (Savarino and Turolla, 2000). The occurrence of *M. senhousia* in the Taranto seas (North-western Ionian Sea) has been recently recorded (Mastrototaro et al., 2003).

The diffusion of this species on the Pacific coast of America is presumably due to transfer of the larval stage in ballast waters while the Mediterranean populations have possibly been introduced with exotic species such as oysters (*Crassostrea gigas*) and clams (*Tapes philippinarum*) used in aquaculture (Hoenselaar and Hoenselaar, 1989; Lazzari and Rinaldi, 1994).

M. senhousia is a small mussel with a life span of about 2 years and a very fast development, reaching a shell-length up to 25 mm in a year (Crooks, 1996). Its shell is thin, equivalve, oval with a modioliform outline and a subterminal umbone. The colour of the shell is olive-green with irregular brownish-purple markings and pale yellow-brown posterior lines.

The Asian date mussel is an opportunistic species that lives attached to hard substrata, on sand and mud flats and on seagrass beds. On soft bottoms it builds a common nest made of byssal threads, dead shells and sediment (Willan, 1985). *M. senhousia* lives, in preference, in protected areas such as lagoons and estuaries. Its abundant presence may have a strong impact on ecosystems, in fact its high density can exclude other infauna species (Crooks, 1996).

The presence of *M. senhousia* in the Taranto seas was casually recorded as part of a study on the marine ecosystem. During that study densities of up to 3800

individuals per square meter were observed on bottoms with pleustophytic algal felt (Mastrototaro et al., 2003). After this first record, the authors carried out some monthly samplings in the same area in order to evaluate the eventual persistent occurrence of the species and to provide a contribution to the knowledge of its recruitment pulses. The relevant results are reported in this paper.

MATERIALS AND METHODS

The town of Taranto is located on the coast of the north-western Ionian Sea (Eastern-Central Mediterranean). It overlooks the open sea to the south-west, the Mar Grande basin and north-eastward the basin of the Mar Piccolo which is made up of two smaller inlets (I and II inlet) (Fig. 1). The Mar Piccolo covers an area of 20.72 km^2. Its maximum depth is 13 m in the first inlet and 9 m in the second (Scardi et al., 1997). The salinity and the temperature follow seasonal variability and vary between 34 and 39 psu and between 10 and 30°C, respectively (Alabisio et al., 1997). The nitrate, nitrite, ammonia, silicate and phosphate concentrations are comparable with those recorded in the areas of the Adriatic Sea with urban pollution (Rinaldi et al., 1993). The Mar Piccolo basin

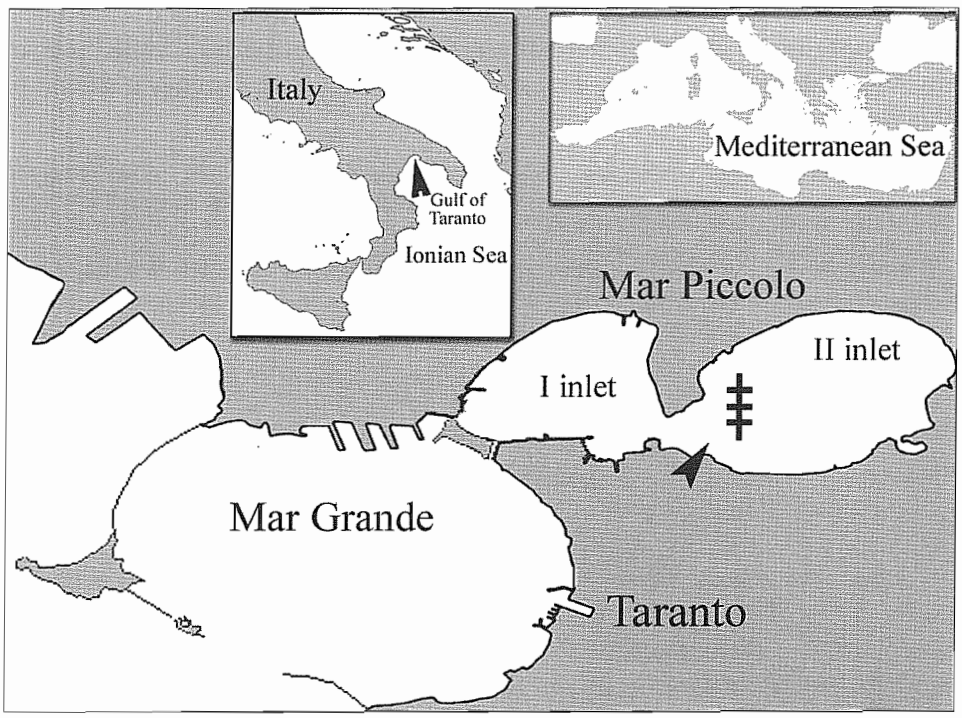

Fig. 1 - Sampling area in the II inlet of Mar Piccolo of Taranto

is connected to the Mar Grande through two small channels. The sampling area was in the second inlet of the Mar Piccolo (Fig. 1).

