TfR
Trends in Fisheries Research
An International Peer-Reviewed Journal
www.sciencejournal.in
DAMA INTERNATIONAL

GROWTH AND YIELD OF RABBITFISH (*SIGANUS GUTTATUS*) REARED IN RIVER FLOATING NET CAGES AT VARIOUS STOCKING DENSITIES AND FEEDING SCHEME

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ABSTRACT
Six treatment combinations consisted of three stocking densities of 50, 100, 200, rabbitfish (*Siganus guttatus*) per cubic meter (m^3) at two feeding schemes of sliding 10, 8, 6, 5% commercial feed of fish biomass (F_1) and 5 % commercial feed of fish biomass daily with *Chaetomorpha linum*, "lumut" fed to satiation (F_2) were tested to determine the growth and yield of rabbitfish in river floating net cages for 120 days. The F_1 at stocking density of 50 fish/ m^3 and feed commercial feeds daily at sliding (10-8-6-5% BW) feeding scheme registered the highest mean growth of 105.6 g/fish. However, statistical analysis showed no significant difference (P>0.05) in growth among treatments. In terms of production, the F_2 at 200 fish/ m^3 and fed commercial feeds at 5% BW plus "lumut" registered the highest mean production of 18.23 kg/m3. Production was highly significant (P<0.01) in between stocking densities but not between feeding schemes. Survival (90-96%) and mean feed conversion ratios (3.6-4.4) were not significantly different (P>0.05) among treatments. Rearing *S. guttattus* in floating net cage at 200 fish/ m^3 fed commercial feeds daily at 5% BW plus "lumut" fed to satiation appeared to give the highest net income of 705.96/ m^3 and a benefit-cost-ratio of 1.42.

KEYWORDS: rabbitfish, growth and yield, stocking density, floating net cage

INTRODUCTION

Fishes in the rabbitfish family (Siganidae) are as efficient as the milkfish in converting plant material into animal protein thus have long been considered suitable for culture (Carumabana and Luchavez, 1979; Ayson, 1989). Of the 15 species of siganids thriving in the Philippine waters (Herre and Montalban, 1928; Pacoli, 1983), *Siganus guttatus* is found to be a potential species for culture in ponds and in floating net cages because of its fast growth, capacity to attain large size, tolerance to a wide range of salinity, temperature and other physical factors such as crowding (Lam, 1974; Alcala, 1979; Carumbana and Luchavez, 1979; Pacoli, 1983; Gerochi et al., 1988 a). Furthermore, this species have been shown to spawn in captivity (Hara et al., 1986). In Pangasinan, only few fish farmers raise *S. guttattus* and *S. vermiculatus* in ponds in commercial scale and they use lower stocking density of 0.3 fish/m^2 (personal interview). Since ponds are not increasing in size and these species command a better price (P100.00/kg) in the local market, there is a need to expand the area for culture. Communal waters, like rivers, in-shore marine waters and coves are possible expansion site for production using net float cages. Some studies on *S. guttattus* in floating net cages gave promising results. Toledo (1990) reported that commercial formulated feed containing 30% crude protein (C.P.) given at a sliding feeding rate of 10%, 8%, 6%, 4% and 3% body weight (BW) gave the highest mean weight gain (77.7 g/fish) and production (4.18 kg/m^3) after 122 days of culture at a stocking density of 50 fish/m^3. Soriano et al., (1993) reported that a combination of commercial formulated feed give at 5% of the average BW plus *Chaetomorpha linum* (lumut) given ad libitum gave best growth and survival of *S. guttattus* stocked at 50 fish/m^3. Ponce (1986), however, found no significant difference in the production of *S. guttattus* stocked at 50 and 100/m^3.

MATERIALS AND METHODS

Experimental Site: The study was conducted along the Manat river, Binmaley, Pangasinan. It is the biggest river in the municipality of Binmaley and a tributary of the Agno River System. It is considered one of the most productive fish communal waters in the municipality. Most fishermen in the community and adjoining places are dependent on this fishing ground. Fish pen, fish corrals, skylabs and oyster culture beds proliferated in the area.

