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Comparative of Growth and Performances of the Warm Water Cultivable Fish Species *Piaractus brachypomus* and *Cyprinus carpio* L. Under Iranian Conditions of Fish Culture

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Abstract: The present research encompasses the growth function of 'pacu' exposed to three different diets with reference to common carp fed with commercial carp feed. The treatments were conducted using different diets viz., Pl, P2, a commercial common carp feed for pacu fish and using commercial common carp feed for common carp (*Cyprinus carpio*) simultaneously. The experiment revealed significant differences of growth functions under different treatments to such an extent that the absolute daily growth rate of pacu fish showed 3.5 times higher than the common carp. The least relative growth percentage and specific growth coefficient belonged to carp fed with commercial carp feed. These differences suggest significant superiority of growth rate of pacu over that of the common carp. The result also indicated that the protein productivity ratio of feed for pacu was significantly higher than the carp feed. Therefore, the rapid growth rate of pacu compared to common carp may be attributed to the higher protein productivity ratio of the fish. Best weight gain, food conversion ratio, growth and fatness coefficient and protein productivity were associated with 10% feeding rate.

Key words: Growth coefficient · *Piaractus brachypomus* · Protein productivity ratio · Carp · Iran

INTRODUCTION

Endowed with rivers, lagoons, reservoirs, natural lakes and extensive coast lines in both southern northern parts as well as suitable metereological conditions, Iran enjoys highly extensive lands suitable for fish farming. This has boosted up aquaculture to the extent that many coastal inhabitants in both southern and northern Iran depend on fish farming or fishing at subsistence level. Aquaculture is therefore considered as a viable means of achieving economic self-sufficiency which could meet part of protein requirements of the country. Considering the growing population and the shrinking animal protein resources, it seems imperative therefore to increase production capacities of the fish farming ponds and move away from the traditional fish farming using only on Cyprinds. The traditional fish farming is not only time consuming, but also relatively less yielding compared to the large spaces they occupy. Being situated in the semi-tropical part of the world and having rather limited water resources, it is necessary to select a fish species for farming purposes in Iran that could yield rather high production within a short farming cycle. The warm water fish species are reared in tropical or semi-tropical areas whereas water temperature ranges between 15-30°C during at least half of the year, such fish species are predominantly reared in earthen ponds and the fish species mainly cultured in Iran include *Cyprinus carpio, Ctenopharyngodon iidella, Hypopthalmichthys molitrix* and *Aristichthys nobilis*. However, certain more productive warm water species of fishes are being cultured in different other countries abroad. *Piaractus brachypomus* or 'pacu' is such a warm water catfish usually cultured in China, Malaysia and Brazil [1]. The domestication of the fish and standardization of its culture system demand systematic investigation in this country. Culture potential under the local conditions as well as adoption of suitable supplemental feeding involves environmental and fisheries aspects of the task.

Piaractus brachypomus (Cavier1818), is a native species of southern American Amazon and Orinoco river.The fish has also other given names including pirapatingn, pacu, tambaqui and Red-bellied pacu. This fish has a thick body and its mouth is anterior. The teeth

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are attached to the jaws and are highly sharp. The body is brackish silvery in colour, the young fish carry a red band below their belly which gradually disappears as the fish grow older. The swim bladder is composed of two parts with Weber bone let [2]. The fish mainly leads a pelagic life and lives in fresh water and prefers acidic environment over alkaline environment. The fish mainly feed on surface aquatic insects in natural water plants as food [3,4].

There have also been reports on the use of live feed and meat in pacu culture [5] since pacu can easily grind food grains.

