PREDATION ON *LITTORARIA SCABRA* (LINNÉ, 1758) (LITTORINIDAE: PROSOBRANCHIA) IN THE MANGROVE OF BUNAKEN ISLAND, NORTH SULAWESI

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ABSTRACT

Bark of mangrove trees harbour populations of *Littoraria scabra*. The snails are preyed upon by aquatic and terrestrial predators. To investigate the main direction of predation, four *Avicennia* trees were seeded with 30 marked snails each. The snails were placed on trees variously protected by net cages: one tree with a fully closed cage to prevent access of all predators, one with a cage open above to allow entry of terrestrial predators, one with a cage open at the bottom to allow entry of aquatic predators. The fourth tree, without net, served as control. Snails were counted every 2 weeks. In the fully closed cage, the number of snails was relatively constant for 12 weeks, and survival was significantly different from the other trees. On the partly caged trees and the control tree, the number of snails declined drastically during the first four weeks. This indicates that aquatic predators (crabs), entering the tree from below, preyed on the *Littoraria*. Terrestrial predators, entering the tree trunk from above, are unknown.

INTRODUCTION

A number of previous studies have addressed predation on *Littoraria* as a major cause of mortality, thereby inducing natural selection (Cook 1990; Cook & Garbett 1992; Cook & Kenyon 1993; Boneka 1996, 1994). The dark shell of the bark living species has been interpreted as camouflage against potential predators (Reid 1986). The colour polymorphism of leaf-living species has been speculated to constitute protective colouring, making concealment easier in a heterogeneously coloured environment (green, brown, yellow leaves). The attractive hypothesis is that birds prey upon snails living in upper levels of the trees. Since birds hunt visually they may cause selection for genetic polymorphism (Reid 1986).

Yipp (1983) found that the behaviour of *L. scabra* was related to feeding at low tide. In laboratory artificial 'tide' the snails moved upward to a height of 20 cm above the highest water level. Similarly, Boneka (1996) showed that bark-living *L. scabra* followed the tide, moving up at rising tide, and down at falling tide. It has been speculated that living in the upper littoral zone demands special adaptation since predators may attack both from sea and land (Reid 1992). The suspected terrestrial predators are birds, lizards, and snakes. The potential aquatic predators are crabs, fish, and carnivore gastropods. It is hypothesised that shell-breaking predators might be the most common predators, since there were very few empty shells of *L. scabra* on the beach of Bunaken Island (Boneka *et al.* 1995) compared with their abundance in mangrove forest (Boneka 1994). The aim of the present work was to provide a first test of possible differences in predation pressure by experiments excluding suspected predators among aquatic and terrestrial taxa in the mangrove forest.

MATERIALS AND METHODS

Exclusion cages were set up around 3 fairly isolated *Avicennia* trees, partly following Reid (1992). Three wooden frame constructions with 3 mm mesh nylon net were used to exclude the potential predators:

(1) Fully closed cage, 200 cm wide and

150 cm high, mounted 0.5 m above ground level. The vertical distance covered the range of tidal migration by *L. scabra*.

(2) Roofed cage, 200 cm wide, extending from ground level and 200 cm up to exclude potential terrestrial predators coming from above.

(3) Cage with bottom, 200 cm wide, extending 200 cm up mounted 0.5 m above ground level to exclude aquatic predators coming from below.

(4) Uncaged tree, serving as a control; exposed to terrestrial and aquatic predators.

The cages were located in the middle of the mangrove, in a protected environment. The distance between cages, as well as from the shore line, ranged from 50-100 m. The study site was described in Boneka (1994, 1996) and Boneka *et al.* (1997).

A population of 30 *L. scabra*, 5-20 mm shell length, were placed on each tree of the experiment. The snails were marked with a small red dot on the shells to distinguish them from new colonisers. This kind of mark will last for months (Boneka *et al.* 1997). The marked snails were counted every two weeks. The neighbouring trees were also checked for marked snails.

