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ECOLOGY OF THE INTERTIDAL BOX MUSSEL *SEPTIFER BILOCULARIS* L., NORTH SULAWESI, INDONESIA

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ABSTRACT

The density of box mussel at two stations ranged from a mean of 165 ± 267 ind/m^2 to a mean of 89 ± 115 ind/m^2. Box mussels were aggregated (I = > 1) (Morisita's Index). Mussels in small patches were large compared to mussels in medium and large patches. But, the mean size of mussels was not significantly different among stations (Two-way ANOVA). The number of recruits was different between stations, but not between patches of all sizes. In laboratory experiments, growth was only statistically different between mussels at medium density and small density (One-way ANOVA). Mortality was high in mussels in large groups. Physical and biological factors which may affect the abundance, size distribution, recruitment, growth, and mortality are discussed.

INTRODUCTION

Sources of disturbance, including biological interactions, have been studied with emphasis on wave action (Dayton 1971; Sousa 1984), desiccation (Suchanek 1978; Underwood 1980), substratum (Young 1983), and predation (Paine 1974). Disturbance may cause marine benthic organisms, which show patchiness or aggregation, to be removed from their substrata, to be stressed, or to die (Sousa 1985). Disturbance has been shown to affect the growth of mussels living in patches of various sizes (Okamura 1986; Lin 1989; and Newell 1990). The effect of patch size on the size distribution of bivalves within a patch has been studied by Svane & Ompi (1993), and Ompi (1995). However, patch size or aggregates vary with local conditions and species. The aim of this paper is to study the population structure of *Septifer bilocularis* with emphasis on abundance, size distribution, recruitment, growth, and mortality.

MATERIALS AND METHODS

Areas investigated

Two stations were studied in the intertidal zone of Tongkaina Molas in Manado Bay, North Sulawesi. Station 1 (at the cape of Tongkaina), is a wide tidal flat covered with live and dead coral blocks separated from the shore by an area with sea grasses, dead coral, sand and muddy sediments. Only a few mangrove trees are present. The area is not fully exposed at low tide, but just covered with sea water. Station 2 resembles station 1, except for a dense forest of mangrove at the upper tidal level. At Station 2, a wide tidal flat is covered with dead coral, coral boulders and sandy sediment. Sea grasses are found close to the upper tidal area. At low water, the area is exposed but still covered by sea water.

Sampling procedure

The abundance and distribution of box mussels were examined in 8 plots, each 1 m^2 (1 x 1 m) chosen at random in October 1994. The same sampling procedure was followed at each of two stations in the study area.

Distribution and recruitment were examined in November 1994 within 3 patches (isolated, medium, and large patches). Four replicates were sampled in each patch, using 15 cm^2 quadrants. Isolated patch size varied from 5-7 cm, medium patch size from >9-

12 cm, and large patches were >15 cm. Samples of box mussels and substrata were collected in plastic bags, labelled, and temporarily stored in a refrigerator. Samples were sieved through 0.5, 1, and 2 mm mesh size to collect recruits which were counted under a dissecting microscope (Nikon SMZ-2b). Shell length was measured as the maximum distance between umbo and ventral margin using Vernier callipers accurate to 0.05 mm.

Laboratory Experiment

Cleaned, medium sized box mussels were selected (12-17 mm). The box mussels were divided into 4 patches: isolated patch (1 individual), small patch (5 individuals), medium patch (15 individuals), and large patch (30 individuals). Mussels were individually numbered using nail paint. Each patch size had 3 replicates placed in aquaria (15 x 15 x 20 cm) filled with 1500 ml aerated sea water. The sea water was changed 2 times/ week. The box mussels were fed with natural plankton during the first week, and thereafter with microalga (*Tetraselmis* sp.) at a concentration of 3 x 10^5 ml^{-1}. Each replicate was fed 200 ml *Tetraselmis* culture 2 times per week. The experiment lasted from ultimo February to the first week of May 1995.

Data Analysis

Field distribution patterns were determined using Morisita's Index (Bakus 1990). To test the difference in size distribution, and number of recruits as an effect of patch size, a Two Way-ANOVA was used (Sokal & Rohlf 1981). The SNK-test was used as posterior test (Zar 1984). To test the effect of group living (density) on growth (size increment), one-way ANOVA was performed. In order to fulfil the assumptions of an analysis variance (ANOVA), the data were tested for homogeneity of variance using the F_{max} test (Fowler & Cohen 1990). For the degrees of freedom, the smaller number of observation was used (Fowler & Cohen 1990). Mortality was calculated as percentage of mean mortality.

