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Growth Performance and Survival Rate of Rabbitfish (*Siganus guttatus*) Juveniles Fed with Two Home-Made Diets

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Abstract - This study was conducted to evaluate the growth performance and survival rate of rabbitfish juveniles fed with two homemade diets and a control (commercial diet) in a two-month culture period. Results revealed that the fastest growth in terms of total weight gain was found in fish fed with the control diet (commercial feeds) with 16.32 g weight gain. This was followed by the homemade diet with Ipil-ipil leaves with 12.67 g whereas the homemade diet with kangkong leaves had a total weight gain of 11.08 g. Likewise, growth in terms of total length gain, it was also found out that highest growth was exhibited by fish fed with the control diet (commercial feed) with a gain of 4.63 cm, followed by homemade diet with Ipil-ipil leaves and kangkong leaves at 4.01 and 3.66 cm, respectively. In terms of body depth, highest growth was observed in the control diet (commercial feeds) with 0.49 cm, followed by homemade diet with Ipil-ipil leaves and kangkong leaves at 0.42 cm and 0.39 cm, respectively. In terms of survival rate, highest was obtained in fish fed with homemade diet with Ipil-ipil leaves at 97.78%, followed by homemade diet with kangkong leaves and commercial diet at 96.67% and 95.55%, respectively. In terms of feed conversion ratio, fish fed with the control diet (commercial feed) utilized the feed most efficiently as indicated by an FCR of 1.77, whereas the two homemade diets with ipil-ipil leaves and kangkong leaves obtained FCRs of 2.08 and 2.16, respectively. The fish in all experimental treatments were in good condition as revealed by condition factors of 1.77 to 1.79, which all exceeded 1.0. A simple cost and return analysis showed that the highest net income and benefit-cost ratio (BCR) were obtained with fish fed with control (commercial) diet at PhP 179.11 and 1.37, respectively.

Key words: *Siganus guttatus*; *Ipomoea aquatica; Leucaena leucocephala*

INTRODUCTION

The rabbitfish or orange-spotted spinefoot, *Siganus guttatus*, locally known as kitong or Malaga, is a highly esteemed food fish in the Philippines and in the Indo-West Pacific Region. Aside from its high price, the rabbitfish is energy efficient as it occupies a low trophic level and it is also relatively fast-growing [1]. The municipality of Binmaley is noted for rabbitfish farming where it is cultured in brackishwater ponds where natural foods are available [2]. In an artificial setting, *S. guttatus* is fed with high protein commercial feeds. However, these feeds are expensive, ranging from PhP 531 to 613.50 per 15-kg sack up to PhP 900 to 1,200 per 25-kg sack, which leads to high production costs. Hence, profit is not maximized and there is a need for alternative diets made from locally available ingredients which are high in protein yet inexpensive.

The present study aimed to assess the growth performance, food conversion ratio, and survival rate of rabbitfish juveniles (*Siganus guttatus*) fed with two homemade diets and a commercial diet and reared in concrete tanks for two (2) months.

MATERIALS AND METHODS

Study Site

The study was conducted at the Bureau of Fisheries and Aquatic Resources – National Integrated Fisheries Technology Development Center (BFAR – NIFTDC) in Bonuan – Binloc, Dagupan City.

Experimental Animals

Hatchery-reared *Siganus guttatus* juveniles with mean initial weights, lengths, and body depths of 5.00-5.37 g, 5.97-6.07 cm, and 0.54-0.55 cm, respectively were used in the study.

Experimental Treatments and Lay-Out

The study used nine (9) larval rearing tanks for the growth experiment. The tanks measured 3 m X 3 m X 1.2 m (L X W X D). There were three treatments (two home-made diets and a commercial diet) with three replicates each. The tanks were laid out using a completely randomized design.

Table 1 presents the treatments, diets, and feed ingredients with their corresponding crude protein (CP) contents used in the study. The CP contents of each feedstuff/ingredient were derived from Millamena et al. (2002) [3], except the fish meal (48.46%). The study utilized the Blackchin tilapia, *Sarotherodon melanotheron* or "tilapiang molmol" as the source of fish meal, which had undergone proximate analysis at the Department of Agriculture – Regional Field Office I in San Fernando, La Union. *S. melanotherodon* is considered a potentially invasive species [4]. Hence, they can be used as source of fish meal as a way to control them.

