THE EFFECT OF PATCH SIZE ON MORPHOLOGY AND GROWTH ON THE INTERTIDAL BOX MUSSEL *SEPTIFER BILOCULARIS L.*, IN NORTH SULAWESI, INDONESIA

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ABSTRACT

Isolated small and large patches of *Septifer bilocularis* were divided into three length size classes: small (>10 to 17 mm), medium (>17 to 23 mm), and large (>23 mm) mussels. Each group was divided into three groups of different densities to form isolated patches (10 individuals), medium patches (50 individuals), and large patches (100 individuals). Three replicates of each patch size were established. Each density group was placed in a cage and returned to their natural hard bottom substrata, placed randomly, 50 cm between cages. At low water level, the area was exposed to air. The length/weight regression line of mussels in small and large patches overlapped, but there was a significant difference between the slopes (ANCOVA, $p<0.05$). Mussels occurring in small patches were heavier and thicker than those of larger patches. Box mussels in small patches had significantly higher growth than mussels in medium and large patches.

INTRODUCTION

The mytilid bivalve, *Septifer bilocularis*, or box mussel, is in Indonesia found attached to various hard substrata (Abbott 1974; 1991). They occur aggregated or patchy distributed (Ompi 1996). A box mussel patch can be defined as the part of the substratum occupied by box mussels and their associated fauna.

In a patch, the biological activities of the box mussels may be influenced by intraspecific competition for both space and food, and interspecific competition with the associated infauna and epifauna. Physical variables such as sedimentation and desiccation may also be important (Newell 1976). Ompi (1996) reported that box mussels in North Sulawesi occur along the intertidal sea shore. At low water level, mussel patches are exposed to wave action, changes in salinity and desiccation.

The obvious ecological question is what factors regulate the observed patchy distribution of the box mussels? Okamura (1986), Barness & Grosholz (1985), and Lin (1989) studied growth of different species of mussels as an effect of different clump or patch sizes. Okamura (1986) and Barness & Grosholz (1985) reported that mussels in small clumps grew faster than mussels in large clumps. Svane & Ompi (1993) and Ompi (1995) reported that mussels (*Mytilus edulis* L. and the oyster *Isognomon* (*Parviperna*) sp.) occurring in small patches were larger than mussels in large patches. Ompi (1996) found that the box mussel, *Septifer bilocularis* L., occurring in small patches were larger than mussels in larger patches, but this condition was not constant between locations.

The above mentioned studies were on population growth and more concerned with groups of certain sizes. It is well known that in culture, young mussels (small sizes) have better growth than old mussels (large sizes), but in the field this phenomenon is not straight forward since mussels in a patch may adapt to different environmental pressures from associated fauna in addition to various physical factors which may influence growth.

The purpose of this study is to investigate morphological characteristics and growth of the mussel, *Septifer bilocularis*, as an effect of different patch and mussel sizes.

MATERIALS AND METHODS

The study was performed in the intertidal zone of Tongkeina in North Sulawesi. The study area is a wide tidal flat covered with dead coral debris and coral boulders on a sandy sediment. At low water level, the area is exposed to air.

Sampling Procedure

Isolated small and large patches of box mussels were sampled in order to examine the morphological characteristics (see Ompi 1995). Samples were collected in plastic bags, labelled, and temporarily stored in a refrigerator. The sampling programme was performed by the end of January, 1996. In the laboratory, the samples were cleaned and shell length (maximum distance between umbo and ventral margin) and shell height was measured using a digital Vernier calliper accurate to 0.01 mm. The bivalves were subsequently dried for 24 h at 105°C and the weight determined.

Field Experiment

Box mussels were collected at Tongkeina and kept in an aquarium with aerator. The mussels were cleaned, and divided into three length size classes. These were groups of small (>10 to 17 mm), medium (>17 to 23 mm), and large (>23 mm) mussels. Each group was divided into three groups of different densities to form the following groups: isolated patch (10 individuals), medium patch (50 individuals), and large patch (100 individuals). Three replicates of each patch size were established. The mussels were left in an aquarium with aerator for two days until aggregates or patches were formed of mussels interconnected by byssus treads. Next, each replicate patch or group was placed into a cage (15x15x5 cm) for deployment at the experimental site. The cages were returned to their natural hard bottom substrata, placed randomly, 50 cm between cages.