RESULTS

Field data

Abundance and Distribution

The box mussels *Septifer bilocularis* were widely distributed on corals or dead coral blocks in the intertidal area of Tongkaina. Mussels were tightly attached to the hard substrata by byssus. The density of box mussels at station 1 ranged from 10-793 ind/ m^2 with a mean of 165 ± 267 ind/m^2. Mussels were aggregated (I = > 1). At station 2, the density ranged from 0-253 ind/m^2 with a mean of 89 ± 115 ind/m^2. Mussels were also aggregated (I = > 1). Morisita's Index was higher at station 1 than at station 2 (st. 1, I = 3.30; st. 2, I = 2.37).

Size Distribution

A Two-Way ANOVA test was performed to determined the difference in size distribution as an effect of patch size and station. A significant effect of patch size ($p<0.05$) but not of station ($p>0.05$) was found. There was no interaction with respect to patch size and station ($p>0.05$). The length distribution of box mussels is shown in Fig. 1.

Mussels located in the isolated small patch at station 2 were significantly larger than those situated in the medium patch (SNK-test; $p<0.05$). However, there were no size differences between box mussels living in medium and large patches (SNK-test; $p>0.05$), and between isolated small patch and large patch (SNK-test; $p>0.05$). At station 1, comparison among sizes of mussels living in small, medium, and large patches were not different (SNK-test; $p>0.05$).

Recruits

The density of juveniles as a function of patch size and station was tested using a Two-Way ANOVA. There was a significant effect of station ($p < 0.05$) but not of patch size ($p > 0.05$). There were no interactions with respect to patch size and station ($p > 0.05$). The distribution of the mean number of recruits among patches at the two stations is shown in Fig. 2. The number of new recruits was significantly larger at station 1 (SNK-test: $p < 0.05$) than at station 2 (Fig. 3).

Laboratory ExperimentsGrowth

A One-Way ANOVA test was performed to detect differences in the means of length increments. A significant effect of size was found ($p<0.01$). The mean increment in length was statistically larger in the medium density group, than in the small density group (SNK-test: $p<0.05$) but not different between the isolated and large groups (SNK-test: $p>0.05$). The distribution of mean increment in length is shown in Figure 4.

Mortality

The mortality was examined as mean mortality. Highest mortality occurred at medium patch density (38 %) followed by large patch density (33 %), and small patch density (20 %). No mortality occurred at isolated patch density.

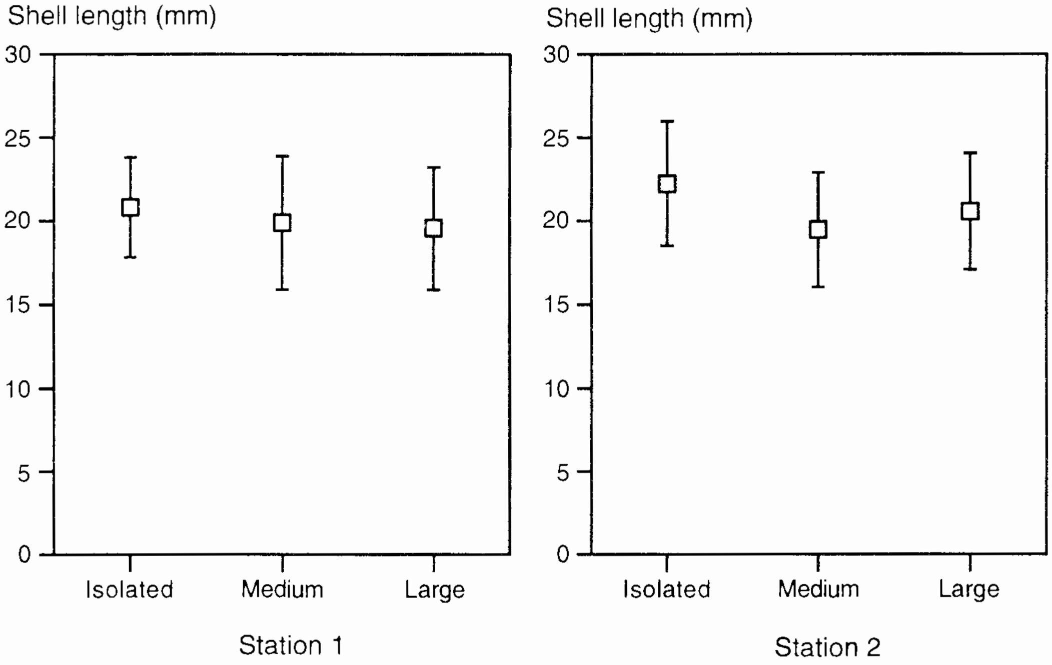

Figure 1. Mean shell length (mm) ± S.E. of box mussels sampled in patches of 3 sizes: isolated, medium, and large. Tongkaina Molas, Manado, North Sulawesi.