Table 1. Treatments used and their ingredients with corresponding crude protein contents.

Treatments/Diets	Ingredients	Crude Protein (CP) Content (%)
I Commercial Diet (Control)	Based on label	38
II Home-made diet with ipil-ipil leaves	Dried/pulverized ipil-ipil leaves	29.3
	Fish meal	48.6
	Soybean meal	45
	Rice bran	10
	Corn starch (binder)	-
	Vitamin mix	-
III Home-made diet with kangkong leaves	Dried/pulverized kangkong leaves	28.5
	Fish meal	48.6
	Soybean meal	45
	Rice bran	10
	Corn starch (binder)	-
	Vitamin mix	-

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Feed Preparation

In the preparation of the feeds, the amount of ingredients to be incorporated in each experimental diet were computed using the Pearson Square Method [4].

The kangkong leaves were sun-dried for about 4-5 days. On the other hand, the ipil-ipil leaves were soaked overnight in water prior to sun-drying in order to remove its mimosine content, which may affect the growth of experimental fish. The dried ingredients (ipil-ipil and kangkong leaves) as well as the other ingredients (i.e. fish meal and soybean meal) were finely ground until fine particles of similar sizes were obtained. The ground ingredients were then sieved using a no. 40 sieve or nylon net. The ingredients to be used were then weighed using a 3-kg digital weighing balance. All of the dry ingredients were mixed thoroughly. The vitamin mix was added to the dry mixture. The mixture was again thoroughly mixed for another 5 minutes.

The corn starch was gelatinized by cooking 1 part of starch with 4 parts of water (50 g corn starch in 200 ml water for a 1 kg of feed) in a saucepan until it turned into a jelly-like consistency within 10-30 minutes. The gelatinized binder was removed from heat and allowed to cool. The cooled gelatinized binder (starch) was then added to the dry mixture and mixed for 5 minutes until a stiff dough was formed. The dough was squeezed through a pelletizing machine. The size of the diets should be about 20-30% of the fish's mouth in order to facilitate ingestion and avoid any loss. The pelleted diets were sun-dried for a day. After sun-drying, the extruded or pelleted feeds were cut to their desired lengths, placed in airtight plastic containers, and stored in a cool, dry place.

Stocking and Sampling

Each tank was stocked with 30 rabbitfish juveniles. Initial data on average total length of 5.6-6.3 cm, weight of 4.3-5.8 g, and body depth were taken and recorded. Total length and body depth of *S. guttatus* were taken using a Vernier caliper whereas the weight was taken using a 3-kg capacity digital weighing balance.

Subsequent sampling (50% of each tank) was done every 14 days or 2 weeks thereafter for 2 months.

Feeds and Feeding

There were 3 different diets used in this experiment. The diets were Treatment 1 (Commercial or Control diet), Treatment II homemade diet with ipil-ipil leaves (*Leucaena leucocephala*), and Treatment III homemade diet with kangkong leaves (*Ipomoea aquatica*). The rabbitfish juveniles were fed at a feeding rate of 5% body weight. Feeding was done thrice a day at 8 am, 11 am, and 4 pm.

Maintenance

Siphoning of the tank bottom to remove feces and unconsumed feeds were done daily at 8 am before feeding the stocks. Water change was 10% of the total volume. Water quality parameters such as temperature, salinity, pH, and dissolved oxygen were regularly taken.

Data Gathering

The data on growth parameters, efficiency of feed utilization (FCR), condition factor, and survival rate were taken using the following formula:

Absolute growth

weight gain = Wf – Wi

where: Wf = final weight; Wi = initial weight

length gain = Lf – Li

where Lf = final length; Li = initial length

Efficiency of feed utilization

Feed conversion ratio = dry feed consumed/weight gain

Condition factor

K = BW/(BL)^3 X 100

where BW = body weight in grams; BL = body length in cm

Survival Rate

Survival Rate = Final number of stocks/Initial number of stocks X 100

Proximate Analysis

The nutritional composition of the two home-made diets were analyzed for proximate composition such as crude protein, fats, fibers, and ash at the Feed Testing Laboratory of Department of Agriculture – Regional Field Office I in San Fernando City, La Union.

Simple Cost and Return Analysis

The computation for the simple cost and return analysis was done by getting the sum of all the expenses utilized in the study including feeds, and feedstuffs or ingredients incorporated in preparing experimental diets such as fish meal, soybean meal, rice bran, corn starch, and vitamin mix. Net income for every experimental diet was also computed so as to obtain the benefit-cost ratio.

