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REARING OF JUVENILE DONKEY-EAR ABALONE (*Haliotis asinina*) IN FLOW-THROUGH TANKS WITH THE ADDITION OF DIFFERENT SUBSTRATES

Dwi Eny Djoko Setyono

Research Center for Oceanography, Jl. Pasir Putih 1 Ancol Timur, Jakarta 14430 Indonesia
E-mail: setdwi@yahoo.co.nz; dwie004@lipi.go.id

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ABSTRACT

This study investigated the effects of the addition of coral rubble and polyvinylchloride (PVC) guttering as substrates on the growth of the donkey-ear abalone (*Haliotis asinina*) reared in a flow-through water system. The tanks were 100 cm long x 50 cm wide x 40 cm deep, filled with sea water up to a height of 30 cm. Hatchery-produced abalone, with a mean initial shell length of 30.9 ± 0.1 mm and wet weight of 5.5± 0.1 g, were stocked at 25 individuals per tank that corresponds to stocking densities of ca. 50 abalone m^{-2} at the bottom of the tank. Juvenile abalone were provided with plenty of red seaweed *Gracilaria* spp daily over 175 days. The results show that the growth and growth rates in shell length and wet body weight were not significantly different between treatments (P>0.05). Survival rates of juveniles reared in the tank with the addition of coral rubble and/or PVC guttering were 100%, but 98% for juveniles in the tank without the addition of substrate. The average daily growth rates of shell length and wet body weight were 0.087±0.037 mm and 0.088±0.044 g for juveniles reared in the tank with coral rubble; 0.081±0.030 mm and 0.077±0.032 g for juveniles reared in the tank with PVC guttering; and 0.082±0.032 mm and 0.078±0.039 g for juveniles reared in the tank without substrates. Juveniles reared in tanks with a flow-through water system grew very well. The increase of body weight was more than double (>250%) the initial size.

Keywords: Rearing, abalone, *Haliotis asinina*, growth-rates, substrates.

INTRODUCTION

Abalone is a species of herbivorous marine gastropod belonging to the phylum Mollusca, class Gastropoda, subclass Prosobranchia, order Archaeogastropoda, family Haliotidae and genus *Haliotis*. Early juveniles feed on benthic diatoms, and after reaching a size of about 5-10 mm shell length they can feed on macro-algae (Personal observation, Setyono and Dwiono, 2011). Seven species of abalone are found in Indonesia, i.e., *Haliotis asinina*, *H. varia*, *H. squamata*, *H. ovina*, *H. glabra*, *H. planata*, and *H. crebrisculpta* (Dharma, 1988). *Haliotis asinina* is the largest of the tropical abalone species and occurs throughout the Indo-Pacific, including eastern Indonesian waters.

There have been extensive studies on commercially important abalone species for aquaculture development. Every country has cultivated its own native species because it is simpler to deal with these animals in relation to water quality (temperature, salinity, and pH) and suitable natural food (micro- and macro-algae). Moreover, there are ecological considerations in culturing exotic species, including possible ecological impacts, genetics and diseases.

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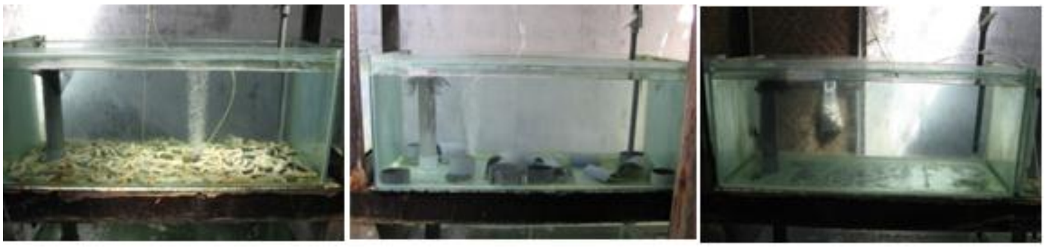

Fig 1. Rearing tanks with different type of substrates to grow juvenile donkey-ear abalone (*H. asinina*). (A). Tank with coral rubbles; (B). Tank with PVC guttering; and (C) Tank without substrates.

Commercial abalone farms throughout the world are now intensively producing abalone to meet increasing market demand. The worldwide interest in culturing abalone is still growing and, in the near future, it is expected to grow even more as a result of the competitive markets for live abalone around the world (Viana, 2002). There are three different methods of commercially culturing abalone to a market size. These are: (1) land-based farming in tanks, raceways, and ponds with intensive feeding; (2) containment rearing in offshore areas; and (3) ocean ranching in closed private areas (Hahn, 1989; Setyono, 1997). A variety of techniques are used to raise numerous species of abalone, including the tropical abalone, *Haliotis asinina* (Capinpin and Corre, 1996; Cesena, 1996; Fleming and Hone, 1996; Jarayabhand and Paphavasit, 1996; Setyono, 1997; Capinpin *et al.*, 1999).

