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The Aquaculture Performance of Red Tilapia (*O. niloticus x O. mossambicus*) and Giant Freshwater Prawn (*Macrobrachium rosenbergii*) as Influenced by Different Stocking Ratios

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Abstract - *A study was conducted at the Pampanga State Agricultural University-Inland Fisheries Project to determine the optimum stocking ratio of red tilapia and giant freshwater prawn in earthen ponds for a period of 3 months. The study focused on some growth parameters of red tilapia and prawn as influenced by 4 stocking ratios. The study revealed that Treatment 1 (3:3 ratio) yielded the best results in terms of growth performance and survival rate among the treatments used (p<0.05). Furthermore, Treatment 1 showed better economic performance compared to other treatments. Therefore, it is advisable to use 3:3 stocking ratio in a polyculture system of red tilapia and giant freshwater prawn.*

Keywords*: polyculture, water quality, growth performance, survival rate, growth pattern*

Introduction

Aquaculture is a huge industry in the Philippines. This sector plays preponderant role in securing food sufficiency and employment of the country's ballooning population. The aquaculture sector contributes the highest production of fish among the 3 subsectors of Philippine Fisheries according to the recent statistical report [6]. Aquaculture production also posted significant increase in the previous years which could be attributed to the development, utilization and adoption of some technologies in fish farms [13]. Though consistent increase was observed, fish farmers are still findings ways on how to elevate their profit that could be linked to the increasing cost incurred in each production cycle.

In order to maximize profit, farmers employed various production measures such as adoption of intensive farming system, shifting to high value commodities, and polyculture method. The latter is an old practice in aquaculture which involves maximizing the capacity of the culture units by raising two or more aquatic organisms with different trophic levels simultaneously [5]. In brackishwater environment, the milkfish is raised with various high value species such as penaeid shrimps, mangrove crabs, mollusks or other finfishes that are demersal or benthic in nature. In the freshwater side, tilapia remains the most commonly grown fish with limited number of species for polyculture.

At present, there were already immense number of researches on growing fish simultaneously with other species in brackishwater environment but there is still paucity of information on the freshwater counterpart. This information was only limited to tilapia with catfish or giant freshwater prawn. Although polyculture was already employed, the main concern is that the price of tilapia is still in stagnancy or sometimes fluctuates on a seasonal basis which provides the farmer with only a small percentage increase in its profit.

The giant freshwater prawn (*M. rosenbergii*) is now considered an important commodity from freshwater capture and aquaculture. However, harvest from the wild is seasonal and production from aquaculture is still very low [23]. Result of the Techno-Demo Project carried out by the Bureau of Fisheries and Aquatic Resources showed 70% survival in lahar-affected ponds with Nile tilapia [7].

Red tilapia is a genetic mutant selected from tilapia species belonging in the genus *Oreochromis*. As of date, the fish is not widely grown in the country but it commands higher market price compared to other tilapia used. The aquaculture production of the red tilapia does not deviate from other strains developed through selection and hybridization which means that there will be no alteration on the production system. Thus, the fish could be a potential candidate for growing with freshwater prawn. However, stocking ratio is still an important factor to be considered for the success of the polyculture. Hence, this research focused on identifying the potential of red tilapia hybrid and giant freshwater prawn under polyculture system with respect to stocking ratios.

Methodology

The present wok was carried out at the Pampanga State Agricultural University Inland Fisheries Project. A total of 12 identical earthen ponds (3 x 1.2 x 0.6 m) were constructed that served as confinements for tilapia and prawn. The tilapia fingerlings and prawn post-larvae were obtained from the Bureau of Fisheries and Aquatic Resources – Technology Outreach Station for Freshwater Species in Castillejos, Zambales. The fingerlings and post-larvae were temporarily confined to nursery tanks for about 2 weeks. Prior to stocking, the initial length and weight of tilapia and prawn were measured.

Four (4) treatments were used in this study as to different stocking ratios. These treatments were arranged in a completely randomized design (CRD) with 3 replications (T1 – 3/m^2 red tilapia: 3/ m^2 giant prawn, T2 - 3/m^2 red tilapia: 6/ m^2 giant prawn, T3 - 3/m^2 red tilapia: 9/ m^2 giant prawn, and T4 - 3/m^2 red tilapia: 12/ m^2 giant prawn). The stocking ratio of treatment 1 was adapted from the common ratio used by fish farmers for tilapia and giant freshwater prawn in Central Luzon [7].

Tilapia stocks were fed with commercial fish grower pellet available in local market having a crude protein of 29%. The ration was given to the stocks twice based on the 90% satiation level. Adjustment of feeding ration was made by observing the satiation level every 15 days for red tilapia. The stocks were fed twice a day. Prawn stocks were given chopped freshwater bivalve (*C. plicata*) taken from the breeding ponds of PSAU-Inland Fisheries Project. The diet was given at a rate of 10% of their initial body weight and 20% of the computed initial amount was added every 15 days.