In the simple economic analysis, the following formula were used:

Feed Expenses = FCR + Cost of feed/kg

Total Expenses = Feed expenses + Miscellaneous

Net Income = Price of fish/kg – Total Expenses

Benefit-Cost Ratio (BCR) = Net Income/Total Expenses

Statistical Treatment of Data

To determine the growth performance, survival rate, feed conversion ratio, and condition factor, one-way analysis of variance (ANOVA) was used as the statistical tool. Computation was aided using Microsoft Excel 2010 and Statistical Package for Social Science (SPSS), followed by the Scheffe's and Duncan'sMultiple Range Test (DMRT) as post-hoc tests.

RESULTS AND DISCUSSION

Growth in Weight

Table 2 presents the growth and mean weight gain of rabbitfish fed with the commercial diet and two home-made diets in the two-month culture period. At the end of the culture period, Treatment I (commercial diet) had the highest weight of 21.32 g, followed by Treatment II (Ipil-ipil) at 18.06 g while Treatment III (Kangkong) had the least weight of 16.35 g. ANOVA revealed no significant difference in weight between Treatments I and II at the end of the culture period but significant difference between Treatment I and III. In terms of weight gain, Treatment I (commercial diet) had the highest total weight gain of 16.32 g while Treatment II (Ipil-Ipil) and Treatment III (Kangkong) had weight gains of 12.67 g and 11.08 g. Further analysis using Scheffe's Multiple Range Test it was revealed that Treatment I and II were comparable with each other but not with Treatment III whereas Treatments II and III are comparable but not with Treatment I.

In the study conducted by Parazo (1990), she reported that rabbitfish will not grow at an optimal rate if only given algae [5]. In that study, *S. guttatus* had the best growth when fed a ration high in energy (3832 kcal/kg feed), and a high content of crude protein (35%) in addition to carbohydrates and fat.

Table 2. Mean weight gain of rabbitfish juveniles fed with commercial diet and two home-made diets in a 2-month culture period.

Treatment	Replicate	Culture Period (Days)					Weight Gain
		Initial	Day 14	Day 28	Day 42	Final	
I	1	4.90	8.70	10.27	16.83	20.63	15.73
	2	4.30	7.53	11.80	17.13	20.57	16.27
	3	5.80	8.43	11.60	18.37	22.77	16.97
	Mean	5.00	8.22^{a}	11.22^{a}	17.44^{a}	21.32^{a}	16.32^{a}
II	1	5.60	9.63	11.57	17.97	19.77	14.17
	2	5.20	7.80	11.23	14.13	17.23	12.03
	3	5.30	8.90	10.40	14.17	17.17	11.80
	Mean	5.37	8.78^{ab}	11.07^{a}	15.42^{a}	18.06^{ab}	12.67^{ab}
III	1	5.30	7.10	13.47	15.90	18.77	13.47
	2	4.90	6.43	10.23	12.23	14.97	10.07
	3	5.60	6.47	10.17	12.17	15.31	9.71
	Mean	5.27	6.67^{b}	11.29^{a}	13.43^{a}	16.35^{b}	11.08^{b}

Means with the same superscripts were not statistically different at 5% level

Growth in Length

Table 3 presents the mean length of the rabbitfish at the different time periods and the mean length gain of S. *guttatus* juveniles fed with commercial diet and two homemade diets in a two-month culture period. At the end of the culture period, the experimental fish in Treatment I (commercial) obtained the highest mean length of 10.58 cm, followed by Treatment II (Ipil-ipil) and III (Kangkong) at 10.07 cm and 9.73 cm, respectively. However, one-way ANOVA showed no significant differences among treatments (P>0.05). As shown in Table 3, the highest total mean length gain was obtained in Treatment I with 4.63 cm after 56th day of the feeding experiment, followed by Treatment II and Treatment III at 4.01 cm and 3.66 cm, respectively. One way ANOVA revealed significant differences in total growth in length among treatments (P<0.05). Further analysis using Scheffe's test and DMRT showed that Treatments I and II are found to be comparable with each other but not with Treatment III, whereas Treatments II and III are comparable but not with Treatment I.