Monthly samplings were carried out by diving from September to December 2002. Each dive was conducted by two divers following a north-south transect at 3-5 m depth. Four samples were taken on a surface of about 400 cm^2 at a distance of about 3 meters apart. Each sample was sorted by species and the individuals of *M. senhousia* were counted and measured. The total length of the shell was measured to the nearest mm by means of a digital calliper. We used the shell-length as an estimate of the individual size. From now on, in the rest of this paper we will use the term size as inferred from the shell-length. Sex was macroscopically determined in mature individuals considering that the males show a white mantle and females a light orange mantle. The length-frequency distribution (2 mm size classes) of the sampled population was performed. The modal components in the size-frequency distribution were separated by means of the Bhattacharya method as reported in the FiSAT program (Gayanilo et al., 1995). Each representative component with a separation index greater than 2 was assumed to be a single cohort.

RESULTS

The species *M. senhousia* (Fig. 2) was found in 7 of the 16 sampled sites in the Mar Piccolo of Taranto. The size distribution of the samples is shown in the Fig. 3.

Fig. 2 - *Musculista senhousia* specimen

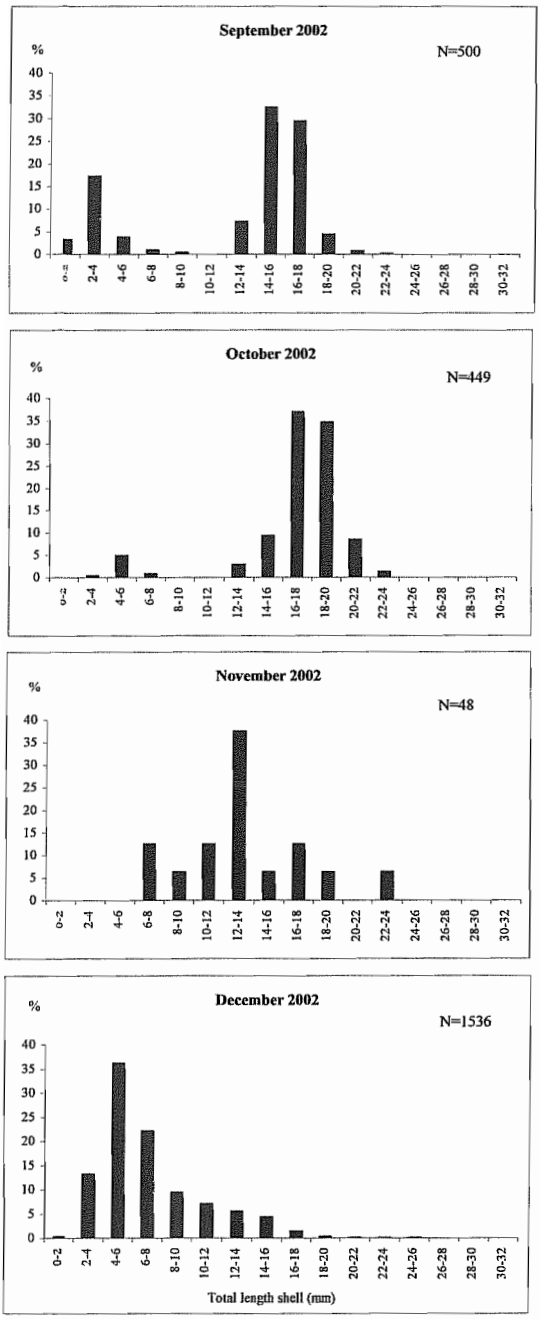

Fig. 3 - Length frequency distribution of *Musculista senhousia* specimens collected in the Mar Piccolo of Taranto from September to December 2002

The minimum and maximum individual sizes in the population sampled in September (500 specimens) were 1.47 and 22.68 mm, respectively. The sizes showed a bimodal distribution with the modal components being 3.05±1.11 mm and 15.81±1.49 mm. The smallest and largest sizes recorded in October were 3.78 and 23.31 mm, respectively. A similar bimodal distribution pattern was observed with the modal classes of 5.16±0.98 mm and 18.11±1.90 mm (449 specimens collected). In November only 48 living specimens were found. Their sizes ranged from 7.3 to 22.23 mm. The individuals collected in December (1536) had sizes between 1.9 and 24.31 mm. A positive asymmetry was shown around the mode of 4-6 mm.

Mature males and females were found during September and October. They constituted the second modal component in each month. Males ranged from 12.15 to 21.16 mm in September and from 12.43 to 23.31 mm in October. Females had sizes between 12.33 and 22.68 mm in the former month and between 12.22 to 23.31 mm in the latter. In September the sex ratio was M/F = 0.77, in October the proportion of males and females was around to 50% (M/F = 1.05) (Tab. I). No sexes were clearly

distinguished in the individuals of the first modal class in September and October or in any of the individuals collected during November and December.

Tab. I - Mature male and female specimens of *Musculista senhousia* collected in the Mar Piccolo of Taranto during September and October 2002 with indication of individual number (N), size range and sex ratio (M/F).