Figure 1. Stock feeding

Water quality parameters such as temperature, dissolved oxygen, pH, and nitrite were monitored on a weekly basis. The surface temperature and dissolved oxygen of the culture units were measured using EXTECH Heavy Duty DO meter model 407510. The pH was measured using a pocket pH meter while nitrite was assessed using colorimetric method of Hannah Instruments. Meanwhile, the turbidity was monitored using an improvised Secchi disc.

Biological data were taken during the termination period. The pond units were drained with the aid of an electric submersible pump. All stocks from each unit were collected and subjected to length and weight assessment. The length of the fish and prawn was measured using a foot rule while the weight was measured using a digital weighing balance with a sensitivity of 0.1 g. The survival rate of stocks was determined by counting all stocks obtained during harvest.

The growth pattern of red tilapia and giant freshwater prawn was estimated using a power function model of the length weight-relationship equation: $W = a \times SL^b$ where W is the wet weight (g), SL is the standard length (cm), a is the intercept and b is the exponent or slope of the equation. The obtained parameter (b) was compared with the isometric value (3) using the modified t-test of Sokal and Rohlf [21]: $t_s = (b-3)/S_b$, where t_s is the t-test value, b is the slope, and S_b is the standard error of the slope to determine statistical significance. On the other hand, the relative condition factor was calculated with the formula [10]: $K_n = w/(a \times SL^b)$, where a and b are the exponential form of intercept and slope of LWR equation.

Meanwhile, the economic viability of the experimental treatments were presented in the form of yield, average feed consumption, FCR, total expenses, gross dale and net income.

Statistical differences on the growth performance, survival rate and economic viability among treatments were tested using One-way Analysis of Variance (ANOVA) and significant differences in separated means were determined by performing Least Significant Difference Test (LSD).

Results and Discussion

Water Quality Parameters

The level of important water quality parameters is indicated in Table 6. It can be seen that surface temperature is not significantly differ ($p>0.05$) among treatments. The dissolved oxygen is recorded highest in treatment 1 followed by treatments 2, 3, and 4. The dissolved oxygen in T1 is significantly different to other treatments ($p<0.05$). As to pH, highest was also recorded in treatment 1 while the lowest was recorded in treatment 4. Significant variation ($p<0.05$) was also observed in this parameter. In terms of turbidity, all treatments are comparable ($p<0.05$) except treatment 1 which suggests better measurement of turbidity. Lastly, nitrite level is not significantly different between T1 and T2, and also between T3 and T4. However, the former treatments have lower nitrite level compared to the latter treatments suggesting better quality.

Table 1. Level of water quality parameters of pond units

Treatment	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Turbidity (cm)	Nitrite (mg/L)
T1	27.79±0.13	5.39^a	6.67^a	24.57^a	0.20^a
T2	28.01±0.07	5.08^b	5.73^b	26.43^b	0.40^a
T3	28.12±0.18	4.72^c	4.79^c	26.83^b	0.53^b
T4	28.26±0.43	4.45^c	4.57^c	26.60^b	0.73^b

Means having the same superscripts are not significantly different (>0.05)

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Growth Performance

As shown in Table 2, treatments 1 and 2 are comparable in terms of length growth and both are significantly differed ($p<0.05$) to treatments 3 and 4. However, it can be noted that treatment 1 was significantly differed ($p<0.05$) to the rest of the experimental treatments as to growth in terms of body weight (Table 3). This result suggests that treatment 1 is the most appropriate stocking ratio for the polyculture of red tilapia and giant freshwater prawn.

Table 2. Performance of red tilapia and giant freshwater prawn in terms of length growth

Treatments	Initial length (cm)	Final length (cm)	Gain in length (cm)	Daily length Increment (cm/day)
Red Tilapia				
T1	6.50	20.60^{a}	14.10^{a}	0.156^{a}
T2	6.43	19.59^{a}	13.15^{a}	0.147^{a}
T3	6.60	17.79^{b}	11.19^{b}	0.123^{b}
T4	6.63	15.91^{c}	9.28^{c}	0.107^{b}
Giant Freshwater Prawn				
T1	3.27	12.31^{a}	9.04^{a}	0.100^{a}
T2	3.27	11.52^{ab}	8.26^{ab}	0.090^{a}
T3	3.43	10.56^{bc}	7.12^{bc}	0.077^{b}
T4	3.37	10.16^{c}	6.80^{c}	0.073^{b}

Means having the same superscripts are not significantly different (>0.05)