The maximum pacu body length is 88cm with, maximum reported weight of 25kg [6]. This fish is capable of swimming in different water depths enabling it to take food at both surface and bottom areas. The physical and chemical condition suitable for pacu culture include water temperature range of 23-280 °C PH5-7, hardness rate of 15dh and the dissolved oxygen content of more tan 4ppm.The water must also contain 50-60 milligrams per liter of $Caco_3$ in terms of hardness an alkalinity level of 6-250 mg/l of $Caco_3$ with less than 2mg/l of nitrite content [6]. Pacu fish was imported to Iran as an ornamental fish nearly a decade ago along with a number of other ornamental fish, pacu are also imported to the country at a small amount from certain east Siam states such as Thailand, Singapore, Malaysia and china. Being Omnivorous in diet and having relative preference to plant origin feed items, it can be a good alternative for certain warm water fish and common carp in fish culture ponds. Considering the warm-water nature of pacu and its high productivity in aquaria and based on the technical advice provided by practitioners engaged in ornamental fish production, the idea of investigating the possibility of replacing the ordinary culture species of fish with pacu was put in the focus of this study.

As a member of characidae, which are mostly carnivorous and level a wild life in nature, they escaped the attention and interest of fish farming industry. Nevertheless, characteristics such as omnivorous habits with certain inclination to plant food and rapid growth rate, began to catch the fancy of fish farmers in south America and east Asia to the extent that pacu are reared mixed with silver carp (*Hypothtalmichty molitrix*) in fish cultivation ponds in China [7]. Cremer *et al.* [6] studied the mixed silver carp pacu cultivation using special synthetic food for pacu which included 32%protein and 9% raw fat showing that pacu enjoys a FCR of 1024 and a weight gain from 40-497 g within a period of 80 days in another experiment using diet containing 22, 27 and 32% protein content for feeding pacu, it was found that food containing 27% protein resulted in the highest productivity [1].

The present study therefore was carried out to throw more light on growth functions of pacu fish fed with different feed and also to compare the results with the growth functions of common carp under Iran's climatic conditions.

MATERIALS AND METHODS

Experiments in aquaria were carried out in Mirza Koochak Khan higher Fisheries Centre of Iran for the period of eight weeks during 2008. One month old pacu fish seeds having 9.12±1.18 g initial body weight were imported from a Singapore based company in Shiraz. In order to acclimatize, the young fishes were placed in a relatively big tank and were fed with pellet food prepared especially for trout. The 60 days old common carp (*Cyprinus carpio*) having 0.3±119 g weight were used as a reference for comparing the growth rate of pacu under experimental conditions. Further, the experiments were designed involving total of four sets of treatment using three diets viz., diet P1, diet P2 as well as commercial common carp feed for pacu. A 4th wxperiment was carried out using commercial carp feed for common carp as the reference set. In the first part of the experiment, the daily feeding were done @ 8% of total biomass weight of fish. The three treatment conditions in the second part of the experiment were maintained @ 1.0-8.0%, 2.0-10.0% and 3.0-12.0 % feeding rate using feed P1 only for pacu fish. Each treatment was replicated three times involving nine (9) individuals of young fishes. For this purpose, total of 21 aquaria each with a volume of 45L were used in the first (12 numbers) and second (9 numbers) experiment fFollowing completely randomized design (CRD) model.

The software MS Excel and SPSS were used for sorting out and analysis of variances of treatments, respectively. Tukey test was applied to assess the differences between the means. The regression line was used for examining the relationship between the variables and accordingly the figures were drawn. In context of formulating the experimental feed, the raw materials were first processed and carefully mixed in required proportions (Table 1). By adding water in the ingredients, feed pastes were prepared to make feed roll followed by use of dryer machine exposing the product at 650°C temperature for about 12 hours. The fine feed rolls of diameter 2.0 mm were made using the pellet machine finally and were analyzed chemically [8] to know the actual composition.

Table 1: The feed ingredients used in the study

	Types of Diet		
Ingredient (%)	Commercial Carp Diet	P1 Diet	P2 Diet
Wheat flour	40	23.6	23.2
Wheat bran	19	10	10
Soybean	15	34.8	52.8
Fish meal	10	20	2
Starch	3.7	0	0
Di-calcium Phosphate	1	2.7	2.7
Corn	11	6	6
Vitamin Permix	0.1	0.1	0.5
Mineral Permix	0.2	0.25	0.25
Animal fat	0	2.55	2.55

