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Comparative Study on Growth, Feed Efficiency and Survival of Hatchery-Reared Juvenile Spotted Babylon *Babylonia areolata* Link 1807 (Neogastropoda: Buccinidae) Fed with Formulated Diets

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Abstract

A six month feeding experiment was conducted on juvenile spotted babylon *Babylonia areolata* (average shell length of 11.39 mm) to evaluate the effect of dietary protein level on growth, feed intake, feed efficiency and survival. Juveniles were fed to satiation once daily with two experimental diets of 35 and 45% protein contents, and fresh meat of carangid fish *Selaroides leptolepis* as control. Growth of snail fed the natural food was not significantly ($P<0.05$) higher than snails fed the experimental diets and no significant differences ($P>0.05$) in growth was found between snails fed the experiment diets of 35 and 45% protein contents. No significant differences in feed conversion ratio was found between the feeding treatments. During the entire period of experiment, survival exceeded 95% for all treatments.

Introduction

In Thailand, the spotted babylon *Babylonia areolata* commonly known as Hoy Wan, is an important commercial marine gastropod. It is abundant and widely inhabits the littoral regions in the Gulf of Thailand, especially muddy sand areas not exceeding 5 to 20 m in depth (Panichasuk 1996). It has been a target species for commercial cultivation and is at present the second most-valuable gastropod fishery product in Thailand after the abalone *Haliotis asinina*. Spotted babylon stocks have sharply declined in traditional fishing areas because of continuous exploitation (Panichasuk 1996). Consequently, decreasing natural stocks and increasing value have led to an increased interest in the culture of this species as a means of increasing market supply and preventing overfishing.

Recent efforts have led to the development of an economically viable operation for increasing market supply and stock enhancement (Chaitanawisuti and Kritsanapuntu 1997). Slow growth and poor survival of juvenile spotted babylons resulting from inappropriate or inadequate food supply during the growing-out period will prolong holding time and increase hatchery costs. Molluskan nutrition lags far behind that of fish and crustaceans and much less is known of the protein requirements of this phylum. There have been various publications concerning the nutrition of marine gastropods such as abalone; *Haliotis midae* (Britz 1996), *H. tuberculata* and *H. discus Hannai* (Mai et al. 1995), *H. asinina* (Capanin and Core 1996), *H. rubra* (King et al. 1996), and queen conch; *Strombus gigas* (Cresswell 1984).

At the moment, the lack of research and development on appropriate feeds for culturing juvenile spotted babylons is a major constraint to its mariculture potential. This study is the first attempt to evaluate artificial diets as potential feasible foods for juveniles *B. areolata* ranging in shell length from 10 to 40 mm of marketable size.

Materials and Methods

Experimental culture system

Juveniles were reared in indoor rectangular rearing tanks of 1.5 x 0.5 x 0.5 m (L:W:H). Feeding treatments were randomly allocated to each tank (three replicates per treatment). Tanks were supplied with flow-through natural, aerated ambient seawater. Water flow was maintained at approximately 300 to 500 l h^{-1}. The bottom of the rearing tanks was covered with a 5 cm layer of coarse sand (500 to 1,000 micron mean grain size) as substrate. After removing the snails from the culture tanks, sand was then cleaned using a water jet flushing then sun dried for 6 hrs at 30-day intervals to remove accumulated waste materials. Temperature and salinity ranged from 28 to 30°C and 28 to 29 ppt, respectively.

Experimental diets

Two experimental diets were formulated to contain protein levels of 35 and 45%, and one lipid level of 5%. Formulations of the experiment diets and their proximate composition are shown in table 1. Fishmeal and squid oil were used as the protein and lipid sources, respectively. Wheat starch was used as the binder. Procedures for food preparation were modified from the method described by Uki and Watanabe (1992). Feed ingredients were homogenized thoroughly in a food mixer. After adding water to the mixed ingredients, a paste was made using a hand mixer. The paste was shaped into 0.5 mm thick sheets, which were cut into 2 cm^2 flakes. The surplus solution was drained naturally, then the flakes were sealed in a plastic bag and stored at –20°C until use. Dry feed samples were analyzed for proximate composition following standard AOAC methods (1990).