Table 3. Performance of red tilapia and giant freshwater prawn in terms of weight growth

Treatments	Initial Weight (g)	Final Weight (g)	Gain in Weight (g)	Daily Weight Increment (g/day)
Red Tilapia				
T1	3.25	153.31^{a}	150.06^{a}	1.67^{a}
T2	3.29	134.14^{b}	130.85^{b}	1.45^{b}
T3	3.30	92.59^{c}	89.29^{c}	0.99^{c}
T4	3.30	83.03^{d}	79.73^{d}	0.89^{d}
Giant Freshwater Prawn				
T1	0.90	22.16^{a}	21.26^{a}	0.24^{a}
T2	0.89	17.37^{ab}	16.48^{ab}	0.18^{ab}
T3	0.91	14.18^{b}	13.27^{b}	0.15^{b}
T4	0.91	12.53^{b}	11.62^{b}	0.13^{b}

Means having the same superscripts are not significantly different (>0.05)

The result on the growth performance of red tilapia can be attributed to the density of stocks in the pond. It can be observed that increasing the number of prawn from a 3:3 stocking ratio could result to poor growth. It was reported that Nile tilapia weighed an average of 191.34 g or 6pieces per kilogram yield in the polyculture system with prawn [22]. In this study, highest obtained body weight is only 153.31 g in treatment 1, resulting to 7 pieces per kilogram yield. However, variation could be attributed to the longer culture period of the previous study. To add, daily weight increment of fish from treatment 1 is almost comparable to various strains (1.85 g) of red tilapia raised in monoculture systems [8]. Further, another study revealed that growth rates in weight and length of Nile Tilapia (black) were higher than for red both in monoculture and in polyculture with common carp using natural feed [18].

The highest growth of giant freshwater prawn was recorded in treatment 1 that represents a 3:3 stocking ratio. This result is slightly lower than the reported average body weight at harvest of the species using the same stocking ratio to Nile tilapia in Region X [19]. Variation could be linked to the wider area utilized in their study. In addition, there is an overall average weight at harvest of 28.09 using polyculture system with Nile tilapia across the country with various stocking densities [22]. However, the average body weight in the present and previous studies is still below the desired weight since consumers preferred 20 to 25 pieces number per kilogram.

Growth Pattern and Relative Condition Factor

It can be seen in Table 4 that fish from treatment 1 obtained the highest b value which suggest that they are growing in a better rate compared with the red tilapia from other treatments. However, comparing the result to the isometric value (3) the fish are growing following negative allometric pattern across treatments. With regards to prawn stocks, treatment 1 also obtained the highest value followed by treatment 2. However, when compared to the isometric value both treatments are not statistically differed ($p>0.05$). This resulted to isometric growth pattern of prawn. On the other hand, prawn in treatments 3 and 4 are growing in a negative allometric pattern.

The result of condition factor analysis (Table 5) showed that treatment 1 has the highest value obtained which means red tilapia in this treatment have better body condition compared with other treatments. The obtained values follow the trend of growth pattern.

Table 4. Growth pattern of red tilapia and giant freshwater prawn

Treatment	a	b	r	t	Growth Pattern
Red Tilapia					
T1	0.055	2.673	0.939	b≠3	-Allometeric
T2	0.110	2.380	0.945	b≠3	-Allometeric
T3	2.279	1.285	0.837	b≠3	-Allometeric
T4	1.381	1.478	0.868	b≠3	-Allometeric
Giant Freshwater Prawn					
T1	0.007	3.177	0.964	b=3	Isometric
T2	0.016	2.843	0.956	b=3	Isometric
T3	0.029	2.613	0.947	b≠3	-Allometeric
T4	0.142	1.918	0.881	b≠3	-Allometeric

Table 5. Condition Factor of red tilapia and giant freshwater prawn

Treatment	Min	Max	Mean
Red Tilapia			
T1	0.716	1.396	1.056
T2	0.706	1.389	1.048

T3	0.826	1.196	1.009
T4	0.804	1.489	1.008
Giant Freshwater Prawn			
T1	0.619	1.243	1.013
T2	0.658	1.242	1.004
T3	0.781	1.373	1.005
T4	0.752	1.381	1.005

Means having the same superscripts are not significantly different (>0.05)

According to recent findings [9], variation on the growth pattern of fish can be observed depending on the condition of its environment. The present work revealed that fish from all treatments are not growing in conjunction with the cube law. The fish exhibits a growth in which length increases faster than the rate in weight. However, parameter b of treatments 1 and 2 were within the range of 2-4 recommended as appropriate for freshwater species [1]. Deviation from the isomeric growth could be linked to the indirect stress caused by other species in the environment of the fish. But, information on this is still lacking specifically in polyculture system. The growth pattern observed in red tilapia was in consonance with the previous study in cemented tanks [14] with b values ranging 1.2-1.3.