There is extensive culture of tropical and subtropical abalone species such as *Haliotis asinina* and *Haliotis diversicolor supertexta* in Thailand and Taiwan (Jayarabhand and Paphavasit, 1996).

Indonesia is an archipelagic nation with more than 17,500 islands, and has many coastal areas that are suitable for growing abalone. The ocean is very productive and natural food for abalone (macro-algae: *Gracilaria spp*, *Hypnea spp*, *Ulva spp*, *Kappaphycus spp*) is highly abundant. All of the culture methods, whether land-based farming, containment rearing in offshore areas, and/or ocean ranching, are suitable to for setting-up in this country (Setyono, 1997). Although much can be learned from the well-established techniques, it is clear that many aspects of abalone culture must be tailored to suit the local species and environmental conditions.

Farmed tropical abalone generally reach marketable size in one year whereas temperate species take 2-3 years (Hahn, 1989). Optimization of production systems is important as they directly affect the growth and survival of the species being cultured. Animal movement in relation to feeding is dependent on the amount of available space for foraging, especially for animals cultured in containment (tanks, cages, and ponds). Appropriate substrate will make animals feel safe enough to continue foraging for food day and night.

The tropical donkey-ear abalone (*H. asinina*) has been harvested extensively in some areas of Indonesia (Kepulauan Seribu DKI, Bali, Lombok, Sumbawa, Sulawesi, Maluku) and has become a commercially important fishery product for the export market. In Indonesia, although donkey-ear abalone (*H. asinina*) forms a valuable fishery commodity, little is known about techniques for its culture, especially regarding the effect of substrates on the growth of juveniles. Therefore, the main purpose of this study was to determine the effect of substrates on the growth rate of juvenile donkey-ear abalone (*H. asinine*) cultured in flow-through tanks.

Table 1. Mean and standard error of shell length (SL) and body weight (BW) at initial and final rearing period, daily increase and relative increase in shell length and body weight, and survival rate of juvenile *Haliotis asinina* reared in tanks with the addition of different substrates (coral rubble, PVC guttering, and none).

Variable	Type of substrates		
	Coral rubble	PVC gutter	Non
Initial SL (mm)	30.97±0.24	30.80±0.26	30.88±0.24
Final SL (mm)	46.15±0.47	45.00±0.38	45.19±0.42
Initial BW (g)	5.49±0.20	5.44±0.21	5.49±0.19
Final BW (g)	20.82±0.58	18.93±0.42	19.14±0.52
Daily increase in SL (mm)	0.087±0.037	0.081±0.030	0.082±0.032
Daily increase in BW (g)	0.088±0.044	0.077±0.032	0.078±0.039
Relative increase in SL (%)	49.5±8.9	46.5±7.6	46.4±7.8
Relative increase in BW (%)	291.8±26.0	257.5±20.1	255.1±23.4
Survival rate (%)	100	100	98

MATERIALS AND METHODS

Experimental design

Prior to the rearing experiment, hatchery-bred juvenile abalone with a shell length (SL) of about 30 mm were selected. Six glass tanks (W x H x L = 50 cm x 40 cm x 100 cm) filled with a flow-through water system up to 30 cm high were set up, 3 tanks with coral rubble as substrates, 3 tanks with PVC guttering as substrates, and 3 tanks without any substrate (Figure 1). Juvenile donkey-ear abalone with a mean initial shell length of 30.9 ± 0.1 mm and wet weight of 5.5 ± 0.1 g were stocked at 25 individuals per tank, that corresponded to stocking densities of ca. 50 abalone m^{-2} at the bottom of the tank. Juveniles were provided an excess of the macro-algae (*Gracilaria* spp) daily. In the morning, waste (feces and pieces of uneaten seaweed) was siphoned off and fresh macro-algae (*Gracilaria* spp) was added.

Data collection

The experiment was carried out from 16 October 2009 to 9 April 2010 (175 days). Water temperature varied from 25.5 to 27.5 °C and salinity from 33 to 35 ppt. During the rearing period, to avoid stress due to measurement, shell length (SL) and body weight (BW) were measured only 4 times, i.e., at the beginning of the experiment and repeated after 33 days, 59 days and 175 days. Before weighing, juveniles were put on a dry towel to absorb the water around the body and shell.

Data analysis

Growth rates in terms of daily increase in shell length (DGR_{sl}) and body weight (DGR_{bw}) were calculated as follows:

$$DGR_{sl}\ (\text{mm day}^{-1}) = G_{sl} : t$$

$$DGR_{bw}\ (\text{g day}^{-1}) = G_{w} : t$$

where: G_{sl} is increase in shell length (mm), G_{w} is increase in weight (g), and t is number of rearing days.

