INFLUENCE OF DENSITY ON THE GROWTH RATE OF GREEN SNAIL, *TURBO MARMORATUS* L. (MOLLUSCA; GASTROPODA) IN CAGES

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ABSTRACT

A grow-out experiment was conducted with *Turbo marmoratus* in an intertidal area. A total of 10, 20, 30, and 40 individuals were put in plastic cages (0.25 m^2 surface area) placed on a reef flat (three replicates). The initial mean shell diameter for these densities was 9.22, 9.17, 9.14, and 9.31 mm respectively. After 16 weeks they measured 23.46, 22.20, 21.4, and 20.48 mm. Similar cages with a coral rubbles substratum were used to rear 30 individuals with three replicates. The initial and final mean shell diameter was 9.21 and 24.53 mm respectively. The variation between replicates for a given density treatment was not significantly different ($P > 0.05$). A pooled t-test showed that the mean cumulative growth was not significantly different ($P > 0.05$) until the 6th week of experiment. After that they were significantly different. The cumulative growth after 16 weeks of experiment for 10, 20, 30 and 40 individuals per cage were 14.24, 13.02, 12.27, and 11.17 mm respectively. This result suggests that there was competition for food. The cumulative growth was higher (15.31 mm after 16 weeks) in the cage filled with coral rubble. It suggests that the addition of coral rubble can increase the carrying capacity of the cage.

INTRODUCTION

Green snail *Turbo marmoratus* L. (family Turbinidae), locally called batulaga or mata bulan, is the biggest snail within its genus (Eisenberg 1981; Abbott & Dance 1986; Wilson 1993).

The snail occurs in the Indo-Pacific region, extending from western part of Indian Ocean (Kenya, Seychelles, Chagos, Andaman and Nicobar islands) to Fiji. Green snail inhabits coral reef areas which have a constant current of clear sea water down to 20 m depth. They feed on micro and macroalgae (Yamaguchi, 1993). As nocturnal animals, they prefer reef flat with many crevices and boulders.

The shell of green snail partly consists of mother of pearl which is used to produce ornaments or handicraft, while the meat is used by local fisherman as protein source. The largest encountered green snail had 25 cm of shell diameter and weighed more than 2 kg (Kubo, 1991). At the local market, the empty shell is sold at Rp. 60.000,- (US$ 5.0) per kilogram. Export of shells from Indonesia ranged from 17.74 to 144.60 metric tons during 1970-87. These catches have caused a decline in natural populations of green snail all over Indonesia (Usher, 1984). In 1987, the green snail was classified as a threatened species, and the capture and trade of this species prohibited (Ministerial decree no. 12/Kpts-II/1987). In the following year an exception was made. Shells of green snail could be traded if they were produced in aquaculture (Ministerial decree no. 07/ Kpts/DJ-VI/1988).

The first hatchery production of green snail has been conducted successfully in Indonesia (Dwiono et al., 1997). Meanwhile, the mass seed production was a problem as the capacity of the hatchery to supply food was limited. Therefore, it was suggested that outgrowing in cages on intertidal area might solve this problem. In order to evaluate the feasibility of outgrowing in cages, an experiment has been performed.

MATERIALS AND METHODS

Animals

Young snails were produced from 1 female and 2 males, spawned on October 28th, 1996. The juveniles were reared under laboratory condition and fed cultured microalgae *Navicula* spp. (Dwiono *et al.* 1997). When the experiment started, the snails were 7,5 months old. Only individuals with shell diameters ranging from 8.0 to 12.0 mm were used.

Cage construction

Cages were made of pre-fabricated plastic covers (LxWxH = 65x45x20 cm),usually used as food protector against flies. The plastic cover was formed of ribs with approximately 2 mm intervals which permitted sea water to get through the cage freely. The cage was nailed to the reef flat, and a window (20 x 40 cm) made on the top of the plastic cover to facilitate access to the cage. The bottom of each cage was covered with a cement mixture to prevent intrusion of predators and competitors through holes and crevices. A total of 15 cages, each with a surface area of 0.25 m^2, were constructed on the reef flat of the intertidal area of Morella, Ambon island. The cages were set at 5 m distance from one to another on the reef at the same elevation (approximately 50 cm below mean sea level). In order to eliminate possible chemical contamination from plastic cover and cement mixture, and to allow microalgae to grow naturally, the cage was left undisturbed for 2 weeks before starting the experiment. To assure good water exchange, the cages were cleaned exteriorly from dirt and fouling organisms every week.

Treatment

Two experiments were conducted in parallel. In the first experiment, no substrates was added (bare cages) and therefore the snails fed only on the microalgae growing on the bottom and inner surface of plastic cover. The influence of density was assessed by introducing 10, 20, 30 and 40 individuals per cage. Each density was tested in triplicate.