Table 2: Chemical composition of the used diets

	Type of Diet		
Chemical composition	Commercial Carp Diet	P1 Diet	P2 Diet
Moisture (%)	6.76	6.39	8.80
Protein (%)	33.60	34.05	32.10
Fat (%)	3.74	3.84	2.06
Ash (%)	7.57	7.30	6.79
Raw fiber (%)	3.54	3.50	3.58
Carbohydrates (%)	44.79	44.92	46.67
Energy (Kcal)	2861	3128	2585

The weight of the residual (uneaten) feed was measured at each stage for estimation of precise food conversion ratio. In addition, the water was replaced every other day in order to take out the residual feed. The fish were fed three times a day at 8.0 a.m., 16.0 p.m. and 24.0 p.m. regularly. Biometric measurements involving weekly measurement of full body length, fork length, total weight and body width were carried out with view to carefully monitor the fish growth rate. From each of set of replication four (04) numbers of fishes were utilized for the analyses of at the end [8]. The weight gain of fish, food conversion ratio (FCR) and specific growth rate (SGR), protein efficiency ratio (PER) etc., were determined finally. The absolute daily growth rate (GR) and the relative growth rate percentage (PGR) were computed using the following equations:

Body length gain = Final weight- Original weight

FCR = The consumed dry feed × body weight increase

SGR = $[(LnW_z\text{-}LnW_1)$/period of farming in days$] \times 100$

PER = Primary protein rate - Secondary protein rate

PGR = Increased body weigh/Primary dry protein weight

GR = (BwF - bwI)/N

During the experimental period, all environment factors such as light intensity, water temperature, physical and chemical characteristics of water, rate of aeration in tanks were kept at same levels. In order to maintain the same the experimental set and also to prevent the changes in quality of water feed was supplemented with such a care that the physical and chemical factors of water remain at equal level throughout the experimental period. Therefore, the daily water temperature of, oxygen content and water pH were measured and monitored carefully.

RESULTS

The results of the experiments have been summarized in Tables 3-8 and Figures 1-9. Table 3 shows that the third treatment whereas common carp fed with commercial carps feed had 5.05% fat content which was increased to 12.2% at the completion of the experiment. This suggests the high lipid reservation capacity of the common carp which was not noticed in case of pacu. This is also indicative of the absence of high lipid storing capability of the pacu.

