THE TREE OYSTER *ISOGNOMON* (*PARVIPERNA*) SP.: EFFECTS OF AN AGGREGATED DISTRIBUTION

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ABSTRACT

Many organisms, which inhabit marine intertidal areas, are found in groups or patches. Patch formation involves processes such as disturbances and biological interactions. The tropical tree oyster *Isognomon* (*Parviperna*) sp. occurs in patches in the intertidal zone of Tanah Wangko, North Sulawesi, Indonesia. The effects of site (tidal level) and position within patches on size (length) and number of adults and recruits were tested using Two-Way ANOVA's. Length was found to be significantly affected by site and position. Significantly larger tree oysters were found in the low intertidal zone than in high and middle zones. Recruits were found in significantly larger numbers in isolated patches than elsewhere. Factors influencing the observed patterns are discussed.

INTRODUCTION

Marine benthic organisms in the intertidal zone experience mortality due to air exposure and biological interaction such as predation and intraspecific competition (Pickett & White 1985). These environmental conditions constrain organisms and influence their distribution and abundance. An aggregated or patchy distribution is a naturally occurring phenomenon which can be observed in the intertidal zone. In benthic organisms, both sessile and mobile, it may have adaptive value. According to Wrona & Dixon (1991) the factors regulating solitary or aggregated life patterns depend largely on the associated fitness cost and benefits determined by natural selection. The tree oyster *Isognomon* sp. is one of the marine benthic organisms which is attached on hard substrata in dense aggregates or patches. This bivalve belong to the Family Isognomonidae, Genus *Isognomon*, Subgenus *Parviperna* Iredale, 1939 (Abbott & Tucker 1974; Abbott 1991).

A study was undertaken to investigate the factors which regulate patch formation in the tree oyster. This paper describes size-distribution patterns, and tests effects of site, patch size, and position within a patch.

MATERIALS AND METHODS

The study area

The present study was carried out in the intertidal areas of Tanah Wangko estuary in Manado Bay. The substratum of the investigated area is heterogeneous. The low intertidal consists mainly of dead corals and large rocks, while the middle and high intertidal consist of rock and boulders on a sandy sediment. At low tide, the area is dry and influenced by one freshwater stream in the high intertidal zone and two streams in the low intertidal zone. The salinity was 5 ‰ at low tides and about 15 ‰ at high tides.

The tree oysters were distributed from the low to the high intertidal area attached to small and large rocks in dense aggregates or patches. On large rocks, the tree oyster was mainly found along the vertical parts. The observed surface areas of large rocks were from 963 to 1,257 cm^2, while the surface areas of small rocks were from 28 to 79 cm^2. At low tidal levels most of the large rocks were exposed to air, but at high tide, all rocks were completely covered with brackish water.

Field Sampling

Tree oyster patches at each site were sampled at the high intertidal level (HL), low intertidal level (LL), and middle intertidal level (ML). Small rocks were considered as isolated small patches. They were sampled in 4 replicates. Within the large patches, line transects were fixed vertically from the top edge of the rocks, and 4 core samples (cylindrical PVC tube, diameter 5.7 cm, and area 26 cm^2) were taken at the top edge, the bottom, and between the top edge and bottom. Furthermore, isolated small patches were also sampled in 4 replicates. The sampling was performed during March and April 1994.

The samples were sieved through a 0.5 mm mesh size, separated from other fauna, and stored in a refrigerator. The samples were cleaned and the shell lengths measured (the maximum distance between umbo and ventral margin) using a Vernier callipers accurate to 0.05 mm.

Data Analysis

A two-way ANOVA was used to test the difference in size, the number of adults, and recruits as an effect of position and size (Sokal & Rohlf 1981). One-way ANOVA was used to test difference in size as an effect of position in a large patch and an isolated small patch (Sokal & Rohlf 1981). SNK-test was used as a posterior test (Zar 1984).

In order to fulfil the assumptions of an analysis of variance (ANOVA) the data were tested for homogeneity of variance using Bartlett's test (Sokal & Rohlf 1981). Since the data were bimodally distributed, three oyster smaller than 10 mm were excluded to obtain normality. Tree Oysters smaller than 10 mm were considered as recruits and larger than 10 mm as adults. Recruits and adults were tested separately. The data were transformed to log + 1 (Fowler & Cohen 1990).

