RECRUITMENT OF THE BOX MUSSEL, *SEPTIFER BILOCULARIS* L.: EFFECTS OF SUBSTRATUM AND ADULT DENSITY

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ABSTRACT

An intertidal population of *Septifer bilocularis* L. was studied in Tongkeina, North Sulawesi, Indonesia. Open and closed cages were applied in field experiments to study the effects of four types of substrata on settling of *S. bilocularis*: live shells of adults, dead shells, coral rubble, and sand. Each substratum was tested with four levels of adult mussel density: 0, 10, 50, 100 individuals per compartment. The number of recruits as a function of cage, substratum, and adult density was analysed using Two-way ANOVA. The experiment showed that new recruits were affected by the substratum but not by the density of adults. The surface of adult box mussels was the most attractive substratum for recruits.

INTRODUCTION

Recruitment is defined as the appearance of spat in a new habitat, or among adults, after the larval stage. Planktonic larvae of box mussels, *Septifer bilocularis* L., spend some weeks (the precise duration is unknown) feeding in the water column. When larvae are competent and ready to settle, they have to find a suitable substratum, the quality of which may depend on physical, biological, and chemical properties (Thorson 1966; Hylleberg & Riis-Vestergaard 1984; Andre & Rosenberg 1991; Pawlic 1992). Metamorphosis may occur when larvae encounter an appropriate substratum, but can be delayed if a suitable environment is absent. The presence of an adult population generally indicates a suitable substratum which may induce larvae of box mussel to settle. However, at the same time larvae must avoid being eaten by the filter feeding adult mussels.

Ompi (1996) found that in the patches of box mussel, new recruits were predominantly attached to adult mussels, dead shells, and coral rubble. They were also found attached to dead corals and coral rubble covered by coralline algae away from the adult's mussel bed.

I wanted to test two hypotheses: (1) Box mussels do not have a particular substratum preference. (2) There is no effect of adult presence on recruitment.

MATERIALS AND METHODS

The field experiment was conducted on an intertidal flat at Tongkeina, District Molas, North Sulawesi, Indonesia. The flat is covered by corals, dead corals, rubble corals, and sand (Ompi 1996). A large population of *Septifer bilocularis* L. is present in this area.

Experimental design

Four types of substrata were used in the experiment: (1) Adult box mussels were collected in the study area by carefully cutting their byssus attachment. Mussels were transported to the marine science laboratory, and placed in an aerated aquarium. Subsequently, they were carefully scraped, washed, and dried to remove possible larvae on the shells. All mussels were checked to make sure that they were alive. (2) Some mussels were sacrificed, the soft parts removed, and the shells sun-dried for a week. Holes were drilled through the shells. A plastic string was passed through the holes, linking the shells together, and then fitted into the cages. (3) Coral rubble and (4) sand were collected about 500 m from the mussel's habitat. Rubble and sand were dried for one

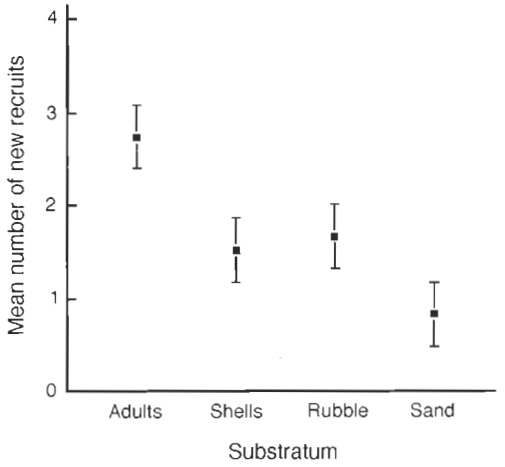

Figure 1. Box mussel *Septifer bilocularis* L. Mean number of new recruits as a function of substrata. (Bars: 95 % confidence interval).