Table 3. Mean length gain of rabbitfish juveniles fed with commercial diet and two home-made diets in a 2-month culture period.

Treatment	Replicate	Culture Period (Days)					Length Gain
		Initial	Day 14	Day 28	Day 42	Final	
I	1	6.00	7.54	7.95	8.91	10.26	4.32
	2	5.60	7.33	7.54	9.67	10.58	4.98
	3	6.30	7.48	8.44	9.99	10.89	4.59
	Mean	5.97	7.85^{a}	7.98^{a}	9.52^{a}	10.58^{a}	4.63^{a}
II	1	6.20	7.79	8.67	9.59	10.13	3.93
	2	6.10	7.22	8.43	9.43	9.85	3.75
	3	5.90	7.27	8.05	9.14	10.24	4.34
	Mean	6.07	7.43^{a}	8.38^{a}	9.39^{a}	10.07^{a}	4.01^{ab}
III	1	6.10	7.44	8.51	9.85	10.15	4.05
	2	5.90	6.95	8.13	8.79	9.43	3.53
	3	6.20	7.00	8.03	8.99	9.62	3.40
	Mean	6.07	7.13^{a}	8.22^{a}	9.21^{a}	9.73^{a}	3.66^{b}

Means with the same superscript are comparable

Survival Rate

Table 4 shows the mean survival rates of rabbitfish juveniles fed with the commercial (Treatment I) and two home-made diets (Treatments II and III) in a 2-month culture period. The highest mean survival rate was observed in Treatment II (Ipil-ipil) with 97.78%, followed by Treatment I (Commercial) with 96.67% and Treatment III (Kangkong) with 95.55%. ANOVA, however, revealed no significant differences (P>0.05) on the mean survival rates per time interval in all treatments. Mortalities observed in some treatments were caused by stress during the sampling particularly in handling fish.

Proximate Composition of Feeds

Table 5 presents the proximate analysis or the nutritional composition of the two home-made diets as compared with the commercial diet. Based on the proximate analysis of the diets, the commercial diet (Treatment I) had the highest crude protein of 38%, followed by Treatment II (Ipil-ipil) and Treatment III (Kangkong) with 32.9% and 31.9%, respectively. In terms of crude fat, highest was observed in treatment II at 13.1%, followed by Treatment III and commercial diet with 12.2% and 6.0%, respectively. In terms of crude fiber, kangkong had the highest with 6.3%, followed by ipil-ipil at 5.8% and commercial at 5%.

Table 4. Mean survival rates of rabbitfish juveniles fed with commercial diet and two home-made diets in a 2-month culture period.

Treatment	Replicate			
	1	2	3	Mean
I	90.00	100.00	100.00	96.67[a]
II	93.00	100.00	100.00	97.78[a]
III	100.00	93.33	93.33	95.55[a]

Means with the same superscript are comparable

Table 5. Proximate analysis* of the two home-made diets and the commercial diet.

Nutrient Composition	Treatment I	Treatment II	Treatment III
	Commercial (Based on Label)	Ipil-Ipil Leaves	Kangkong Leaves
Crude Protein	38.0	32.9	31.9
Crude Fats	6.0	13.1	12.2
Crude Fiber	5.0	5.8	6.3
Crude Ash	12.0	12.0	14.2
Moisture Content	12.0	9.1	9.4

* Proximate analysis conducted at the Department of Agriculture, regional Field Office – I (DARFO-1), Feed Testing Laboratory

Feed Conversion Ratio

Table 6 shows the feed conversion ratio of the three diets. The FCRs obtained from this study ranged from 1.77 to 2.16. This means that it would need 1.77 to 2.16 kg of feeds to produce a kg of *S. guttatus* in tanks. Treatment 1 (commercial) utilized the feeds most efficiently as indicated by an FCR of 1.77, followed by Treatments III and II at 2.16 and 2.17, respectively. One-way ANOVA detected significant differences among FCRs (P<0.05). Further analysis using DMRT showed that the commercial diet (Treatment I) was most efficient among the diets, while Treatment II (Ipil-ipil) and Treatment III (Kangkong) are comparable but not as efficient as the commercial diet.

According to Shelley and Lovatelli (2011), the FCR is defined as the amount of feed required to produce a kg of fish [6]. FCR is one of the most important parameters in feeding success because this relates to the quantity of feed consumed and the increase in body weight and to the cost of production [7]. Furthermore. Chiu (1989) added that feed efficiency could be well quantified if feeding is well managed and excess food negligible [8].