RESULTS

Effects of site and position

The results of two-way ANOVA on large patches, with position and sites as main effects, performed on shell length, are shown in Table 1. A significant effect of site and position was found. There were no interactions with respect to site and position. The mean size of the tree oyster in the investigated intertidal areas is shown in Fig. 1.

Effect of position

At the center position in a patch, tree oysters had a significantly larger mean size than the ones at the edge, high position (SNK-test; p<0.01), while no difference was found at the low position (SNK-test; p<0.05). Since no difference was found between oysters at the center compared to the low edge position, the mean shell length at the edge low position was excluded, and the mean shell length at the center position was compared to the isolated small patch (Fig. 1) This comparison showed that the oysters situated at the center position were larger than the oysters of isolated small patches (SNK-test; p < 0.01).

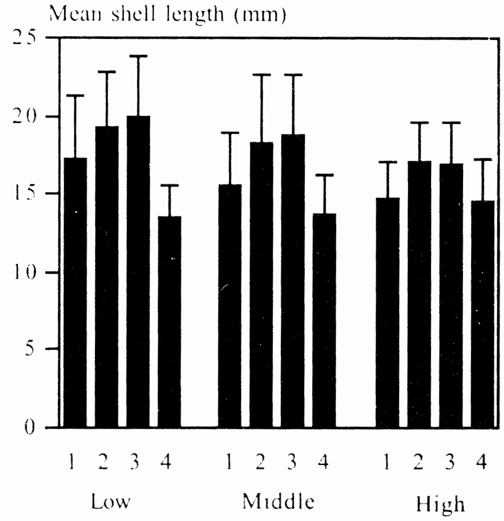

Figure 1. Mean shell Length of *Isognomon* (*Parviperna*) sp. 1 = edge, high position of large patch, 2 = center position of large patch, 3 = edge, low position of large patch, 4 = isolated small patch.

Effect of tidal level

The tree oysters were significantly larger in the low intertidal than in the high intertidal (SNK-test; p < 0.01) There was no difference in length of tree oyster in the low and middle intertidal (SNK-test; p > 0.01). Mean shell lengths are shown in Fig. 2.

Density of tree oyster

A significant difference in density of adults between sites was found (Table 2). The density was higher in the low intertidal compared with the high intertidal (SNK-test; p < 0.05), but there was no density difference between the low and middle intertidal (SNK-test; p > 0.05). No interaction in number of adults with respect to positions and sites was evident. The means of distribution of adults is shown in Fig. 3.

Recruitment

Oysters smaller than 10 mm were considered recruits. They had probably settled during the previous dry season in May - October 1993. A significant effect of sites and position on number of recruits was found (Table 3). There were no interactions with respect to position and sites. The distribution of the mean number of recruits among positions and patch sizes is shown in Fig. 4.

Table 1. Two-Way ANOVA. Shell length of tree oyster *Isognomon* sp. with position and sites as main effects (**:p<0.01, *:p<0.05; n.s.:not significant).

Source	df	SS	MS	F	P
Sites	2	1580.65	778.25	66.06	0.0001 **
Position	2	2061.96	1074.82	91.24	0.0001 **
Position * Sites	4	92.00	23.00	1.95	0.1 n.s
Residual	1486	17505.57	11.78		

Table 2. Two-way ANOVA. Density of tree oyster (> 10 mm) with sites and position in patch as main affects (**: p < 0.01; *: p < 0.05; n.s.: not significant).

Source	df	SS	MS	F	P
Position	2	44.22	22.11	0.43	0.713 n.s.
Sites	2	1800.72	900.36	13.95	0.0001 **
Position * Sites	4	582.78	145.69	2.26	0.089 n.s.
Residues	27	1742.5	64.54		

Table 3. Two-way ANOVA. Recruitment in large patch of *Isognomon* sp. (< 10 mm) with sites and position in the patch as main affects (**: p < 0.01; *: p < 0.05; n.s.. not significant).