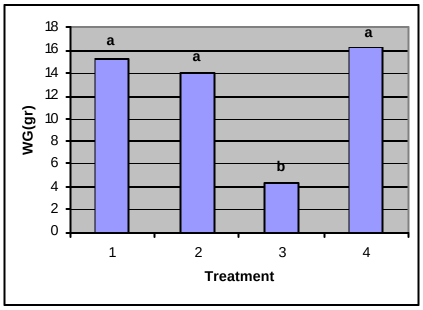

Fig. 1: Comparison of WG in studied treatments

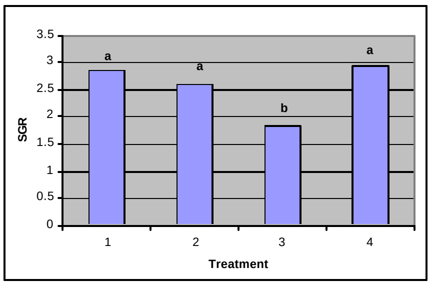

Fig. 2: Comparison of SGR in studied treatments

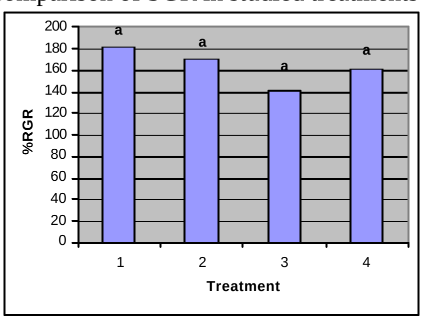

Fig. 3: Comparison of PGR in studied treatments

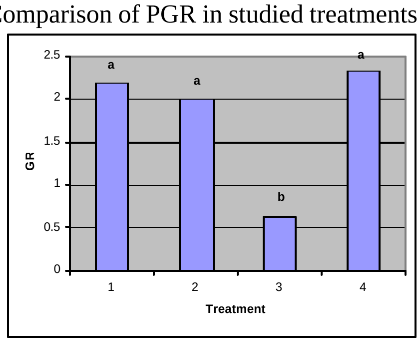

Fig. 4: Comparison of GR in studied treatments

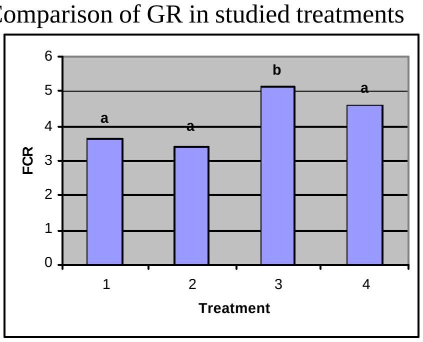

Fig. 5: Comparison of FCR in studied treatments

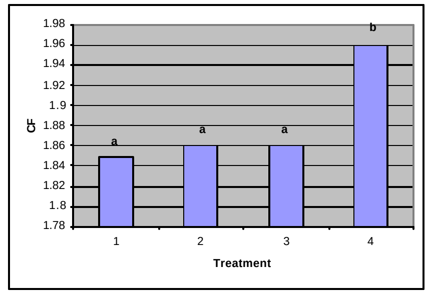

Fig. 6: Comparison of CF in studied treatments

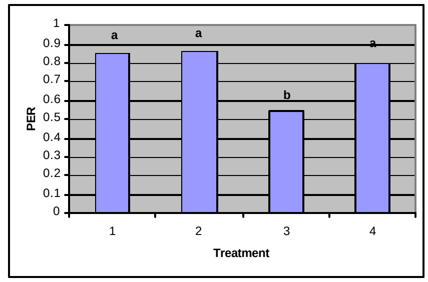

Fig. 7: Comparison of PER in studied treatments

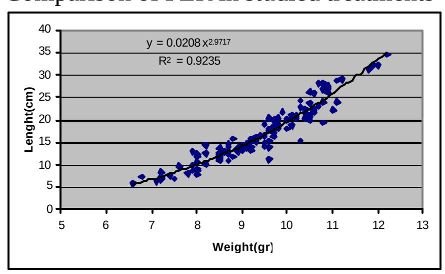

Fig. 8: Relationship between total length and body weight in pacu

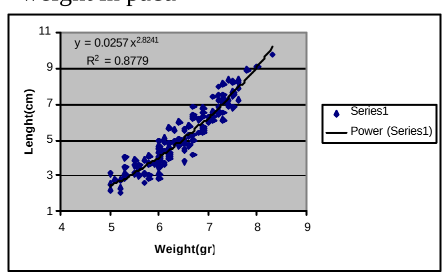

Fig. 9: Relationship between total length and body weight in carp

Table 3: Changes in protein fat and ash percentage in fish tissue samples prior and after the first experiment

Treatment	Sampling Time	Ash	Fat	Protein
1	Prior to experiment	3.87	6.53	15.035
	After experiment	3.2	5.97	15.33
2	Prior to experiment	3.87	6.53	15.035
	After experiment	3.24	5.46	13.33
3	Prior to experiment	3.75	5.05	13.32
	After experiment	1.59	12.2	14.089
4	Prior to experiment	3.87	6.53	15.03
	After experiment	3.55	6.63	14.8

Table 4: Changes in factors during biometric measurement in treatments 1-4 (first experiment)