Juvenile rearing

Juvenile spotted babylon *Babylonia areolata* produced from the same cohort at the mollusk hatchery of Sichang Marine Science Research and Training Station, Chulalongkorn University, Cholburi province, Thailand, were used for the experiment. Juveniles were hand-graded to a uniform size, with a mean total weight and shell length of 0.24 $\pm$0.2 g and 11.35 $\pm$0.1 mm (n = 50), respectively. They were reared in three replicate culture tanks as described above. Initial stocking density was 75 snails per tank ($100 \cdot m^2$). Prior to each feeding experiment, juveniles were starved for 48 hrs.

Based on visual observation, juveniles were fed to apparent satiation with experimental diets and fresh meat of carangid fish *Selaroides leptolepis* once daily (09:00 AM.). The amount of feed consumed by the snails in each tank was recorded daily. The experiment was conducted for 180 days. Twenty randomly selected snails per tank from each treatment were measured for their total weight and shell length every 30 days, and returned to the tank. Mean monthly growth rates (G) were calculated from average increments in shell size and weight according to the formula:

$$G = (W_1 - W_0) / (t_1 - t_0)$$

where W_0 and W_1 = shell size or total weight at time t_0 and t_1, respectively. Feed conversion ratio (FCR) = total diet fed (g)/total weight gain (g). The number of dead individuals in each treatment was recorded at monthly intervals, and an average monthly survival rate was calculated.

Data analysis

All statistical analyses were performed using the SPSS System for Windows version 9.0. Differences in growth, FCR and survival of all treatments were determined through a one-way analysis of variance (ANOVA) at $\alpha = 0.05$. and the Tukey's studentized range test to determine significant differences ($P<0.05$) among treatment means in length and weight.

Results

The average monthly growth in length and weight of juvenile *B. areolata* among the three feeding treatments over the entire period of the experiment are presented in figures 1 and 2. Growth of snails fed the natural food was not significantly ($P<0.05$) higher than snails fed with the experimental diets and no significant difference ($P>0.05$) in growth was found between the snails fed with experiment diets of 35 and 45% protein contents.

Growth rates in shell length were 3.84, 3.91 and 4.28 $mm \cdot mo^{-1}$ for snails fed with experimental diets of 35 and 45% protein contents, and natural food, respectively, and 1.17, 1.18 and 1.62 $g \cdot mo^{-1}$ for those of body weight growth rate, respectively (Table 2). No significant difference ($P>0.05$) was observed in feed conversion ratio (FCR) between the feeding treatments (Table 2). Over the period of experiment, survival exceeded 95% for all treatments and did not appear to be affected by dietary protein type or content.

Table 1. Composition of the experimental diets (g·100 g dry wt.).

	Diet 1	Diet 2	Control[1]
Fish meal[2]	27.0	45.0	-
Squid oil[3]	8.0	5.0	-
Wheat starch	40.0	25.0	-
Gluten	20.0	20.0	-
Vitamin and mineral premix[4]	5.0	5.0	-
Proximate analysis			
Protein (%)	35.0	45.0	75.2
Lipid (%)	5.0	5.0	7.8

[1] fresh meat of carangid fish, *Selaroides leptolepis*
[2] composed of crude protein 55%, crude fat 6%, fiber 2.4% and humidity 9.7%
[3] commercial product (Eka oil) produced by T.C. Union Food Company, Thailand
[4] vitamin A 2400 IU, vitamin D 400 IU, α-tocopherol 30 mg, menadione 14 mg, thaimin 10 mg, riboflavin 9.0, pyridoxin 14.0, vitamin B_{12} 0.008 mg, nicotinic acid 40 mg, Ca-pantothenate 30 mg, folic acid 2.4 mg, biotin 0.2 mg, vitamin C 60 mg, inositol 60 mg, manganese 10.0 mg, copper 0.4 mg, iron 4.0 mg, zinc 8.0 mg, selenium 0.05 mg, iodine 0.2 mg, cobolt 0.05 mg.

Table 2. Average growth parameters of *B. areolata* fed with two experimental diets and a natural food item; there were no significant differences ($\alpha > 0.05$) in any of the performance parameters as determined by analysis of variance.

	Dietary protein contents		
	35%	45%	Control[1]
Initial weight (g)	0.24	0.23	0.24
Final weight (g)	7.26	7.29	9.99
Initial length (mm)	11.38	11.13	11.64
Final length (mm)	34.42	34.58	37.37
Weight gain (g)	7.02	7.05	9.75
Length increment (mm)	23.04	23.45	25.99
Growth rate ($mm \cdot mo^{-1}$)	3.84	3.91	4.31
Growth rate ($g \cdot mo^{-1}$)	1.17	1.18	1.62
FCR[2]	1.53	1.54	1.38
Total food intake (g)	516.3	513.6	638.5
Survival rate (%)	95	96	100

[1]fresh meat of carangid fish, *Selaroides leptolepis*
[2]food conversion ratio (wet weight basis) = total diet fed (g)/total weight gain (g).