Source	df	SS	MS	F	P
Position	2	1.0449	0.5225	5.90	0.007 *
Sites	2	2.0198	1.0010	11.41	0.0001 **
Position * Sites	4	0.3380	0.0885	0.95	0.45 n.s.
Residues	31	2.7270	0.5224		

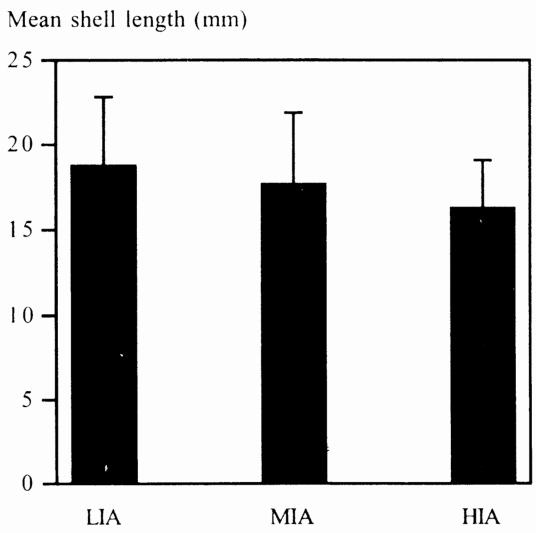

Figure 2. Mean shell lenght of tree oyster at three sites. LIA = low intertidal area, MIA = middle intertidal area, and HIA = high intertidal area.

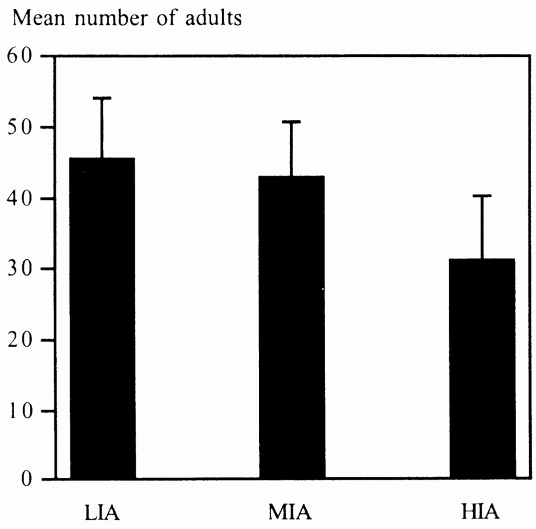

Figure 3. Mean adult distribution at three sites. LIA = low intertidal area, MIA = middle intertidal area, and HIA = high intertidal area.

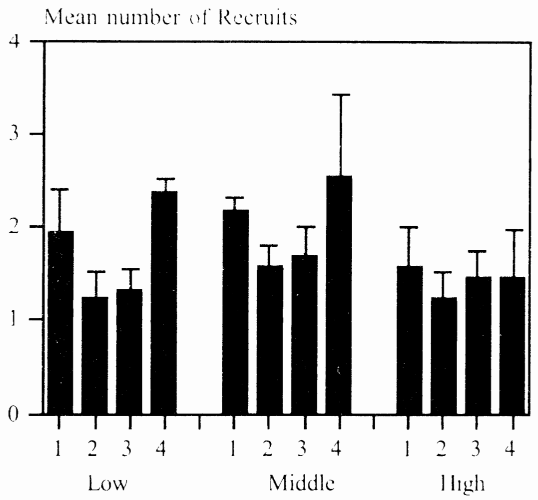

Figure 4. Mean number of recruits (tree oyster < 10 mm) sampled at different positions of large and isolated patches. 1 = edge high position of large patch, 2 = center position of large patch, 3 = edge low position of large patch, and 4 = isolated small patch.