Condition Factor

Before the feeding experiment, the recorded mean condition factor of Treatments I, II, and III were 2.35, 2.41, and 3.36, respectively. After the experiment, fish in treatment I was found with the highest mean condition factor of 1.79, followed by Treatments II and III, both with a mean condition factor of 1.77. One-way ANOVA, however, failed to show significant differences in computed condition factors in all treatments (P>0.05). The low values of K in all treatments especially starting in day 28 up to the end of the culture period were believed to have been due to stress of the fish during the sampling periods. However, Bennet (1970) reported that fish with a body form like rabbitfish, tilapia, and the like, is in good condition if it attains a condition factor of at least 1 [9].

Water Quality Conditions

Water quality parameters during the experimental period were all within optimum range. The recorded water temperatures in all experimental tanks ranged from 25-27°C with a computed mean temperature of 25.68°C. According to Kohno et al. (1988), survival of *S. guttatus* larvae is improved when rearing is at lower temperatures (22-26°C) [10]. In terms of salinity, it ranged from 32-35 ppt in all experimental tanks having a mean of 33.64 ppt. Rabbitfishes are generally tolerant of wide salinity changes ranging from 14-37 ppt [11]. However, Pillai (1962) remarked that rabbitfishes may not tolerate very low salinity [12]. In terms of DO, it ranged from 6.23 to 6.41 mg/L with a mean of 6.30 mg/L. Chapman (1996) reported that values of 5 mg/L and lower may cause lower functioning and survival of most fish [13]. Results of pH readings ranged from 7.28 to 7.64 with a mean of 7.47. The optimum range for culturing *S. guttatus* ranges from 6-8.5.

Table 6. Computed feed conversion ratio for the three experimental diets.

Treatment	Replicate	Total Feed Consumed	Total Weight Gain	FCR
I Control (Commercial)	1	820.82	442.50	1.85
	2	826.28	491.50	1.68
	3	887.32	501.00	1.77
	Mean	**844.81**	**478.33**	**1.77[a]**
II Home-made (Ipil-ipil leaves)	1	901.88	421.00	2.41
	2	768.74	381.50	2.02
	3	776.80	372.00	2.09
	Mean	**815.81**	**391.50**	**2.17[a]**
III Home-made (Kangkong leaves)	1	840.28	402.50	2.09
	2	667.38	313.00	2.13
	3	699.02	309.80	2.26
	Mean	**735.56**	**341.77**	**2.16[a]**

Simple Cost and Return Analysis

Table 7 shows the simple cost and return analysis of rabbitfish juveniles fed with two home-made diets as compared with the commercial feed in a 2-month culture period.

The cost of commercial feeds per 15-kg sack/kg was PhP 561.00, hence it was PhP 34.40/kg, whereas both the two home-made diets were computed based on the amount of ingredients incorporated wherein the amount of PhP 36.92 and PhP 37.58 per kg, respectively were obtained. Feed expenses among the three treatments, likewise, were computed by multiplying the FCR into cost of feed. Based on a price of rabbitfish (*S. guttatus*) or Malaga which costs PhP 310.00 per kg, the highest net income (PhP 179.11) was obtained in Treatment I followed by Treatments II and III with PhP 163.21 and PhP 158.83, respectively. On the other hand, based on the simple economic analysis, Treatment 1 which was the commercial feed, was found to be most profitable as evidenced by its benefit-cost ratio (BCR) of 1.37, wherein for every peso invested, 37 centavos was gained.

Based on the results, a similar study should be conducted using different plant-based diets having relatively high crude protein contents to improve the home-made diets in order to formulate a diet comparable with commercial feeds but yet are inexpensive.

Table 7. Simple cost and return analysis of rabbitfish juveniles fed with two home-made diets and a commercial feed in a 2-month culture period.

	Treatments		
	I	II	III
FCR	1.77	2.08	2.16
Cost of Feed/kg (PhP	34.40	36.92	37.58
Feed Expenses (PhP)	60.89	76.79	81.17
Miscellaneous	70.00	70.00	70.00
Total Expenses	130.89	146.79	151.17
Price of Fish/kg	310.00	310.00	310.00
Net Income	179.11	163.21	158.83
Benefit-Cost Ratio	1.37	1.11	1.05

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