Discussion

In the present study, the differences in growth and feed conversion ratio of juvenile spotted babylon *B. areolata* fed with experimental diets of 35 and 45% protein contents and natural food are relatively small. Survival was 100% for feeding diet treatments. Based on the present data, it is demonstrated that juveniles fed on the experimental diets produced good results in growth (weight gain and length increment), FCR and survival, which are similar to those fed with the natural diet.

This study suggests that the experimental formulated diets is considered to be suitable for growing out of juvenile *B. areolata* over a long-term period of 180 days due to its ready acceptance of formulated feeds with a relatively rapid growth rate, low FCR, and high survival. Chaitanawisuti and Kritsanapuntu (1998) reported that shell growth rate and feed conversion of juvenile *B. areolata* fed with fresh meat of carangid fish *Selaroides leptolepis* were 3.65 mm $month^{-1}$ and 1.9 respectively, which compares with 3.84 to 3.98 and FCR of 1.53 in this experiment.

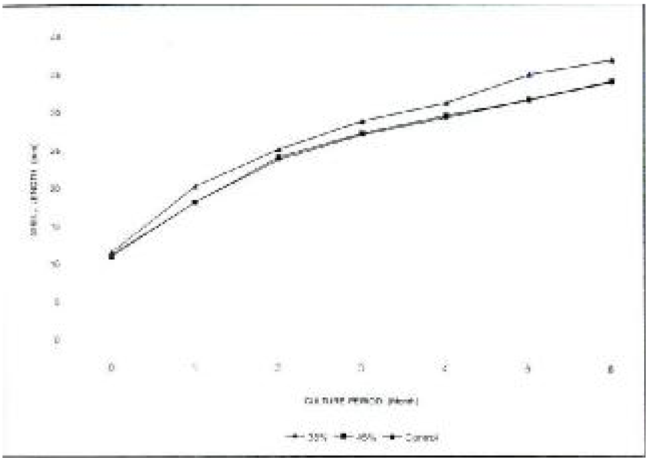

Fig. 1. Monthly average shell length of juveniles *B. areolata* fed with experimental formulated diets and natural food.

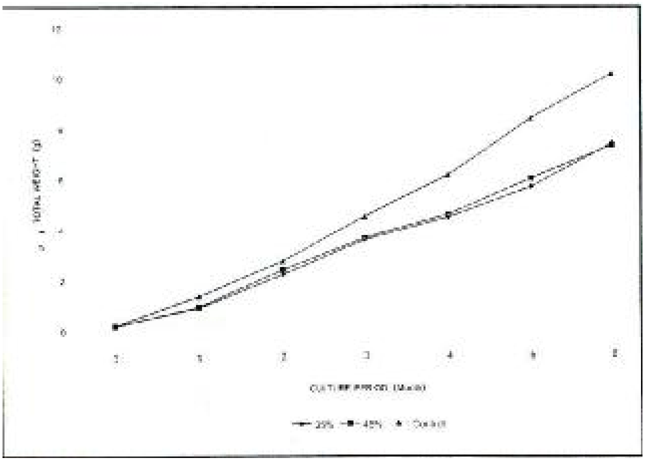

Fig. 2. Monthly average total weight of juveniles *B.areolata* fed with experimental formulated diets and natural food.

The present study indicates that artificial diets are accepted for juvenile spotted babylons in culture systems, although the precise dietary protein level for optimum growth and feed efficiency should be further studied. Improved growth and feed conversion efficiency with increasing dietary protein levels as observed in this study are well documented with other species. Britz (1996) obtained a significant increase in weight gain and feed conversion efficiency with South African abalone *Haliotis midae* fed increasing levels of dietary protein from 27 to 42%.

Similarly other authors have reported higher growth and better FCR with increasing protein content of diet for abalones (Creswell 1984; Mai et al. 1995; Capanin and Corre 1996; Britz and Hecht 1997). However, no information on the nutritional requirements of spotted babylon under controlled conditions have been reported. The present study further indicates that spotted babylon is now considered as a suitable candidate for mariculture due to its ready acceptance of formulated feeds that promote a relatively rapid growth rate, low FCR and high survival.

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