Treatment	Biometric Stage	Total Lenght	Total Fork	Length Body (cm)	Weight (gr)
1	1	7.9±0.13	7.12±0.14	3.25±0.03	9.38±0.57
	2	8.6±0.09	7.7±0.1	3.57±0.07	11.93±0.7
	3	9.1±0.02	8.3±0.13	3.6±0.14	13.1±0.67
	4	9.36±0.17	8.52±0.12	3.74±0.16	14.76±2.1
	5	9.45±0.21	8.58±0.14	3.77±0.15	16.56±2.1
	6	9.7±0.3	8.7±0.23	3.9±0.2	18.01±2.3
	7	9.95±0.21	9.4±0.24	3.99±0.15	19.56±2.3
	8	10.5±0.3	9.56±0.34	4.18±0.14	22.71±2.4
	9	10.7±0.31	9.7±0.31	4.35±0.11	25.57±2.4
2	1	8.2±0.64	7.4±0.65	3.48±0.17	10.75±2.7
	2	8.57±0.67	7.86±0.57	3.61±0.21	12.07±2.6
	3	9.2±0.61	8.53±0.61	3.69±0.18	13.9±2.09
	4	9.62±0.56	8.7±0.52	3.82±0.16	15.55±2.2
	5	9.72±0.57	8.8±0.52	3.92±0.2	18.13±2.4
	6	10.0±0.46	9.06±0.44	3.98±0.24	20.2±2.8
	7	10.56±0.35	9.65±0.32	4.34±0.22	23.49±2.8
	8	11.05±0.3	10.04±0.31	4.51±0.37	27.04±4.0
	9	11.27±0.3	10.2±0.34	4.63±0.68	29.7±3.7
3	1	5.49±0.15	5.05±0.11	1.6±0.07	3.17±0.19
	2	5.75±0.18	5.13±0.13	1.73±0.03	3.29±0.18
	3	6.0±0.06	5.31±0.05	1.8±0.05	4.03±0.14
	4	6.18±0.11	5.47±0.09	1.89±0.03	4.43±0.19
	5	6.3±0.14	5.63±0.15	1.93±0.06	5.14±0.46
	6	6.56±0.21	5.71±0.11	2.04±0.06	5.66±0.5
	7	6.84±0.22	5.97±0.28	2.14±0.04	6.29±0.58
	8	7.26±0.21	6.4±0.16	2.26±0.05	7.01±0.72
	9	7.47±0.25	6.62±0.26	2.38±0.05	7.66±0.68
4	1	8.2±0.64	7.4±0.65	3.48±0.17	10.75±02.7
	2	8.57±0.67	7.86±0.57	3.61±0.21	12.07±2.6
	3	9.2±0.61	8.53±0.61	3.69±0.18	13.9±2.09
	4	9.62±0.56	8.7±0.52	3.82±0.16	15.55±2.2
	5	9.7±02.57	8.8±0.52	3.92±0.2	18.13±2.4
	6	10.0±0.46	9.06±0.44	3.98±0.24	20.2±2.8
	7	10.56±0.35	9.65±0.32	4.34±0.22	23.49±2.8
	8	11.0±0.3	10.04±0.31	4.51±0.37	27.04±4.0
	9	11.27±0.3	10.2±0.34	4.63±0.68	29.7±3.7

Table 5: Comparison of growth factors in the first experiment

Treatment	WG	RGR	SGR	GR	FCR	CF	PER
1	15.29±7.26	181.15±102	2.85±0.25	2.18±1.00	3.65±0.32	1.85±0.26	0.85±0.01
2	14.06±10.9	170.23±126	2.60±0.67	2.008±1.56	3.42±0.26	1.86±0.3	0.86±0.16
3	4.36±1.21	141.93±62	1.85±0.15	1.6233±0.17	5.18±0.18	1.86±0.23	0.55±0.08
4	16.25±2.95	161.44±66	2.95±0.12	2.32±0.42	4.59±0.28	1.96±0.21	0.80±0.15

Table 6: Comparison of protein pacu tissue contents pre and post second experiment

Treatment	Sampling Time	Ash (%)	Fat (%)	Protein (%)
1	Pre-experiment	3.877	6.537	15.035
	Post-experiment	3.290	8.612	15.112
2	Pre-experiment	3.877	6.537	15.035
	Post-experiment	3.387	8.002	10.160
3	Pre-experiment	3.877	6.537	15.035
	Post-experiment	3.207	5.974	15.331

Table 7: Changes of studied factors during the biometric stage in treatments 1-3 (Second experiment)

