THE OCCURRENCE AND SIZE DISTRIBUTION OF *TURBO* SPP. IN THREE INTERTIDAL AREAS OF NORTH SULAWESI, INDONESIA

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ABSTRACT

The occurence and size distributions of the tropical gastropod *Turbo* spp. were studied in three intertidal areas of North Sulawesi, Indonesia. Two species were found. *T. brunneus* was most abundant with up to 5 ind./m^2. A second but not identified species of *Turbo* was present but only occasionally recorded. The size distributions at the three stations were significantly different. This difference was related to difference in exposure and substratum. Other factors influencing variability could not be ruled out.

INTRODUCTION

The distribution of benthic organisms, including molluscs, depends on local environmental factors, food availability, predators, and competition. Soemodihardjo and Kastoro (1982), and Dharma (1988) found more than 10 species of the tropical gastropod genus *Turbo* distributed on various substrata from the intertidal to deeper water.

Environmental variations may affect recruitment and growth of the species and may give different patterns of population structure. Size distribution is influenced by different environmental conditions. The purpose of this study was to investigate the occurrence of *Turbo* spp. and the size structure in tropical intertidal areas.

MATERIALS AND METHODS

The study was performed at three intertidal areas of North Sulawesi, Indonesia (Fig. 1). Station 1 is located on the west of Bunaken intertidal zone and is situated close to Bunaken Park. This area is covered by dense mangrove with sand and muddy sediment. Station 2 is located on Mangatasik intertidal zone. At low water levels, a large tidal flat, consisting of sand, corals and dead coral, is exposed. A few mangrove trees still exist in this area. The area is sheltered by large coral rocks. Station 3 is close to the Marine Station of Likupang. It is situated at Cape of Asak. The area is covered by various large coral rocks and is considered exposed. About six mangrove trees were observed.

Sampling Procedure

Systematic sampling and simple random sampling were chosen. Each study area was subdivided into equal squares, each 10 m^2. 51 samples were chosen from 400 samples taken randomly at each station in an area of about 200 m^2 around each station mark. Samples were collected using a 2 m^2 frame from the centre of each squares. Before sampling the total sampling area was mapped and by using a random number table (Campbell, 1990) a predetermined number of square were selected. Additional collecting was also carried out at each station in order to find more species of *Turbo* snails.

The sampling programme was performed during the middle of July at the west of Bunaken Island intertidal zone (station 1), during the beginning of August at Mangatasik intertidal zone (station 2), and during the late of August at Cape of Asak intertidal zone (station 3).

In the laboratory, the samples were sorted, cleaned, identified to species, and counted (Soemodihardjo and Kastoro, 1982; Dharma, 1988; Oemarjati and Wardhana, 1990). Shell length was measured using vernier caliper accurate to 0.01 mm and the snails were weighed.

