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Growth potential of Pacu, *Piaractus Brachypomus* in different Culture Approach

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Abstract

The study was conducted to evaluate the growth potential of pacu, Piaractus brachypomus in monoculture and polyculture system with feeding, fertilization and substrate addition. The experiment was carried out for 120 days in outdoor circular cement cistern of 380 litre capacity. The culture strategies/treatments employed are monoculture of pacu with feeding alone (T_1), monoculture of pacu, with fertilization alone (T_2), polyculture of pacu with Indian major carps with feeding alone (T_3), polyculture of pacu with Indian major carps with fertilization alone (T_4) and polyculture of pacu with Indian major carps in periphyton based system (T_5). Each treatment was subjected to three replication. In case of monoculture a total numbers of 10 fishes were stocked in each cistern. Where as in case of polyculture pacu, catla, rohu and mrigal were stocked in the proportion 3:2:3:2 respectively. In treatment involving feed, feeding was done with locally available conventional feed with overall protein content of 30% and given at the rate of 10% of body weight daily. In the treatments involving fertilization, and substrate all tanks were initially fertilized with raw cow dung of 150g in combination with 2 g of urea. Subsequent fertilization of 1/4th of the initial level was done fortnightly. Coconut spadix in mat form was used as a substrate for periphyton growth. Fish were sampled every fortnightly for weight gain measurements. All the water quality parameters were within the desirable range. Mean weight gain of pacu in monoculture was 29.58g (T_1) and 17.33g (T_2). In polyculture mean weight gain of pacu, was 27.13g (T_3), 16.48g (T_4) and 18.29g (T_5).Mean survival rate of pacu was good in all treatment with average value ranging from 83.33 % (T_1) to 100% (T_5). Inclusion of pacu along with Indian major carps does not have any impact on the survival rate of catla, rohu and mrigal. Highest mean specific growth rate of pacu was recorded in T_3 (2.16). The result of this experiment indicates that the best growth performance of pacu was in monoculture with feeding. In polyculture the best growth performance of pacu was obtained with feeding alone followed by periphyton based system. The present study concluded that pacu is a promising candidate species in freshwater aquaculture. Monoculture with feeding is a feasible approach. Monoculture in fertilized systems is less productive. Pacu is a compatible species for culturing along with Indian major carps. Growth of pacu is higher in fertilized systems with added substrates.

Keywords*:* Growth potential, pacu (*Piaractus brachypomus*), monoculture, polyculture, feeding, fertilization, periphyton, outdoor cement tank.

Introduction

Aquaculture production is increasingly being looked up to as the answer to food security issues the world over. Recently aquaculture industries, its massive expansion in the last decades has begun to face some important limitations like scarcity of water due to low annual precipitation, increasing feed cost, poor feed quality, disease outbreak and socio-economic constraints. To cope up with the limitation wide range of approaches are being adopted to step up the production levels to match the steadily increasing demand. The promising strategies adopted include diverse culture techniques, improved diets, inclusion of new entrants into the culture basket, varied stocking combinations etc. Freshwater aquaculture in India is still basically a carp oriented enterprise, however, of late; there have been a number of welcome additions to the culture basket. These include the Pangasiids, GIFT tilapia and pacu to name a few. Pacu, was introduced in India as an alien species during 2003 and 2004 from Bangladesh[1]. These Pacu species are South American fishes which are native of Brazil, Peru and Venezuela[2,3]. Pacu (*Piaractus brachypomus*) is a freshwater fish of order characiformes, family characidae and sub-family serrasalminae. The common name *Pacu*is generally applied to fish classified under the genera *Colossoma*, *Metynnis, Mylesinus (Mylopus), Mylossoma, Ossubtus, Piaractus, Tometes,* and *Utiaritichthys*[4]. However common name for these species vary by region, in Brazil the fish is known as Pirapatinga, USA as Cachama, UK as freshwater pompano and in India especially in Tripura, Assam and West Bengal the fish is locally known as *Rupchanda*.