Data Analysis

The statistical analysis of morphological characters followed the procedure described by Brown & Rothery (1993). The allometric equation $y=ax^b$ was used; y= height or weight of box mussels, b= slope, a = y value when x=1. Length/height and length/weight relationships were fit to the power equation with the regression method. Analysis of covariance (ANCOVA) was used for comparison and in order to find slope and intercept regression line. A two-way ANOVA was used to separate the effects of patch sizes, length and growth. The SNK-test was used as a posterior test (Sokal & Rohlf 1981). In order to fulfil the assumptions of an analysis variance, the data were arcsin transformed (Sokal & Rohlf 1981).

RESULTS

Morphometric analysis of the sampled box mussels

A total of 401 individuals from large patches and 233 individuals from small patches were measured. Tab. 1 shows the correlation coefficient (r), intercept (a), slope (b) of the small and large patches or groups of box mussels.

Shell length / height relationships

The correlation coefficient (r) of the two shell parameters of mussels which inhabited small and large patches was high indicating a significant linear relationship (Tab. 1). This indicates that variation in shell height was influenced by shell length. The regression line (shell length/height) of the mussels in small patches was different to the regression line of mussels in large patches. The slopes of the regression lines show no significant difference (ANCOVA, $p>0.05$) and accordingly covary. However, a significant difference of intercept was found (ANCOVA, $p<0.05$). It means that at the same length, box mussels in a small patch have greater shell height than mussels in a large patch.

Shell length / weight relationships

Correlation coefficients (r) of length/weight of mussels found in small and large patches were also high indicating a significant lin-

Table 1. Values of the regression parameters length/height and length/weight ($y = ax^b$), of the box mussel, *Septifer bilocularis*.

	N	a	b	r
Shell length/height				
small patch	233	0.391	1.135	0.918
large patch	401	0.336	1.169	0.959
Shell length/weight				
small patch	233	4×10^{-4}	2.989	0.952
large patch	401	7.9×10^{-5}	3.139	0.982

ear relationship (Tab. 1). The length/weight regression line of mussels in small and large patches overlap each other but there was a significant difference between the slopes (ANCOVA, $p<0.05$). It means that at increasing length, box mussels in a small patch are heavier than box mussels in a large patch.

Field Experiment

Growth: A two-way ANOVA was performed to determine differences in the length increments as an effect of patch size and length. A significant effect of patch size was found ($p< 0.05$), but there was no effect of length ($p> 0.05$), and no interactions ($p > 0.05$). Accordingly, mussel growth was influenced by patch size and the influence was independent of mussel size. However, a posterior test showed that the groups of large box mussels had statistically larger mean increment in length when occurring in small patches compared to large and medium patches (SNK-test, $p< 0.05$).

DISCUSSION

Morphological characteristics

There was a good linear relationship between morphological parameters of mussels. Mussels occurring in small patches were heavier than those of larger patches.

We did not examine shell thickness, but since mussels located in small patches have a greater shell height than mussels in large patches this might indicate that mussels in small patches also have thicker shell than mussel in large patches. Thick shell is often observed in intertidal mussels (Newell 1976). A thick shell might protect mussels from harmful solar radiation when exposed to air. In this case box mussels in small patches might be more exposed than those in larger patches.

However, a thick shell may also be a character influenced by predation. Ompi (1996) reported that crabs are important predators on box mussels. Mussels in smaller patches might be more exposed to predation than mussels in larger patches. But mussel in smaller patches may survive attack from predators if they have thicker shell.

Growth

The results showed that box mussels in small patches have better growth than mussels in medium and large patches. We explain this pattern as a result of intraspecific competition for food.

Many studies have been concerned with growth of aggregated suspension feeding mussels, influenced by intraspecific competition for food (Buss & Jackson 1981; Lin 1989). Blue mussels in small clumps grew faster than mussels in large clumps which is in concordance with our results. Fre'chette and Bourget (1985) showed that many mussels may reduce the absolute amount of food available to any one individual, thereby limiting growth. Okamura (1986) showed that competition for food occurring in large clumps may reduce growth. In our study, competition for food may not be so important since the effects of patch sizes was not constant among length classes of box mussels. Mussels in larger patches may not only be relatively slow growing, but may also be forced to shell twisting and thickening. The process of twisting and thickening of the shell was not observed in this study due to short time of the experiment.

The study area seems to be susceptible to sedimentation and most of the natural populations of box mussels were covered by sediment as was also the case with the box mussels used in cage experiments.

Jørgensen (1975, 1990) showed that *Mytilus edulis* and others mussels grew slower in the early stages or at smaller sizes, and then grew faster in later stages. In the adult stage, growth declined. In the present study there was no effect of length on the mean length increments.

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