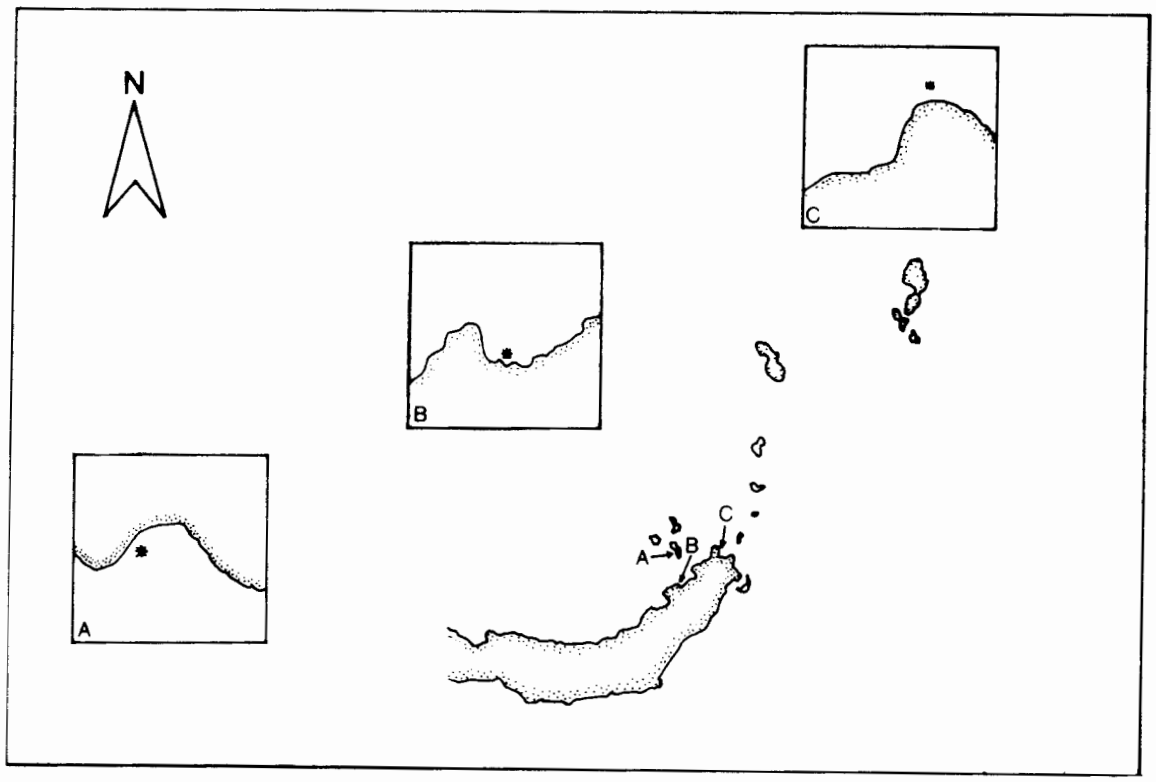

Figure 1. Map showing North Sulawesi with three stations (A = station 1, B = station 2, C = station 3)

Data Analysis

The data obtained from frame sampling were used to calculate the number of individual *Turbo* snail/2 m^2. A one-way ANOVA with unequal sample size (Sokal and Rohlf, 1981) was used to test for differences in length. *Post hoc* comparisons were performed using Student-Newman Keul's test (SNK-test) (Zar, 1984). In order to fulfil the assumptions of an of ANOVA the data were tested for homogeneity of variance using Bartlett's test (Sokal and Rohlf, 1981). Since the data were bimodally distributed, snails smaller than 20 mm were excluded to obtain normality. This group of small snails was considered as recruits.

RESULTS

Abundance and Distribution

Two species of *Turbo* spp. were found at the three stations. One species was identified as *Turbo brunneus*, and another one was not identified to species. It was designated as species B.

Turbo brunneus was found at a density of 5 ind./2 m^2 at Station 2, and 3 ind./2 m^2 at Station 3, and about 1 ind./2 m^2 at Station 1. Both species were found living in the same type of habitat such as coral reef, dead coral, and rocks. At day-time, *Turbo* were tightly attached to crevices in the rock, corals or dead coral, or they were found under any hard substrata. Especially at Station 1, *T. brunneus* was found attached to the roots of mangrove trees and to the sand or mud among the roots of mangrove trees. Species B was present at Stations 2 and 3 with low densities and was totally absent at Station 1.

Size Distribution

The result of a one-way ANOVA with station as main effect on shell length is shown in Table 1.

The mean size length was larger at Station 1 than at Stations 2, and 3 (SNK-test: $p < 0.05$) and the three stations were significantly different in the mean size length ($p < 0.001$). A graphical depiction of the difference in mean shell length is shown in Fig. 2.

Recruitment

Turbo snails smaller than 20 mm were considered as recruits. The highest density was found at Station 2 (1.53 ind./2 m^2, N = 78) and lower density at Station 3 (0.26 ind./2 m^2, N = 13). No recruits were found at Station 1.