The second experiment aimed at assessing the influence of substrate on the growth of the snail. Three cages were filled with a 10 cm high layer of coral rubble and 30 snails were put in each cage. The snails fed on microalgae occurring on the coral rubble, as well as on the bottom of the cage and the inner surface.

Measurement

The maximum diameter of the shells was measured with Mitutoyo digital callipers to the nearest 0.01 mm. The growth rate was measured individually every two weeks, except in the 4th week, which was cancelled because of bad weather. Dead individuals were removed and replaced by snails of similar size.

Growth increments is presented in the following terms:

a. Instantaneous growth = Shell diameter at t_n - Shell diameter at t_{n-1}

b. Growth = (shell diameter at t_n - shell diameter at t_0) / shell diameter at t_0 x 100 %

where t_0 = is the beginning of the experiment; n = regular observation time (2 weeks).

Statistical tests

It was assumed that the data were sampled at random, normally distributed, and had equal variation. An analysis of variance (ANOVA) was done of instantaneous growth using statistical software DataDesk 4.1. (Data Description, Inc. Ithaca, N.Y.) The least significant distance (LSD) test was used to identify significantly different mean values. The statistical significance level was set at 5 % (the means are significantly different if $p < 0.05$)

RESULTS

Bare cages

Measurements of shell diameters are shown in Fig. 1 showing that individuals in all treatments grew well during the study but was related to density. During 16 weeks, the shell diameter increased from 9.22, 9.17, 9.14, and 9.31 mm to 23.46, 22.20, 21.41, and 20.48 mm for 10, 20, 30 and 40 individuals per cage respectively. Those values gave a cumulative growth of 14.44, 13,14, 12.27, and 11.19 mm equal to 0.90, 0.82, 0.77, and 0.70 mm per week for the density of 10, 20, 30 and 40 individuals per cage respectively.

Although the standard deviation of instantaneous growth (IG) between replicates were small, test of homogeneity of variance was performed. The test showed that the variances of IG between replicates for a given density at a given observation time were not different (P>0.05). This allowed us to pool IG values obtained from replicates at a given treatment to strengthen further tests.

Pooled t-test, performed after a homogeneity test, showed that in general the means of the instantaneous growth were significantly different (P<0.05) among the densities. The LSD-test was used to identify the different levels of significance (Table 1).

Table 1. Least Significant Distance (LSD) test on the means of instantaneous growth of *T. marmoratus* reared at different densities. D = density (ind./cage); S = significantly different; NS = not significantly different.

Density (number per cage)	Initial length ±SD (mm)	Length after 16 weeks ± SD (mm)
10	9.23 ± 0.81	23.67 ± 1.68
20	9.17 ± 0.61	22.31 ± 1.75
30	9.14 ± 0.73	21.41 ± 1.45
40	9.31 ± 0.72	20.50 ± 1.50
30 + coral rubble	9.22 ± 0.84	24.53 ± 1.49

The IG values (Table 1) were not consistent. Both density and time affected the instantaneous growth (Figure 1). The figure exposes variation in IG values for a given density. On the first observation after 2 weeks, the IG values for all treatment were very low. Since the observation of the 4th week was not done due to bad weather, the value for 4th week was estimated as half of the growth increment between the 2nd and 6th week. From the 8th to the 10th week, the influence of density on the instantaneous growth was obvious, separating low densities (10 and 20 ind./cage) from high densities (30 and 40 ind./cage). On the 14th and 16th week, the IG values for high densities (30 and 40 ind./cage) were very low suggesting that the food were already lacking in these cages.

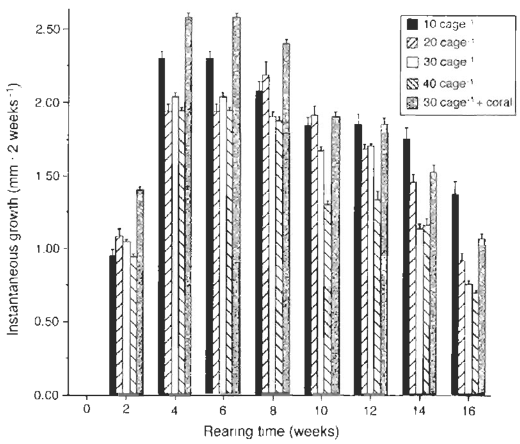

Figure 1. Mean of instantaneous growth (IG) of *T. marmoratus* at 4 density levels in bare cages and at a density of 30 ind. in cages with coral rubble.