Pacu, contrary to its popular image of an active carnivore is actually an herbivore / omnivore, preferentially feeding on leaves, flowers, fruits and seeds of superior plants[5]. Pacu have also been reported to feed on zooplankton, insects, snails and decaying plants[6]. A hardy fish, this characid combines several desirable features like fast growth, superior flesh quality,

omnivorous feeding habit and compatibility, besides accepting a wide range of low cost feed. However before introducing any new species in culture basket it is necessary to study its compatibility with other species, as well as its growth performance in different culture approaches. Thus the present study aim at assessing the suitability of pacu (*Piaractus brachypomus*) as a component species in conventional culture practices / approaches.

Objective of the study: To evaluate the suitability of pacu for inclusion in conventional fed culture systems. To assess the compatibility of pacu with Indian major carps. To determine the possibility of culturing pacu in fertilized culture systems. To determine the potential of periphyton based systems in the culture of pacu.

Material and Methods

Experimental setup: The experiment was carried out for 120days in outdoor circular cement cistern of 380 litre capacity, located at Kerala University of Fisheries and ocean Studies. Prior to initiation of the study the cisterns were repaired, cleaned manually and sundried. The cleaned and dried cisterns were provided with a soil bed of 10 cm thickness. The soil was collected from the farm land and washed prior to addition to the tanks. This soil bed was allowed to dry for a few days, after which the tanks were filled with fresh water. The tanks were covered with wide meshed nylon nets to prevent extraneous matter like leaves from falling into the culture cisterns, to prevent escaping of fish by jumping, to protect against insects and to prevent the fishes from predation by birds. Water was filled in the tanks to a height of 80 ± 5 cm. Water levels were maintained by replenishing as needed.

The culture strategies/treatments employed namely i. monoculture of *P. brachypomus* with feeding alone (T_1), ii. monoculture of *P. brachypomus,* with fertilization alone (T_2) iii. polyculture of *P. brachypomus* with catla, rohu and mrigal with feeding alone (T_4), iv. Culture of pacu in combination with indian major carps with fertilization alone (T_4) and v. Culture of pacu in combination with Indian major carps in periphyton based system (T_5). Each treatment was subjected to three replication. In case of monoculture a total no of 10 fish were stocked in each cistern. Whereas in case of polyculture pacu, catla, rohu and mrigal were stocked in the proportion 3:2:3:2 respectively. In the treatments involving fertilization, and substrate all tanks were initially fertilized 10 days prior to stocking of fish with raw cowdung (150 g) in combination with 2 g of urea after cleaning the cisterns and filled with fresh water. In treatment involving substrate coconut spadix was used as a substrate in the form of mat each weighing 350 g and was installed during the initial stage of fertilization. Subsequent fertilization of $1/4^{th}$ of the initial level was done fortnightly. In treatment with feeding locally available conventional feed was used with overall protein content of 30% and feeding rate was done at the rate of 10% of body weight daily.

Monitoring of water quality: Water quality parameters *viz.,* temperature, pH, dissolved oxygen, total alkalinity, ammonia, nitrite and nitrate were analysed once every 15 days, starting on day 0 (fish stocking day). Temperature was determined by using mercury bulb thermometer with 0.1^0C accuracy. pH was assessed by using the universal pH indicator solution method, while dissolved oxygen was determined by using standard Winkler method. Total alkalinity was determined by following the acidimetric titration method[7]. Ammonia was determined by phenate methods[8].