Table 1 One-way ANOVA with unequal sample size. Shell length of *Turbo brunneus* with station as main effect (***: $p < 0.001$)

Source	DF	SS	MS	F	P
Factor	2	11856.9	5928.4	126.73	0.0001***
Error	313	14642.6	46.8		
Total	315	26499.5			

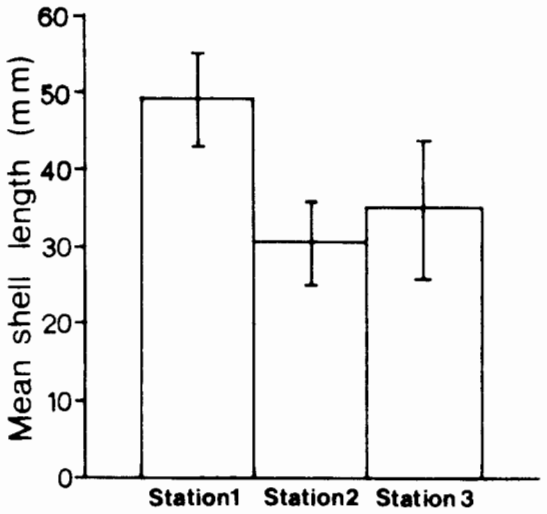

Figure 2. Mean shell length of *Turbo brunneus* sampled at the three stations. (Bars: 95% confidence interval). Station 1: N = 49, x = 49, s = 6.4; Station 2: N = 156, x = 30.7, s = 5.5; Station 3: N = 117, x = 35.2, s = 6.4.

DISCUSSION

The environmental variations of an intertidal reef flat may be of importance in order to explain distribution of *Turbo* snails and the difference in length distribution.

The data showed that *T. brunneus* was found in high density at Stations 2 and 3 which were dominated by dead coral and rocks. This substratum may be considered as their favourite habitat as observed by Dharma (1988) and Oemarjati & Wardhana (1990). Food availability may also affect the distribution of *Turbo* snails. Dance (1977) has pointed out that most gastropods are mobile herbivores. *Turbo* feeds on algae (Soemodihardjo and Kastoro, 1982; Dharma, 1988) which grow on various substrata, especially coral reef, dead coral, rock, wood, and roots of mangrove trees. Consequently, there may be a relationship between substratum with microalgae and distribution of *Turbo* snails. *Turbo* snails may also be absent in deeper waters as microalgae are absent there, since there is a limitation of growth of microalgae towards deeper waters as intensity of light is successively reduced.

T. brunneus was present at low density at Station 1, where the substratum was covered by a dense mangrove on mud and sand. Muddy substratum may be a poor habitat for growth of microalgae. However, *Turbo* snails may still survive in this area because the roots of mangrove trees may function as substratum.

Recruitment may be the main factor explaining the differences in mean size of *Turbo* snails at the three stations. Smaller *Turbo* snails were absent at Station 1 while the highest number was found at Station 2 and somewhat lower at Station 3.

At Station 1, the conditions for recruits may be insufficient for growth due to muddy substratum. Variable recruitment may not alone explain the observed size differences. Variation in physical and biological factors such as desiccation, predation and growth may also affect the observed size distribution pattern of *Turbo* snails. However, it is difficult to conclude anything about this since no data are available.

The topography of Station 2 indicate that this station is more protected from currents and waves than Station 3 which is the most exposed. At this Station, small *Turbo* snails could easily be washed away by currents and waves.

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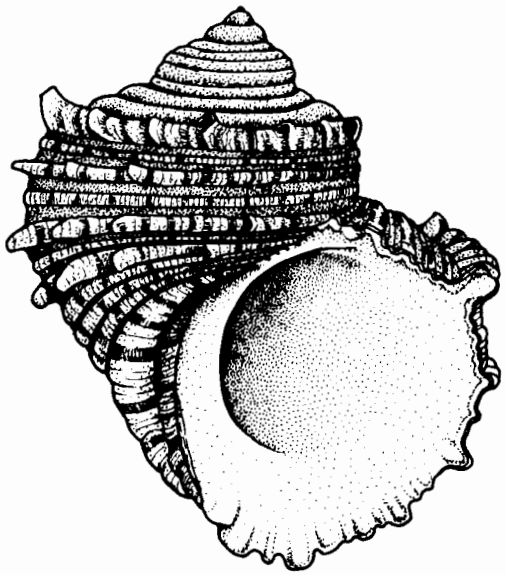

Turbo agyrostoma L., 1758. PMBC 8819.
Drawing by Patairat Singdam.