As to the growth pattern of the prawn, individuals from treatments 1 and 2 are growing following the cube law. This pattern could be a direct influence of stocking density. Higher number of individuals competing for space and food could result to stress. This resulted to a lower rate of increase in the weight of individuals compared to their length. At present there is still a handful of information on the growth pattern of giant freshwater prawn from the wild and captivity. The result in treatments 1 and 2 follows the previous results in the assessment of giant freshwater prawn growth pattern [20][11][12][16]. Meanwhile, it was reported negative allometric growth for both sexes of *P. monodon* in Digha Coast, India [17].

In the present study, it was observed that condition factor of red tilapia and prawn is above 1 across treatments. The present finding on the condition factor of red tilapia is coherent with the previous studies [9][16] under monoculture system. The relative condition factor of prawn was in accordance with the findings of [11] in rice field-cultured giant freshwater prawn. Condition factor higher than 1 suggest better health condition in cultured stocks which is desirable for fish farming [3]. In this study, treatment 1 has the highest relative condition factor for red tilapia and prawn which could be a direct influence of stocking density. Also, nitrite level may have affected such variation. Although comparable to findings of previous works, the result is lower than the range indicated by [4] as the ideal range of condition factor for the normal growth and nutrient utilization by a normal freshwater fish.

Survival Rate

Highest survival rate of red tilapia was obtained in treatment 1 as indicated in Table 5. However, comparison of means among treatments did not bear any significant difference (p>0.05). Meanwhile, the survival rate of prawn in treatment 1 is significantly higher compared to other treatments (p<0.05). This suggests that higher rate of survival can be obtained using this stocking ratio of tilapia and prawn.

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Table 5. Survival rate r of red tilapia and giant freshwater prawn

Treatment	Survival Rate (%)
Red Tilapia	
T1	81.48
T2	75.92
T3	68.51
T4	70.37
Giant Freshwater Prawn	
T1	68.52[a]
T2	44.46[b]
T3	28.30[c]
T4	20.83[c]

Means having the same superscripts are not significantly different (>0.05)

The result in the survival rate of both stocks in Treatment 1 was slightly higher than the overall survival rate of tilapia (76.54%) and giant freshwater prawn (58.79%) previously reported [22]. Almost comparable result was recorded by [2] for prawn survival (63.6%) using a corresponding tilapia rate of 0.5 fish per m^2. For a 3:1 stocking ratio of tilapia and prawn, survival rates of 76% and 58%, respectively was reported by [24]. Also, it was reported that survival of prawn in a polyculture system with Nile tilapia using 3:3 stocking ratio reaches as high as 70% [7].

Economic Viability

In terms of economic viability (Table 7), it can be noted that treatment 1 has the highest net income among treatments. This figure can be linked to feed conversion ratio of tilapia and prawn despite of greater feed consumption of tilapia. Also, survival rate and growth performance of the two species significantly influenced this income. It can be observed that highest average yield was posted by treatment 1, a clear indication of greater survival and growth.

Table 6. Presentation of the economic viability of experimental treatments

Treatment	Average Yield (kg)	Average Feed Consumption (kg)	FCR	Total Expenses (P)/unit	Gross Sale (P)/unit	Net income/unit (P)
Red Tilapia						
T1	2.25[a]	6.38[a]	2.91±0.14[a]	253.69[a]	449.52[a]	195.83[a]
T2	1.85[b]	5.79[b]	3.23±0.24[b]	238.85[b]	370.19[b]	131.34[b]
T3	1.13[c]	3.77[c]	3.56±0.65[c]	188.37[c]	226.86[c]	38.49[c]
T4	1.05[c]	3.22[c]	3.29±0.57[b]	174.80[d]	209.90[d]	35.10[d]
Giant Freshwater Prawn						
T1	0.22[b]	0.24[d]	1.07[a]	26.40[d]	140.27[a]	113.87[a]
T2	0.29[a]	0.34[c]	1.24[b]	47.73[c]	101.09[b]	53.36[b]
T3	0.22[b]	0.52[b]	2.48[c]	69.32[b]	78.59[c]	9.27[c]
T4	0.21[b]	0.69[a]	4.38[d]	90.71[a]	60.47[d]	-30.24[d]

Means having the same superscripts are not significantly different (>0.05)

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Conclusion and Recommendation

The research work disclosed that the stocking ratio of 3:3 for red tilapia and giant freshwater prawn provides better growth performance, yield and income. Therefore, it is recommended that this stocking ratio shall be followed when raising red tilapia and giant freshwater prawn simultaneously.

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