Periphyton sampling: Coconut spadix was used as a substrate in the form of mat of 20×35 cm^2 in each replicated tank. A total number of two coconut spadix mat were installed in each tanks. Care was taken to ensure placement of substrate units at equal distance from the tank walls as well as each other. The substrates remained submerged throughout the study period. The substrate was installed 15th days prior to stocking of fish during the initial fertilization. For this, substrates were suspended from the poles kept horizontal position across the cisterns, about 30-35 cm below the water surface after adding the fertilizer. Periphyton biomass was measured quantitatively by estimating the dry matter (DM), ash free dry matter (AFDM), ash content (AC) and chlorophyll-*a* following standard methods[9] beginning from the 15th day of the substrate installation and continued at fortnightly intervals. Periphyton samples for dry matter (DM) ash-free dry matter (AFDM), ash content (AC) and chlorophyll-*a* analysis was taken from a 2×2 cm^2 area scraped from the substrate. The sampling point is marked so that these can be excluded during next sampling. For the analysis of dry matter (DM) ash-free dry matter (AFDM), ash content (AC) samples were dried at 100◦C to constant weight, and the ash content was determined in a muffle furnace (4 h at 550^0C). Ash-free dry matter (AFDM) was calculated by subtracting the ash value from the dry matter content.

Harvest and yield measurements: On termination of the experiment, fish were harvested by draining the tanks. All surviving fish were counted and their weight were estimated individually and the following parameters are calculated

Average gain in weight: Average gain in wt. (g) = Average Final wt. (g) – Average Initial wt. (g)

Specific growth rate (SGR) =

$$\mathrm{SGR}(\%) = \frac{\ln(\mathrm{W2}) - \ln(\mathrm{W1})}{\text{Time interval in days}} \times 100$$

Where: W1= Initial weight of animal (g), W2= Final weight of animal (g)

Survival rate= $$\mathrm{Survival}(\%) = \frac{\text{Final Number}}{\text{Initial Number}} \times 100$$

Statistical analyses: The experiment was conducted in a completely randomized block design with three replications for each treatment. For statistical interpretation of the growth data the five treatments were group into two set.

T_1 (monoculture of pacu with feeding alone) and T_4 (monoculture of pacu with fertilization alone), T_3, (polyculture of pacu with Indian major carps with feeding)T_4(Culture of pacu in combination with Indian major carps with fertilization) and T_5 (Culture of pacu in combination with Indian major carps with fertilization plus substrate addition).

The average fortnightly gain in weight for each species was subjected to a two way analysis of variance (ANOVA). The multiple comparisons was done by post hoc test using Tukey's HSD. Water quality parameters were subjected to two way analysis of variance (ANOVA) and the significance differences were subjected to post hoc test using Duncan test. All the statistical analysis was performed using IBM SPSS Statistics version 20.

Results and Discussion

Water quality parameters: In the present study the water quality parameters monitored over the experimental duration are as follows: temperature 26.6±0.57^{0}C-29.6±^{0}C, pH-7.00± to 8.83±0.28, Ammonia- 0.00±0.00 to 1.11±0.44ppm, Alkalinity-71.53±1.23 to 121.53±4.0 mg/l and Dissolved oxygen-4.23±0.30 to 5.50±0.41mg/l.All the water quality parameter, temperature[10-12] dissolved oxygen[13], pH[14], ammonia[15], and alkalinity[16,17] are within the optimum range for the cultured species.