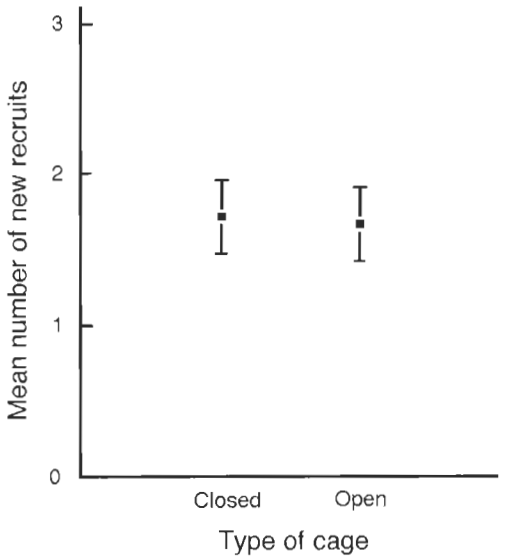

Figure 2. Box mussel *Septifer bilocularis* L. Mean number of new recruits in net covered and open cages. (Bars: 95 % confidence interval).

week (outdoors, sunshine) before use.

Two cages were used. Each cage was divided into 16 compartments each 15 x 15 x 6 cm. The bottom of each cage was covered with 0.5 mm mesh size plastic net. The substrata had three replicates and were randomly placed in the cages. The top of one cage was covered with a 0.5 cm mesh size plastic net, while the other cage was open. The distance between the two cages was 5 m. The cages were covered by sea water at low tide. They were placed where box mussels were abundant.

Three patch sizes (densities) of box mussel were applied: large patch (100 individuals), medium patch (50 individuals), and isolated patch (10 individuals). Coral rubble (without mussels) served as the control. The rubble had previously been used by box mussels for attachment of byssus, with the exception of that used in the control.

The experiment was left in the field for three months from September till mid-December 1996.

Box mussels from each substratum, density, and replication were harvested and stored in a freezer. The surface of box mussels, shells, and coral rubble were subsequently inspected using a magnifying glass and a dissecting microscope. Sand was sieved (0.5 and 1 mm mesh size) and checked directly under a dissecting microscope for recruits. New recruits were collected with a pipette, counted, and stored.

Data analysis

Data on number of recruits as a function of substrata and cages were tested using a Two-way ANOVA. Square root transformation was used to obtain homogeneity after using the F-max test. In cases where the ANOVA-test showed significant treatment effects, the means were compared using the SNK-test (Sokal & Rholf 1981).

RESULTS

The Two-way ANOVA, showed a significant effect of cage and substratum on recruitment ($P<0.05$).

Mean density of recruits was significantly higher on live adults than on dead shells, coral rubble, and sand (SNK-test, $P<0.05$). Mean densities of recruits on shells and coral rubble were not significantly different (SNK-

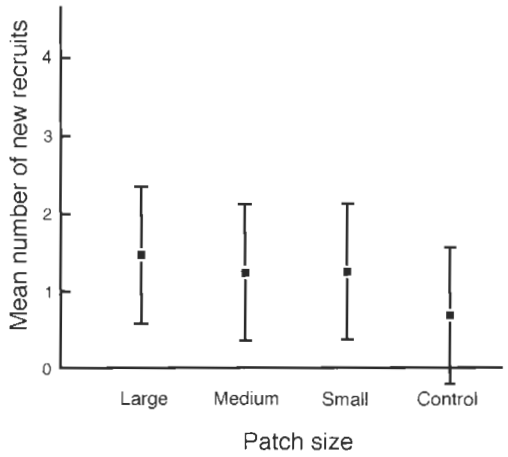

Figure 3. Box mussel *Septifer bilocularis* L. Mean number of new recruits as a function of adult densities in the open cage. Control: Coral rubble but no box mussel. (Bars: 95 % confidence interval).

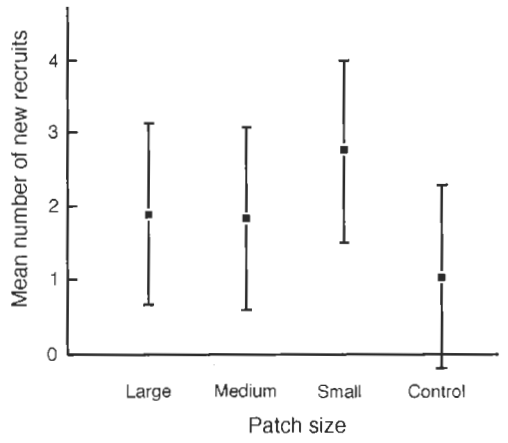

Figure 4. Box mussel *Septifer bilocularis* L. Mean number of new recruits as a function of adult densities in the net covered cage. Control: Coral rubble but no box mussel. (Bars: 95 % confidence interval).

test, P>0.05). Recruitment was significantly lower on sand than on shells and rubble (SNK-test, P<0.05) (Figs. 1, 2).