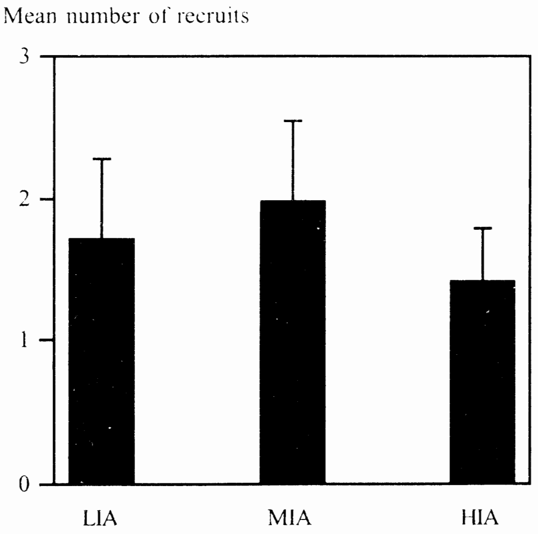

Figure 5. Mean number of recruits (< 10 mm). LIA = low intertidal area, MIA = middle intertidal area, and HIA = high intertidal area.

The middle intertidal: the mean number of recruits was significantly larger at the edge high position than at the middle and low edge positions of large patches (SNK-test; $p < 0.01$); but there was no difference between positions in large patches in both the low and high intertidal area (SNK-test; $p > 0.05$). The mean number of recruits at edge high position, edge low position of large patch, and isolated small patch showed that there was significantly higher number of recruits in a small patch than at both high edge and low edge positions of a large patch (SNK-test; $p < 0.01$).
The mean number of recruits at the different sites showed that there was a larger number of recruits in the low and middle intertidal compared with the high intertidal (SNK-test; $p < 0.05$). The distribution of recruits is shown at Fig. 5.

DISCUSSION

There are several factors which can explain the observed patterns of variations in size distribution of the tree oyster: abundance of food which is related to density of the bivalves (intraspecific competition) and time of submergence (Suchanek 1978; Lin 1989), selective predation (Bayne 1976), and differential recruitment (Buss 1981).
Food availability and time of submergence, may explain that tree oysters in the low intertidal, and at the bottom of vertical distributed patches were larger than elsewhere. Fréchette & Bourget (1985) found that active feeding may reduce the amount of food available to any one individual of the blue mussel, thereby limiting growth. Asmus & Asmus (1991) suggested that mussels positioned along an edge of a patch, and along edges perpendicular to the prevailing water current, may have more phytoplankton available than mussels positioned elsewhere. Svane & Ompi (1993) demonstrated that mussels positioned along the edges of patches were larger than elsewhere within a patch.
Mussels in a small patch may have more food available than those situated in a large patch. Peterson (1982) manipulated the density of two infaunal suspension-feeding bivalves and showed that the growth and reproductive effort of the animals were reduced at high density per unit area. By studying clump dynamics of the blue mussels, Okamura (1986) showed that isolated mussels and mussels living in small clumps grew faster than those associated with large clumps. Svane & Ompi (1993) showed that mussels in isolated small patches were larger than mussels situated at the edge position of large patches. In this study, the tree oyster in isolated small patches were smaller than those in large patches. Similarly, Ompi (1994) found a high

number of recruits in isolated small patches of *Turbo*. These observations may be related to differential predation since the probability of a predator finding a small patch is lower than finding a large one. But the pattern of recruitment can also influence the size-frequency distribution. It is possible that larvae of tree oyster settle preferentially in locations rich in small colonies.
In several field studies, a negative relationship between adult density and recruitment has been shown. Woodin (1976) found that there were more recruits in areas which have low number of conspecific adults than in areas which have high numbers (See also Williams 1980; Möller 1986; and André & Rosenberg 1991). Buss (1981) demonstrated that larvae of the bryozoan *Bugula turrita* preferred to settle on small sized colonies when adult density was high but settled on large colonies when adult density was low.
Mussels in the high intertidal zone have longer exposure time than at the low and middle intertidal zones and consequently experience more physiological stress (Suchanek 1978; Lin 1989). This may possibly explain why the high intertidal zone has low numbers of recruits since larger size mussels may be more resistant to desiccation than small size.
Because tree oysters are sessile, they are highly vulnerable to predation just as well as other oyster (Bayne 1976). The main predators is most likely several species of gastropods, and *Thais* sp. is the most abundant and observed to feed actively on the tree oyster. The problems of how predation regulate the population structure is the objective for future studies.

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