Experimental Units: Two sets of cages measuring 1 x 1 x 1.5 m each cage were fabricated in an anchored bamboo raft at a distance of one m in between rows and in between columns and held in place using uncovered bottles tied by nylon rope at the bottom corners of each cage. The bottles were tied in upward position to fill in water for additional weight. The raft was made of full length bamboos to strongly maintain its floatation.

Experimental Design and Treatments: The experiment was conducted following the two-way factor analysis in randomized complete block design (RCBD) with six treatment combinations.

Stocking Density (SD):

S_1 = 50 fish/m^3
S_2 = 100 fish/m^3
S_3 = 200 fish/m^3

Feeding Scheme (FS):

F_1 = commercial feeds given at sliding 10%, 8%, 6%, 5% BW on the first, second, third and fourth months, respectively.
F_2 = commercial feeds given at sliding 5% BW plus *Chaetomorpha linum* "lumut" fed to satiation for four months of culture.

Experimental treatments were randomized and replicated three times as illustrated in Figure 1.

B_1	$F_1S_2(T_2)$	$F_2S_1(T_4)$	$F_1S_3(T_3)$	$F_2S_2(T_5)$	$F_1S_1(T_1)$	$F_2S_3(T_6)$
B_2	$F_1S_3(T_3)$	$F_2S_2(T_5)$	$F_1S_1(T_1)$	$F_2S_3(T_6)$	$F_1S_2(T_2)$	$F_2S_1(T_4)$
B_3	$F_1S_1(T_1)$	$F_2S_3(T_6)$	$F_1S_2(T_2)$	$F_2S_1(T_4)$	$F_1S_3(T_3)$	$F_2S_2(T_5)$

Figure 1. Experimental lay-out with six treatment combinations (T_1-T_6) in a randomized complete block (B_1-B_3) design.

Experimental Fish: A total of 2,100 *S. guttattus* juveniles with an average weight of 10.65 g and average length of 8.5 cm were used in the study. These were purchased from a fishpond operator in Binmaley, Pangasinan. They were placed in a 3 x 3 x 2 m cage and were acclimated to site's condition for two weeks. Since the fish fed entirely on "lumut" from the source, they were trained to feed purely on commercial formulated feed alone during the acclimation period.

Feeds and Feeding Schedule: The commercial formulated feed used was composed of starter, grower and finisher milkfish pellets supplied by B-meg San Miguel Food Inc., Makati, Metro Manila. Starter pellet was administered for the first 30 days, grower pellet for the next 60 days and finisher pellet for the last 30 days of culture.

The green algae, *Chaetomorpha linum*, "lumut" was purchased from local fishfarmers (30 kg wet weight/sack). This was given fresh and fed to satiation daily in treatments F2S1 (T4), F2S2 (T5), F2S3 (T6). The amount of "lumut" given per day was weighed and recorded. The fish were fed twice daily (8:00-9:00 a.m. and 3:00-4:00 p.m.). Daily feed ration was divided into two equal parts for the morning and afternoon feeding. Feeding trays measuring 45x45 cm and made of fine meshed nets were used for each cage to avoid feed losses.

RESULTS AND DISCUSSIONS

Growth: The periodic mean weight and mean weight gain and periodic mean length and mean length of gain of *S. guttattus* during the 120 days culture period.

S. guttattus exhibited varying weight gain during the entire culture period. On the first month, the fish showed relatively the same pattern of growth with sharp increases the weights. On the second month, a decreasing growth pattern was observed, although there was a relatively slight increase in BW in all treatments. Sharp increases in weight gain were observed during the third month. On the fourth month, the growth pattern was changed. Treatment 6 (F_2 at 200 fish/m^3) registered the highest weight gain of 8.7 g. At the end of the culture period, Treatment 3 (F1 at 200 fish/m^3) registered the lowest weight gain of 5.1 g. Periodic weight gains were not statistically significant (P>0.05) in all treatments except between 57-70 days of culture when F_2 at 200 fish m^3 registered a gain of 9.1 g, was significantly lower with all other treatments. Periodic length were likewise not significantly different (P>0.05) among treatment combinations.