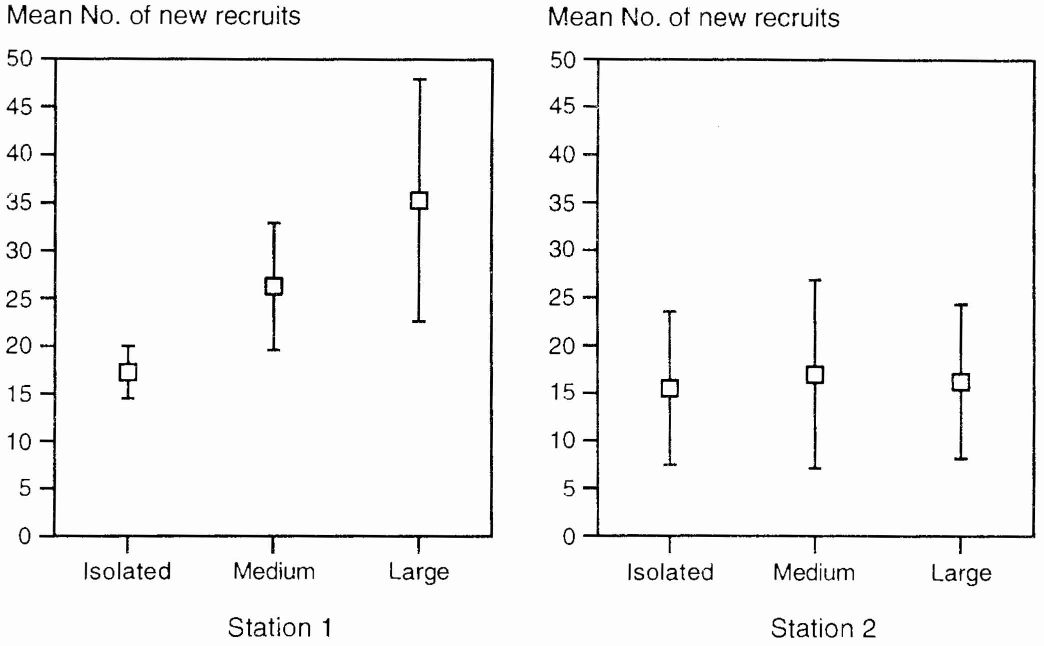

Figure 2. Mean number of new recuits ± S.E. of box mussels sampled in patches of 3 sizes: isolated, medium, and large. Tongkaina Molas, Manado, North Sulawesi.

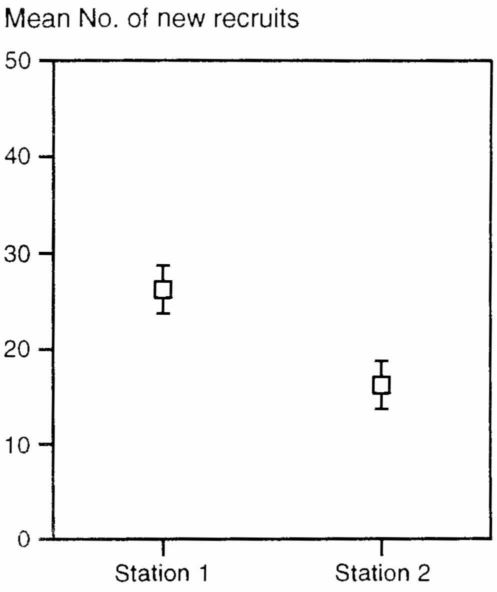

Figure 3. Mean number of new recruits ± S.E. of box mussels at two stations sampled in Tongkaina Molas, Manado, North Sulawesi.