A high number of recruits were found attached to adults in both closed and exposed cages (Figs. 3, 4).

No interactions between the treatment cages and substrata were found (P>0.05). The mean distributions of recruits in the two types of cage are shown in Fig. 5.

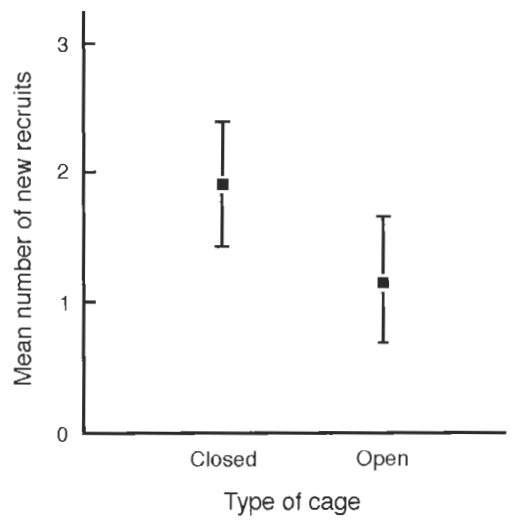

Figure 5. Box mussel *Septifer bilocularis* L. Mean number of new recruits as a function of the type of cage. (Bars: 95 % confidence interval).

DISCUSSION

The surface of adult box mussel was the most attractive substratum for recruits compared to dead shells, coral rubble, and sand. Marine animals are known to release chemical cues that may either induce larvae to settle (Chia 1990), or deter them from doing so (Sears *et al.* 1990). It is likely that adult box mussels release compounds which induce competent larvae to settle, as found in *Mercenaria mercenaria*. This clam settled in higher numbers on a substratum treated with clam extracts compared to untreated substratum (Keck *et al.* 1973).

In general, sand has a well developed microflora and fauna which may induce invertebrate larvae to settle and metamorphose (Woodin 1986). However, sand is also an unstable substratum (Levington 1972) which may hamper the establishment of juvenile box mussel. This would be in accordance with the present experiment showing

a low number of recruits on sand.

Adult suspension feeders may induce larvae to settle, but there is also a risk of being sucked into the inhalant siphon, ending up as prey (Thorson 1966; Mileikovsky 1974). Andre & Rosenberg (1991) found a decreasing number of recruits of suspension feeders with increasing number of adults. However, in the present study there was no indication of an effect of adult density on recruitment. Ompi (1996) also observed that settling of mussel larvae was not affected by the adults' density. This may be related to the behaviour of adult box mussels. The bottom of the experimental compartments was uniformly covered with mussels. But later, the mussels clumped along the edges and there was empty space among clumps in each cage.

In this study, recruits were also found on dead shells and coral rubble where adult mussels previously had been attached. This indicates that larvae may keep a distance from the adults when they settle.

The higher number of recruits observed in the closed cages compared to the open cages may be caused by the net itself, but also by the exclusion of predators (Reise 1985). Regarding the first possibility, the net structure could induce larvae to settle, and subsequently act as a buffer for crawling larvae until they could attach to substrata in the closed cages. Regarding predators, crabs are known to prey on box mussel (Ompi 1996), but also other benthic organisms, *eg* echinoids and sea stars may prey on small sessile organisms (Hyman 1955). Echinoids and sea stars were always found in the open cage and may have eaten some of the recruits.

Secondary settlement has been described for *Mytilus edulis* and suggested to be general in the family Mytilidae. According to Bayne (1964) *M. edulis* larvae should initially settle on filamentous algae (the primary settlement). Recruitment to the adult's beds followed after a period of growth and involved a second phase. However, McGrath *et al.* (1988) and Peterson (1984) reported direct settlement of larvae on adult beds of *M. edulis* and *M. californianus*. It is unknown if secondary settlement occurred in box mussels as found in *Mytilus edulis*.

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