The computed mean daily weight gain based on the entire culture period ranged from 0.69-0.88 g with treatment 1 (0.88 g) as the highest, followed by Treatment 2 (0.82 g), Treatment 4 (0.77 g), Treatment 6 (0. 75 g), Treatment 5 (0.71 g) and Treatment 3 (0.69). Differences among treatments were not significant (P>0.05).

Final weight and weight gain and final length and length gain were not significantly different (P>0.05) among treatments. From an initial length of 8.5 cm and weight of 10.65 g in all treatments, Treatment 1 recorded the highest mean final length of 17.5 cm (9.0 cm gain) and weight of 116.2 g (105.55 g gain). This was followed by fish in Treatment 2 which grew to a mean final of 17.1 cm (8.6 cm gain) and weight of 109.3 g (98.65 g gain). Fish in Treatment 4 grew to a mean final length of 17.0 cm (8.5 cm gain) and weight of 103.3 g (92.65 g gain), while fish in Treatment 6 grew to a mean final length of 16.8 cm (8.3 cm gain) and weight of 96.5 g (85.85 g gain). The fish in Treatment 3 registered the lowest final length of 16.5 cm (8.0 cm gain) and final weight of 94.1 g (83.45 g gain).

Condition Factor: The mean condition factor of *S. guttattus* for the six treatment combinations after a culture period of 120 days.

Before stocking, the initial condition factor was 1.73 in all treatments. During harvest, the mean condition factor ranged from 2.07-2.18. The highest was obtained in Treatment 2 (2.18) followed by Treatment 1 (2.15), Treatment 6 (2.14), Treatment 3 (2.10), Treatment 4 (2.09) and the lowest is Treatment 5 (2.07). These values, however, were not significantly different from each other (P>0.05).

Survival: The mean survival rate ranged from 90% to 96% for all treatment combinations. The highest was obtained in Treatment 2 (96%) followed by Treatment 4 (94%), then Treatments 1, 3 & 5 (92%) and the lowest is Treatment 6 (90%). These values were not significantly different from each other (P>0.05).

Production: The mean fish production ranged from 4.88-18.23 kg/m^3. The highest was obtained in Treatment 6 (18.23 kg/m^3) followed by Treatment 3 (17.36 kg/m^3), Treatment 2 (10.51 kg/m^3), Treatment 5 (8.92 kg/m^3), Treatment 1 (5.44 kg/m^3) and the lowest is Treatment 4 (4.88 kg/m^3). Differences in treatment means were highly significant (P<0.01) between stocking densities. However, within each stocking density, no significant differences (Pr>0.05) in fish production was observed when given feeding schemes 1 or 2.

Feed Conversion Ratio: Treatment 2 (F1 at 100 fish/m3) utilized the feed most efficiently as indicated by a feed conversion ratio of 3.6. This was followed by treatment 4 (F2 at 50 fish/m3) with conversion value of 3.7. Treatment 6 (F2 at 200 fish/m3) at 3.9. Treatment 1 (F1 at 50 fish/m3) at 4.1, Treatment 5 (F2 at 100 fish/m3) at 4.2. The least efficient was Treatment 3 (F1 at 200 fish/m3) with feed conversion of ratio of 4.4. These values were not significantly different (P>0.05) from each other. However, in overall performance, the F2 (5% commercial feed with "lumut" fed to sanitation) was found to be more efficient than F1 (commercial feed at sliding feeding rate).