Common crabs in the study area were brought to the laboratory, and individually placed in plastic boxes filled with 3 cm sea water, together with various sizes of snails. These trials were conducted to determine whether the most common crabs were able to prey on *L. scabra*.

RESULTS

During low tide some *L. scabra* could crawl down to about 30 cm from ground level (Boneka 1994) but, 91 % of the snails were counted 50-200 cm above ground level. Normally, snails do not migrate away from the tree where they are living. This was confirmed by careful checking of the trees surrounding the experiment. No marked snails were found. Thus disappearance of marked snails from the study area was considered due to natural mortality, or the effect of predation.

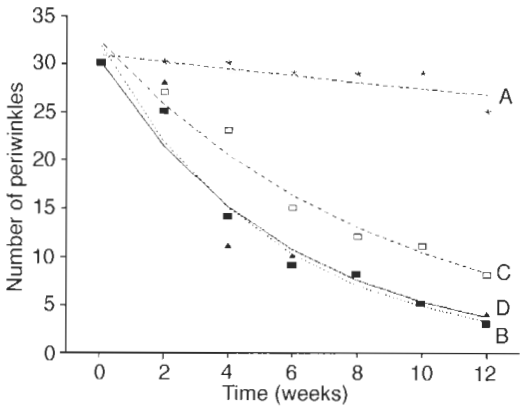

Figure 1. Mortality rate of *Littoraria scabra* in mangrove forest on Bunaken Island: A = fully closed cage, B = roofed cage, C = cage with bottom, D = uncaged control.

The rate of mortality in the fully closed cage was significantly lower than the other two treatments and the control (Fig. 1). The snail number in the fully closed cage was relatively constant throughout the period, except for the last two weeks where a hermit crab successfully invaded the cage. The hermit crab probably ingested the five missing snails. Shell fractions were found on the cage net base.

The potential aquatic predators found around the area were mainly crabs: portunids (*Scylla serrata, Thalamita crenata, Portunus pelagicus*), grapsids (*Metopograpsus* sp., *Sesarma* sp.), and hermit crabs (*Calcinus* sp.). The crabs were mainly active at night. Portunids were active at high tide; grapsids and hermit crabs at both low and high tide. When the tide was in, numerous crabs and fish invaded the mangrove. Some portunid crabs remained buried, or hidden underneath rubble, during low tide to avoid exposure.

Laboratory trials showed that the portunid crabs were able to crush a wide range of shell sizes. Yet it seems the small size will become first target. During three days of laboratory trials, the grapsid crabs took the small shells only.

DISCUSSION

The high rate of snail's disappearance from the study area indicated that predators regulated the abundance of *Littoraria scabra*. Predation is probably a very powerful selective force for maintaining shell properties and behaviour of the snails in nature.

Within the first 4 weeks, snail numbers on the tree with a roofed cage, and the uncaged control tree, declined to less than half the original numbers. It took 6 weeks before snail numbers were reduced to less than half the original numbers on the tree with a closed bottom cage.

It suggests that the most significant predation on *L. scabra* in the mangrove forest must be aquatic predators coming from below as also suggested by Reid (1992). Crabs are likely to be responsible for most of the snail mortality.

After 4 weeks, few snails were left on the uncaged tree, the cage with bottom, and the roofed cage. It was no longer meaningful to estimate differences in predation intensity. The few surviving snails could be related to the density-dependent predation. Predators may have moved to other mangrove trees where prey would be abundant, or switch to the best exploitable prey. The high mobility of predators among crabs and birds allows them to seek out always the most profitable site in terms of prey availability (Nybakken 1993).

Some portunid crabs were apparently able to swim into the cage with a bottom during spring tide. Thus the declining snail number was probably due to a combination of terrestrial and aquatic predators. However, it is still unclear which group of terrestrial predators could prey from above. When the tide is out, birds pick invertebrate prey on the ground, but we did not observe birds feeding on *Littoraria*.

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