Growth performance, Specific Growth Rate and Survival rate: The mean initial average body weight of pacu under monoculture was 2.81g (T_1) and 3.26 g (T_2) respectively. In polyculture the initial average body weight of pacu in different treatments are 2.20g (T_3), 1.88 (T_4) and 2.83 (T_5) and for catla, rohu and mrigal the initial weight ranged between, 4.00g to 5.00 g, 10.00 to 11.60g and 2.00 to 2.53g respectively. At final harvest the average weight obtained by pacu in monoculture ranged between 18.30 g (T_2) to 35.56 g (T_1) and forcatla, rohu and mrigal the average final weight ranged between, 18.51g to 32.60g, 23.25g to 37.10g and 15.60g to 26.50g respectively. The present study can be attributable to Vidotti *et al.*[18] who had conducted an experiment on *Piaractus mesopotamicus* fingerlingsanother species of pacu, fed with diets containing co-dried fish silage and obtained weight gained varied from 30.3 to 37.2 g for the 90-day period. These values can also be attributable to the 29 to 37 g range reported for pacu fingerlings by Fernandes *et al.*[19], while using different protein sources and different levels of crude protein in a 100-day experiment. Vásquez-Torres *et al* 2011[20] had conducted an experiment for a period of 60 days in 500 litre capacity tanks to determine the optimal dietary protein requirement for juvenile cachama, *Piaractus brachypomus*. They had found that pacu show best weight gain of 46.5±5.0g with 32 % of protein. The present study shows that overall average gain in body weight of all the fish species were higher in treatments involving feeding alone followed by substrate based system and treatment involving fertilization alone respectively. In monoculture average gain in weight of pacu was significantly ($p<0.05$) higher in T_1 (29.58±2.50) as compare to T_2 (17.33±2.17). In case of polyculture pacu with Indian major carps, T_3(27.13±1.15) show significantly ($p<0.05$) higher gain in growth followed by T_5 (18.29±4.19) and T_4 (16.48±1.55) respectively.SGR of pacu was highest in T_3 (2.16) which was slightly higher than SGR obtained by Kohler *et al.* [21]; Vidotti*et al.*[18] and Fernandes *et al.*[19]. The survival rate of pacu with 100% was highest in T_4 and T_5. The present study shows that inclusion of pacu in combinations with Indian major carps does not have any impact on the mean survival rate catla (T_3-100%, T_4 -83.33% and T_5- 100%), rohu (T_3-88.86%, T_3-88.86% and T_5-88.86)and mrigal (T_3-100%, T_4 -83.33 , & T_5- 100%) respectively. In the present study the average weight gain of all the species was higher in treatment involving substrate addition (T_5)than that of substrate free treatment (T_4) and these findings can be attributable to Hem and Avit[22]; Wahab *et al.* [23] Ramesh *et al.*[24]; Azim *et al.*[25] Keshavanath *et al.*[26]. They had demonstrated that fish production from ponds supplied with substrates for periphyton is higher than that from substrate-free controls. In substrate based treatments the weight gain obtained by rohu (20.39g) was higher followed by pacu (18.53g), catla (17.52g) and mrigal (16.90g) respectively, which is attributable to Keshavanath *et al.*[27] who had conducted an experiment with four locally available biodegradable substrates—sugarcane (*Saccharum officinales*) bagasse, palm (*Borasus flabellifera*) leaf, coconut (*Cocos nucifera*) leaf, and bamboo (*Bambusa bambos*) mat and were evaluated for the production of periphyton and a polyculture of rohu (*Labeo rohita*) and common carp (Cyprinus *carpio*) in poultry-manured ponds and found that growth of rohu was highest with coconut leaf. Since no literature is available regarding the culture of pacu in periphyton based system, higher growth increment of *Piaratus brachypomus* in substrate based treatment (T_6) than substrate free treatment (T_5) can be attributable to Tavares *et al.*[28] who had studied the feeding habit of pacu (*Piaractus mesopotamicus*) larvae in fish ponds and reported that preference of pacu on phytoplankton which constitute more than 90% of their stomach contents. In treatment with substrate addition periphyton biomass growth trendsincreases steadily during first 90th days of sampling and then decreased continuously until the end of experiment (figure-1a and b). In the study conducted by Keshavanath *et al*[27], periphyton biomass growth trends increases steadily during first 60th days of sampling and then decreased continuously until the end of experiment (table-2, figure-1a and 1b). This might be due to low grazing pressure on periphyton at initial stage followed by increasing grazing pressure which is attributable to the increase in the fish biomass.

It was evidence from the present study that the growth of fish biomass varied from treatment to treatment due to the effect of different types of culture strategies/combination in each treatment. *Piaractus brachypomus* showed higher growth with application of supplementary feed in the culture tanks. In the present study, the enhanced production in tanks treated with fertilization only can be justified by the fact that the fertilizer contributed to the fertility of the pond.