Statistical analysis

Growth, in terms of increased shell length and body weight at the end of the observation of abalone reared in tanks with different type of substrates, was analysed using an analysis of variance (Anova). The statistical significance level (P) was set at 0.05.

RESULTS AND DISCUSSION

Juveniles used in this study had an initial size range of 30.9 ± 0.1 mm shell length and 5.5 ± 0.1 g wet weight (data not shown). Setyono (2005) reported that the population of donkey-ear abalone in southern Lombok waters reached sexual maturity at a shell length of 40.1 - 45.0 mm for males and 50.1 – 55.0 mm for females. It signifies that juvenile donkey-ear abalone with a shell length less than 40 mm are still in a growing phase. The data of mean shell length and body weight at the initial and final rearing periods, the daily increase and relative increase in shell length and body weight, and survival rate are presented in Table 1.

The growth rate in shell length (0.081-0.87 mm day^{-1}) in this study was higher than the result found in *H. asinina* (0.06 mm day^{-1}) at a similar size (±30 mm) fed with *Gracilaria* spp cultured in indoor tanks in Thailand (Singhagraiwan and Sasaki, 1991). However, this is lower than the result found in *H. asinina* (0.10 mm day^{-1}) reared in cages suspended in an outdoor tank with a similar initial size (±30 mm) and similar density (50 individuals m^{-2}) (Setyono and Aswandy, 2007) and also lower than their counterpart in the Philippines in which juveniles were reared in net cages in the sea, i.e. 0.117 mm day-1 (Castanos, 1997).

The mean initial sizes in shell length and body weight were not significantly different (P>0.05) between types of substrate (coral rubble, PVC guttering, and without substrate). Single factor analysis of variance showed that the mean daily increase in shell length and body weight were not significantly different between treatments (Data not shown). However, juveniles reared in a tank with the addition of coral rubble looked healthier than the others, i.e. the colour of the foot is greenish and more shiny.

The growth rate in body weight (0.077-0.088 g day^{-1}) in this study was higher than the result found in *H. asinina* (0.066 g day^{-1}) at a similar size (±30 mm) and density (50 individuals m^{-2}) (Setyono and Aswandy, 2007). However, this is lower than their counterpart in the Philippines in which juveniles were reared in net cages in the sea, i.e. 0.225 g day^{-1} (Castanos, 1997).

These differences could be affected by environmental factors such as water quality (Fallu, 1991; Harris *et al*., 1999), waves and currents (Chan *et al*., 1985), feeding rates and food consumption rates (Marsden and Williams, 1996). Increases in feeding rates and food consumption will augment the body size (in terms of body muscle). An increase in muscle weight is indicative of good consumption or feeding rates (Barkai and Griffiths, 1988; Fermin, 2002). However, due to limited time and equipment, feeding rates and food conversions were not measured in this study.

The relative increase in shell length and body weight (Table 1) shows clearly that at the end of rearing period (175 days), juveniles reared in tanks with a flow-through water system grew very well. The increase of body weight was more than double (>250%) the initial size.

In this study, no juvenile mortality occurred in either the tanks with coral rubble or PVC guttering, and only 2% mortality occurred in the tank without substrate. This phenomenon indicates that juvenile *H. asinina* are hardy animals (Setyono, 2007: Setyono and Aswandy, 2010) and the culture system (flow-through water system) provides good conditions for the juveniles. This result is comparable to that which was found in *H. asinina* reared in cages suspended in an outdoor tank (Setyono and Aswandy, 2007; Setyono, 2011), but higher than the result found by Castanos (1997) 94-98%, Fermin (2002) 87-98%, Bautista-Teruel *et al.* (2003) 85-100%, Thongrod *et al.* (2003) 74.7-92.7%.

Setyono and Aswandy (2007) reported that a stocking density of 50 individuals m^{-2} for juveniles of 30-40 mm was optimum in an outdoor tank culture. However, these stocking densities may still be lower than the carrying capacity of net cages suspended offshore as water quality is known to influence the growth of juvenile abalone (Fallu, 1991). The density of 50 individuals m^{-2} for juveniles of 30 mm shell length in this study were comparable to those which were applied by Setyono and Aswandy (2007). Using a flow-through water system, a density of 50 individuals m^{-2} resulted in higher survival rates and higher relative growth in body weight (>250%).

CONCLUSION

In general, the growth of juvenile *H. asinina* reared in a tank with a flow-through water system was good. The addition of coral rubble or PVC guttering did not influence the growth rates. Probably more important was how to provide the juveniles with enough food and use less energy to reach it.

Although the addition of substrates had no effect on the growth of juvenile donkey-ear abalone reared in indoor tanks with a flow-through water system, a substrate of coral rubble was needed to provide the juveniles with natural conditions, less stress, better health and decreased mortality.

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