Cages with coral rubbles

Snails reared in cages with coral rubbles had higher instantaneous growth than individuals reared in bare cages at all densities. After the 10th week, the instantaneous growth of individuals in cages with coral rubble was not different from lower densities (10 and 20 ind./cage), while from the 14th week the IG of these animals was significantly lower than individuals in bare cage at the lowest density (10 ind./cage). However, the instantaneous growth of individuals in cages with coral rubble was higher than those in bare cage at similar

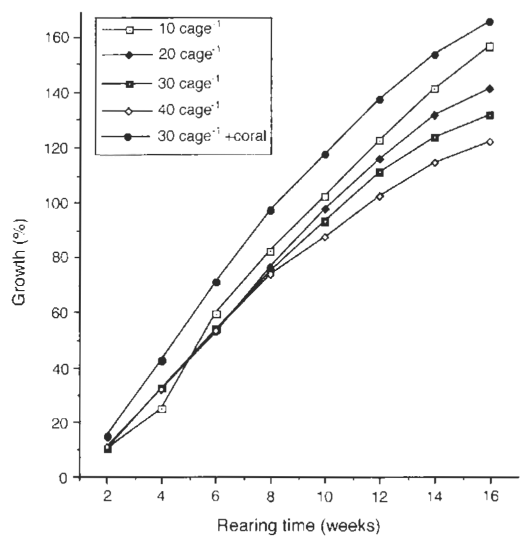

Figure 2. Growth of *T. marmoratus* at 4 densities in bare cages and at a density of 30 ind. in cages with coral rubble.

density (30 ind./cage).

The overall growth of individuals in bare cages at different densities and in cages with coral rubble is plotted against rearing time (Figure 2). In general, the individuals reared at high density grew slower than at lower densities. During the experiment, individuals reared in cages with coral rubble had the best growth. The growth of individuals in bare cage at low density (10 ind./cage) was lower than those in cage with coral rubbles and their slopes were different.

During the experiment, the mortality rate of individuals in the cages was low (Table 2). Of 390 individuals used in the experiments, 19 individuals (4.8 %) were dead and replaced by individuals of similar size. The highest mortality occurred at a density of 20 individuals per cage and the lowest at 30 individuals per cage. The data do not indicate a relation between either density or condition of the cage (with or without coral rubble) and mortality.

Table 2. Mortality of *T. marmoratus* during the experiment.

Density (ind. cage^{-1})	Replicate	Releasing time (week)							
		2	6	8	10	12	14	16	n
Bare cages									
	1	0	0	0	0	0	0	0	0
10	2	1	0	0	0	0	0	0	1
	3	0	2	0	0	0	0	0	2
	1	0	0	0	0	0	0	0	0
20	2	0	0	0	1	0	0	0	1
	3	2	4	1	0	0	0	1	8
	1	0	0	0	0	0	0	0	0
30	2	0	0	0	0	0	0	0	0
	3	1	0	0	0	0	0	0	1
	1	0	0	0	0	0	0	0	0
40	2	0	0	1	2	0	0	0	3
	3	0	0	0	0	1	0	0	1
Coral rubble									
	1	0	1	0	0	0	0	0	1
30	2	0	0	0	0	0	0	0	0
	3	1	0	0	0	0	0	0	1
Total		5	7	2	3	1	0	1	19

DISCUSSION

The culture techniques of *T. marmoratus* was developed in Okinawa (Murakoshi et al., 1993). In Indonesia, the first attempt to culture green snail was made in October 1996 and yielded approximately 30,000 individuals of 7 mm shell diameter (Dwiono *et al.* 1997).

The average growth rate was 0.24 mm per week compared to Murakoshi *et al.* (op. cit.) who found a growth rate of 0.04 to 0.34 mm per week, depending on the food source. The present growth rates were also higher than rates obtained in the laboratory using cultured sessile diatom (*Navicula* spp.) and natural food occurring on coral rubble or pieces of bivalve shells. (Setyono & Dwiono, 1998).

The grazing rate of green snail increased steadily, and the cultured sessile diatom (*Navicula* spp) was grazed out within short time. Therefore, Dwiono et al. (1997) suggested a rearing system of cages in intertidal areas as a possible solution. The present study showed that plastic cages can be used to rear the snail up to a certain size.

The effect of density on the instantaneous growth rate (IG) became increasingly evident from the 10th or 12th week, suggesting that the quantity of food in the bare cages was no longer sufficient to satisfy the snails. It happened at all densities suggesting that even 10 ind./cage was too high for the growing snails. The maximum density must be lower than 10 individuals per cage or 40 individuals per square meter.

The addition of coral rubble resulted in higher instantaneous growth of the snails during the first 8 weeks. The IG of individuals in cages with coral rubble was significantly higher than in bare cages at the lowest density. Taking this result into consideration, it may be possible to increase the density to 50 individuals m^{-2} when rearing snails up to 25-30 mm diameter.

The present study suggests that the rearing of green snail in intertidal area could be profitable since the high growth rates could reduce the rearing period. Furthermore, the mortality of the snail was very low suggesting that the young green snails adapted well to the environmental conditions.

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