Table-1
Weight gain, SGR and Survival rate(%) of pacu, catla,rohu, and mrigal in different treatments

Treatments	Species	Average Initial weight (gm)	Average Final weight (gm)	Gain in weight (gm)	SGR	Survival rate (%)
T_1	pacu	2.81±0.70	32.40±3.18	29.58±2.50*	2.01±0.17	83.33±5.77
T_2	pacu	3.26±0.25	20.60±2.25	17.33±2.17*	1.52±0.09	86.66±5.77

Treatments	Average initial weight(gm)				Average final weight(gm)				Gain in weight(gm)				Sgr				Survival rate (%)			
	Pacu	Catla	Rohu	Mrigal	Pacu	Catla	Rohu	Mrigal	Pacu	Catla	Rohu	Mrigal	Pacu	Catla	Rohu	Mrigal	Pacu	Catla	Rohu	Mrigal
T3 Feeding only	2.20 ± 0.34	4.16 ± 0.28	10.70 ± 0.81	3.03 ± 0.50	29.33 ± 0.96	30.6 ± 2.29	35.16 ± 2.0	24.61 ± 1.75	27.13 ± 1.15*	26.93 ± 3.0	24.46 ± 1.8*	21.57 ± 1.5*	2.16 ± 0.15	1.65 ± 0.11	0.98 ± 0.06	1.74 ± 0.12	88.86 ± 19.20	100 ± 0.00	88.86 ± 19.28	100 ± 0.00
T4 Fertilization only	1.88 ± 0.24	4.5 ± 0.24	10.30 ± 0.50	2.41 ± 0.17	18.37 ± 1.79	21.53 ± 3.09	26.02 ± 3.99	17.18 ± 0.83	16.48 ± 1.55*	17.03 ± 2.61	15.72 ± 3.7*	14.76 ± 0.6*	1.89 ± 0.04	1.38 ± 0.11	0.76 ± .10	1.63 ± 0.02	100 ± 0.00	83.33 ± 28.86	88.86 ± 19.28	83.33 ± 28.86
T5 Fertilization + substrate addition	2.83 ± 0.76	4.6 ± 0.52	11.41 ± 0.09	2.16 ± 0.28	21.12 ± 4.02	22.12 ± 3.94	31.80 ± 2.10	19.06 ± 4.64	18.29 ± 4.19*	17.52 ± 3.61	20.39 ± 2.0*	16.9 ± 4.84*	1.68 ± 0.33	1.29 ± 0.10	0.84 ± 0.05	1.79 ± 0.28	100 ± 0.00	100 ± 0.00	88.86 ± 19.28	100 ± 0.00

*Significantly different($p<0.05$)

Table-2
Quantitative analysis of periphyton biomass in T_5

Days	Dry Matter (DM) (mg/cm²)	Ash free dry Matter (AFDM) (mg/cm²)	Ash content (AC) (mg/cm²)	Chlorophyll-*a* (µg /cm²)
15	0.44	0.31	0.13	2.32
30	0.56	0.35	0.21	3.25
45	0.93	0.55	0.38	5.01
60	1.11	0.70	0.41	6.52
75	1.34	0.87	0.47	7.23
90	1.37	0.85	0.52	7.88
105	1.09	0.74	0.35	6.41
120	0.98	0.71	0.27	5.57