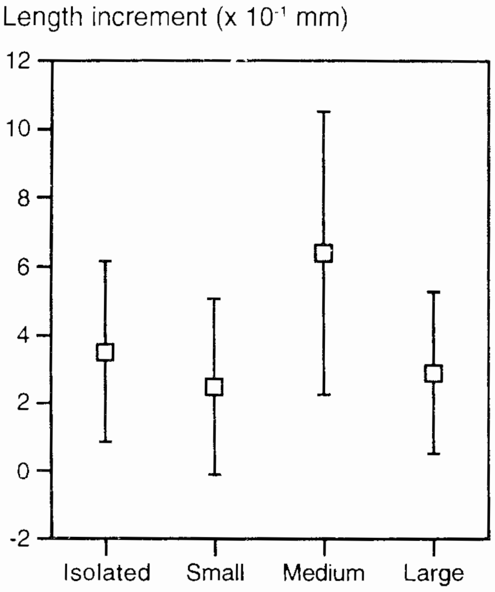

Figure 4. Mean length increment ± S.E. of box mussels from patch sizes (isolated, small, medium, and large). Laboratory experiment.

DISCUSSION

Box mussels were found in greater abundance at station 1 than at station 2. The distribution and abundance seemed to be a complex product of biological and physical factors determining recruitment and mortality (Seed 1976; Suchanek 1978; Bertness & Grosholz 1985; Okamura 1986; Svane & Ompi 1993). Variation in larval recruitment is due to the availability of competent larvae as well as the presence of inducing factors in the substratum (Thorson 1966; Luckenbach 1984; Chia 1989). Substratum quality, such as contour, texture, thermal capacity, and sediment characteristics could affect settlement (Thorson 1966; Crisp 1984; Young & Chia 1987). Paulic *et al.* (1991) showed that the biological and chemical nature of the substratum have the greatest influence on larval settlement. Unfortunately, no data are available on the quality of substrata in the present study area.

Sessile organisms are highly vulnerable to predators (Bayne 1976). Potential predators are whelks, starfish, and crabs (Seed 1976; Suchanek 1981; Svane & Ompi 1993). In this study, the main predators were most likely crabs which were abundant and observed to feed on the box mussels. Human collection can be excluded because box mussels are without commercial value. Of course, mortality can also be caused by physical factors such as desiccation, waves and currents (Bertness & Grosholz 1985; Sousa 1985) but I have no data to support this possibility.

In several field studies, an inverse relationship between adults and new recruits was found (Williams 1980; Moller 1986; André & Rosenberg 1991; Svane & Ompi 1993). In this study, the number of new recruits were not affected by patch size, but they were affected by station. In other words, the number of recruits might be influenced by local environmental factors. Larvae which can find a proper substratum may have a good chance to grow and reach the adult stage (Crisp 1976; Buss 1981). The latter authors suggest that marine benthic invertebrates could benefit from aggregation. Larvae that settle on, or near adults have chosen a habitat more likely to support post larval growth, than one chosen indiscriminately.

Growth of suspension feeding mussels may be influenced by intraspecific competition for food (Levinton 1972; Buss & Jackson 1981; Bertness & Grosholz 1986; Okamura 1986). Isolated mussels and mussels living in small clumps have access to more food, and grow faster than those associated with large clumps (Okamura 1986). Svane & Ompi (1993) showed that mussels situated in isolated small clumps or small patch sizes were larger compared to mussels in large patches. Mussels at the edge of patches were larger than elsewhere. Bertness & Grosholz (1985), and Peterson & Black (1987) found that the growth rate of mussels became reduced due to intraspecific competition for food at high densities In this study, the effect of patch size on length distribution was not constant between stations, and intraspecific competition for food may not be the only factor which affected growth. I suggest that physical factors such as wave action and desiccation play a major role.

Fre'chette & Bourget (1985 a,b), and Fre'chette *et al.* (1989) suggested that benthic filter-feeders may reduce phytoplankton biomass in near bottom waters. Asmus & Asmus (1991) showed that in an experimental flume, 20-30 % of the phytoplankton was taken up over a distance of 20 m. The uptake, which included both filtration and deposition among mussels, increased with increased phytoplankton biomass. However, since the growth rate of box mussels in my experiment was larger in groups of medium density than in groups of small density, but not in isolated and large groups, and since algal concentrations were identical in each treatment, then patch size was not a factor determining growth. But, deposition of microalgae in the aquaria may have affected the outcome of the experiment. Riisgaard & Randløv (1981) suggested that mussels (*Mytilus edulis*) could have maximum net growth efficiency on algal concentrations between 3 x 10^3 and 2.6 x 10^4 cells ml^{-1}. They also found that the filtration rate was reduced after 2 hrs at the high concentration of 3 x 10^4 cells ml^{-1}. In the present study, the algal concentration was 3 x 10^5 cells ml^{-1}, so decreasing filtration rate might occur and result in increasing deposition of microalgae on the bottom of the aquaria. This may cause increasing decomposition which again could cause high mortality in the group of high density.

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