Physico-Chemical Parameters: It was colder from the 4th week of January to the second week of March, as evidenced by temperature range of 23.5-25.5 C was maintained during the last two months of culture. Water salinity ranged from 30-40 ppt during the culture period. Highest salinity of 40 ppt was recorded during the whole month of April to the 1st week of May. Salinity was mostly higher during downstream than in upstream. Highest visibility reading of 2.6 was observed during the colder months (January-February) where temperature is low and aquatic nutrients (zooplankton and phytoplankton) are less abundant. The lowest visibility of 1.4 m was observed during the month of April when the temperature and salinity were at its peak.

Water velocity was observed to be 0.03 to 0.06 m/sec during the culture period. Dissolved oxygen ranged from 2.0 to 4.6 ppm. The water pH ranged from 6.8-7.3. The water depth in the site ranged from 4m (low tide) to 5 m (high tide).

Simple Cost and return Analysis: Juveniles of *S. guttattus* cost P 4.00/fish stocking the densities of 50,100 and 200 fish/m3 the cost was P 200.0, P 400.00 and P 800.00 each cave, respectively. The commercial feed which consisted of starter (32.8 CP), grower (31.8 CP) and finisher (31.7 CP) pellets cost P 12.00/ kg, whereas, "lumut" cost P 1.00/kg or P 30/sack (30 kg wet weight). Mean total feed cost per kg gain was base on the mean FCR multiplied by mean feed cost/kg per treatment combination. Mean total feed cost per cage was computed from the mean feed cost per kg gain multiplied by the mean gain in weight. The cost of materials and construction of one unit cage was P 496.11. However, it can be brought down to P 82.70 assuming that one cage would last for three years and at 2 fish croppings per year. Based on a price of P 130/kg (May 1994; Dagupan City) , highest gross income (P 2,369.90) was obtain in F2 at 200 fish/m3 stocking density in lowest (P 634.40) in F2 at 50 fish/m3 stocking density. Likewise, highest net income (P 705.96) was obtained in F2 at 200 fish/m3 but lowest (P 69.90) in F1 at 50 fish/m3. Based on the cost and return analysis, the 200 fish/m3 stocking density fed with commercial feed at 5% of fish biomass daily with "lumut" fed to satiation was found to be most profitable as evidenced by its benefit-cost ratio (BCR) of 1.42 and return on investment (ROI) of 42%. However, in the non-availability of "lumut" in the locality, the commercial feed at sliding feeding rate of 10-8-6-5% of fish biomass daily at 100 fish/m3 stocking density is recommended second most feasible as indicated by its BCR of 1.36.

The remarkable growth of *S. guttattus* in this study was probably related to the protein content of the feed, proper feeding management, good water quality and appropriate cage size and proper maintenance. Soletchhik (1984) reported that production of *S. guttattus* juvenile would require 33% protein. Gerochi et al. (1988 b) found that 25% protein gives the highest growth increment if given as supplemental diet. Parazo (1989) observed that specific growth rate of juvenile *S. guttattus* increases directly with the protein and energylevels. She stressed that 35% protein would be economical. In this study, the required protein for optimum growth of *S. guttattus* was probably met with the use of diets containing 31.7-32.8 crude protein.

Proper feeding management is important for the attainment of maximum growth. The feeding schemes used in this study: 1) sliding feeding of 10-8-6-5% BW of commercial feed; and 2) 5% BW commercial feed with "lumut" fed to satiation in F2 probably equated the amount of protein given to fish in F1 at sliding feeding rate resulting to growth that was not significant. *Chaetomorphalinum*, "lumut" which contains 10% protein (BAI, 1990) is the primary food of *S. guttattus* in ponds. According to Bwathondi (1983), the optimum amount of feed required by animals per day is between 3-10% of BW. Anything less is considered insufficient or starvation, whereas, anything more is considered overfeeding or wastage. He added that 5% is just about the optimum amount of food that brings optimum growth. Feeding frequency varies with different species. For optimum growth, milkfish (*Chanos chanos*) feeds 8 times a day (Chiu et al., 1976), tilapia (*Oreochromis niloticus*) once a day (de Saliva et al., 1986) and grouper (*Epinephelus tauvina*) once or twice a day (Chua and Ten, 1978). In the present study, *S. guttattus* is fed twice a day because it is believed that this conditioning of fish to feeding frequency minimizes wastage of food . Bwathondi (1983) stressed that once the fish is conditioned to a particular feeding time. They would come to the surface at the scheduled time. Every fish is active at such as time and would try to consume as much food as possible, probably to its satiation.