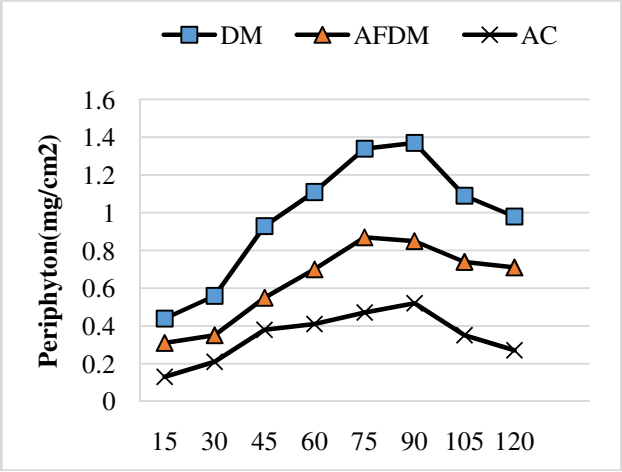

Figure-1a
Growth of periphyton biomass over the experimental period of 120 days in T_5. DM- dry matter, AFDM-ash free dry matter, AC-ash content and chlorophyll-a

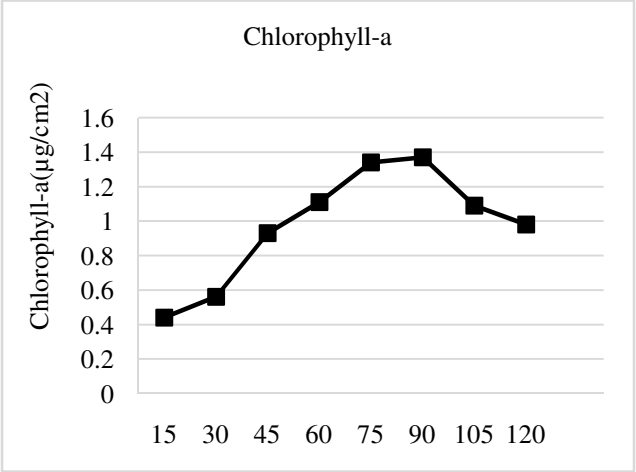

Figure-1b
Growth of periphyton biomass over the experimental period of 120 days in T_5. DM- dry matter, AFDM-ash free dry matter, AC-ash content and chlorophyll-a

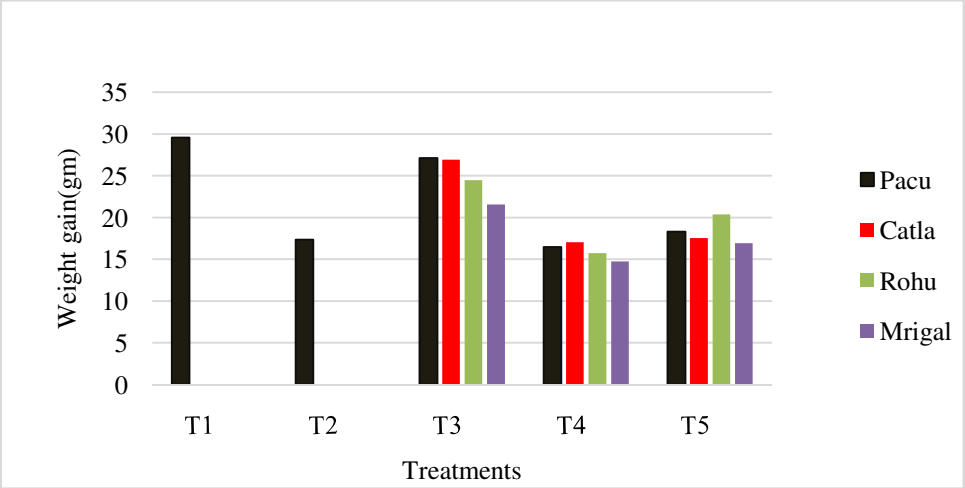

Figure-2
Average weight gain of Pacu, Catla, Rohu and Mrigal in different treatments

Conclusion

The present study shows that overall best growth performance of of *P. brachypomus* was in monoculture with feeding followed by polyculture with Indian major carps with feeding, and substrate based system. The present study concluded that pacu is a promising candidate species in freshwater aquaculture. Monoculture with feeding is a feasible approach. Monoculture in fertilized systems is less productive. Pacu is a compatible species for culturing along with Indian major carps. Growth of pacu is higher in fertilized systems with added substrates.

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