	Males		Females		sex ratio
	N	size range	N	size range	M/F
September 2002	**159**	12.15-21.16	**207**	12.33-22.68	0,77
October 2002	**214**	12.43-23.31	**202**	12.22-23.31	1,05

DISCUSSION AND CONCLUSIONS

After the first record of *M. senhousia* in the Mar Piccolo of Taranto during July 2001 (Mastrototaro et al., 2003), we confirm the settlement of this species in this Mediterranean area. In fact, juveniles and adults were collected each month and mostly during September and October when mature specimens were sampled. Two recruitment pulses were shown during September and December, respectively. The individuals belonging to the first recruitment pulse showed a modal progression in size until November. The specimens distributed around the first mode in September reached the size class of 4-6 mm in October and 6-8 mm in November showing a growth rate of 2 mm/month.

A massive decrease in the abundance of the samples was detected in November. Although, the causes of such a decrease have not been investigated, several factors can determine high mortality in *M. senhousia*, from overheating of the water, during summer, to reduced salinity during autumn (Willan, 1987; Hooker and Creese, 1996). In the Sacca di Goro the mussel beds were recorded with very variable densities. Here summer dystrophy may be responsible for very high mortality in the mussel population (Mistri et al., 2001; Mistri, 2002b). Changes in the population structure and abundance of *Mytilus galloprovincialis* in the Mar Piccolo of Taranto were found to be linked to both dystrophic conditions and very cold water temperature (Tursi et al., 1985). In the Mar Piccolo, marked depletion of dissolved oxygen was also recorded during autumn (Alabisio et al., 1997). Furthermore, predation by different organisms, such as snails, crabs, and ducks, may play an important role in population decrease (Reusch, 1998; Yamamuro et al., 1998; Mistri, 2002b).

The occurrence of two recruitment pulses would suggest a prolonged spawning period of *M. senhousia* in the Mar Piccolo of Taranto. In agreement with observations in the Sacca di Goro (Sgro et al., 2002), mature individuals in the Mar Piccolo of Taranto were collected during September and October. Sgro et al. (2002) reported that both females and males reach their first maturity

between 14-16 mm in size. They also reported that spawning starts in mid-September and lasts until November. Thus, considering that larval phase lasts from three to six weeks (Morton, 1974), after which individuals settle at about 0.25 mm (George and Nair, 1974; Kulikova, 1978) and that the growth rate in the early life stages is about 2 mm/month (Crooks, 1996; Creese et al., 1997; present paper), the smallest specimens collected in December might be the consequence of spawning in late summer-early autumn. The size distribution pattern in December showed an unimodal trend with a marked asymmetry, suggesting that the size composition in the sampled population could be due to a prolonged spawning period. Furthermore, the population sampled during September and October, differently from December, showed the presence of two, well separated, cohorts as a consequence of two discrete spawning events. Considering the above considerations on the duration and growth rate of the larval phase, the juveniles constituting the first cohort in September and October might be due to gamete emission during late spring-early summer. According to Sgro et al. (2002) and Mistri (2002b), the individuals belonging to the second cohort should be 6-8 months old and thus they might be due to spawning occurred during late winter-early spring of the same year.

Although this study only covers four months of the year, the recruitment pulses observed in the Mar Piccolo would suggest that gamete emission in *M. senhousia* occurs from late summer-early autumn to late spring-early summer, coinciding approximately with that of *M. galloprovincialis* in the area. In fact, Matarrese et al. (1993), reported that spawning in mussels extends chronologically from autumn to late spring. The phase of sexual inactivity occurs during July-August when the water temperature rises to approximately 25°C.

In *M. senhousia* the temperature also has a primary role in the reproductive cycle (Sgro et al., 2002). However, as shown by Mistri (2002b), within a prolonged spawning period, the year-by-year variability in the climatic conditions can determine changes in the gamete emission and thus in the recruitment pulses and population structure. In addition, the timing and intensity of larval settlement is controlled by physical and biological factors. In Lake Nakaumi (Japan), even though recruits are mostly found in summer and autumn, the recruitment appears to be continuous throughout the year (Chiba, 1977). On the contrary, in its native area, the population was first found alternately structured by a single and two cohorts and then disappeared (Tanaka and Kikuchi, 1978), showing characteristics of a fugitive species. In two sites of the east coast of New Zealand, Creese et al. (1997) recorded populations dominated by a single cohort, with sporadic and occasional recruitment into the existing mussel mats. All the abovementioned observations point out the high variability in the spawning and recruitment of *M. senhousia* according to the different study areas.

Considering the short life cycle of the Asian date mussel and its r-selective characteristics together with the remarkable seasonal changes in some environmental factors in the Mar Piccolo of Taranto, further studies considering the physico-chemical parameters of the waters, hystoloy of the gonad of the specimens and the annual coverage in the sampling, are required in order to clarify whether a self-perpetuating population has settled in the Taranto Seas and, if so, to describe its population dynamics.

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