A fish is in good condition when it attains a condition factor of at least 1.0 (Bennet, 1970). In the present study, the condition factors which ranged from 2.07-2.18 remained constant throughout the culture period. This indicates better body condition of the fish. The fish must have attained physiological adaptation to various environmental factors. The above data is similar to the condition factors of 2.04-2.17 obtained by Toledo (1990) in *S. guttatus* reared in floating cages.

Other factors that contributed to the high survival rates of *S. guttatus* were probably the proper maintenance of cages and good water quality. Two sets of cages were utilized in this study. Cage constructed from smaller mesh size nets was set for the first two months of culture. This was done to avoid the entrance of predators and larger species which would compete with the cultured fish during feeding. In the last two months of the experiment, another set of cages with bigger mesh size were used. In this stage, the smaller fish that enter the cage may not have access to food because the cultured fish (*S. guttatus)* could chase them.

Feed conversion ratio is one of the most important parameters in feeding success (Boonyaratpalin, 1989) because this relates to the quantity of feed consumed and increased in body weight and to the cost of production. Chiu (1989) added that feed efficiency could be well quantified if feeling is well managed and excess food negligible. The feed conversion ratio obtained from this study ranged from 3.6-4.4. This means that it would need 3.6-4.4 kgs of feed to produce a kg of *S. guttatus* in floating cages. This value is close to the computed feed conversion ratio of 3.08-5.38 different levels of protein. Water quality parameters obtained during the culture period were within the desirable range required by *S.guttatus*. Observed water temperature of 23.5-27 C were relatively similar to the data of Drew (1971) and Alcala (1979) in siganid juvenile which was between 23-26 C. Although, the observed temperatures were relatively low compared to 29.5 C obtained by Parayno (1986) in the same area, this did not affect the growth and survival of *S. guttatus*. This proves that *S. guttatus* could tolerate wide ranges of temperature. Dissolved oxygen ranged 2.0-4.6 ppm throughout the culture period which was higher than the lower limit of 0.7 ppm observed by Carumbana and Luchavez (21979) and Tobias (1976).

The size of the cage which 1 m3 may have contributed to the insignificant effect on growth of *S. guttatus*. Abdel-Fatah et al,. (1993) indicated thart siganids reared in smaller cages had better feed conversion than those reared inlarger cages, given the same amount of feed at 7-8% BW per day. The smaller the cage, the greater is the water exchange rate potential. A water flow rate of 1m/min will exchange water one time in one meter wide (1 m3) cage but only time in seven minutes in seven meter wide (98m3) cage.. Hypothetically, if oxygen concentration was 3.2 ppm as it entered the 1 m3 cage, it would be 2.2 ppm after flowing one meter. However, if oxygen concentration was 3.2 ppm as it entered the 98m3 cage, all fish would have been dead from lack of oxygen within the first meter (Schmittou, 1993). The data on the fish production in this study are relatively high. The lowest mean production (4.88 kg/m3) obtained in this study is higher than the highest than the highest mean production (4.18 kg/m3) obtained by Toledo (1990) using both 50 fish/m3 in floating net cage. Production was statistically different between stocking densities but not between feeding schemes. Therefore, it is expected that highest production of *S. guttatus* will be obtained in higher densities due to insignificant difference in mean BW. The finding agrees with the work of Salvador (1990) that space limitation does not influence the growth of tilapia hybrids in seawater net cages at 50-200 fish/m3 stocking densities. Likewise, this study confirms the statement of Ayson (1988) that *S. guttatus* holds a good promise for culture because of its fast growth rate and capacity to attain large size even in confinement.

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