Treatment	Biometric Stage	Body Length (cm)	Fork Length (cm)	Body Depth (cm)	Weight (gr)
1	1	7.85±0.182	6.933±0.057	2.94±0.207	8.396±1.172
	2	8.27±0.069	7.506±0.110	3.333±0.135	9.987±0.916
	3	8.696±0.241	7.796±0.161	3.833±0.500	12.223±0.910
	4	9.18±0.149	8.313±0.206	3.773±0.110	14.735±0.785
	5	9.933±0.284	8.976±0.247	4.066±0.119	18.345±1.008
	6	10.46±0.257	9.473±0.219	4.563±0.275	22.768±1.334
	7	10.816±0.076	9.876±0.102	4.773±0.127	26.176±1.058
	8	11.52±0.312	10.546±0.325	5.003±0.205	33.697±1.884
	9	11.84±0.197	10.815±0.403	5.205±0.148	39.717±0.774
2	1	7.816[a]±0.140	7.02[a]±0.115	3.120±0.158	8.78±0.593
	2	8.520±0.492	7.706±0.417	3.546±0.166	12.208±1.253
	3	9.03±0.155	8.19±0.075	3.68±0.052	14.325±0.335
	4	9.55±0.390	8.683±0.225	4.016±0.076	17.3±1.102
	5	10.30±3.2	9.43±0.242	4.35±0.173	20.457±2.004
	6	10.68±.065	9.77±0.125	4.62±0.141	23.46±0.695
	7	10.913±0.14	10.05±0.271	4.59±0.107	25.647±0.903
	8	11.32±0.282	10.35±0.237	4.78±0.155	30.22±2.112
	9	11.98±0.015	10.80±0.107	5.16±0.176	35.28±4.971
3	1	7.98±0.131	7.12±0.14	3.25±0.030	9.386±0.574
	2	8.62±0.091	7.74±0.105	3.57±0.07	11.931±0.777
	3	9.16±0.023	8.39±0.133	3.68±0.144	13.166±1.663
	4	9.36±0.17	8.52±0.12	3.74±0.166	14.765±2.149
	5	9.45±0.211	8.58±0.144	3.77±0.155	16.5±2.287
	6	9.7±0.307	8.76±0.231	3.91±0.201	17.75±2.792
	7	9.95±0.219	9.04±0.243	3.99±0.15	19.564±2.366
	8	10.52±0.303	9.56±0.341	4.18±0.14	22.71±2.466
	9	10.7±0.31	9.7±0.316	4.35±0.117	25.633±2.523

Table 4 shows the trend of changes in factors during biometric measurement in treatments 1 - 4 at first experiment. Figures 1-7 indicate the alteration of WG, SGR, PGR, GR, FCR, CF and PER of both common carp and pacu at various treatments. Figures 8 and 9 present the relationship between total body length and weight of pacu and carp, including the regression line. Meanwhile, 8 weeks of sampling in different treatment, for measurements of specific growth rate (SGR) absolute weight gain (WG) daily growth rate (GR),relative growth rate (RGR), food conversion ratio (FCR), condition factor (CF), protein efficiency ration (ER) reflected the outcome in the descriptions concerned with the comparison of the means. Meaningful differences among the means of different treatments showed that the absolute daily weight gain of pacu was 3.5 times greater than those of common carp. The lowest percentage of relative growth rate belonged to carp fed by commercial carp feed with the lowest specific

A significant difference was also detected in terms of (WG) between treatment comprising of carp fed by commercial carp feed (Treatment 3) and treatments 1, 2 and 4 containing pacu fish showing the slower growth rate of carp them that of pacu at lower weight range (i.e.<100g). The results of experiments reflect noticeable difference between the absolute growth rate of carp (Treatment 3) and pacu, whereas the growth rate among various treatments.In other words, the diet P1, P2 and commercial carp diet do not particularly have any different impacts on absolute growth rate. In fact as the results indicate the daily growth rate of pacu by diet P1 and P2 were 2.81±1 g and 2.008±0.56 respectively whereas pacu fed by commercial carp feed enjoyed a daily weight rate of carp was 0.623±0.17 upon comparing the net daily growth rate of carp with commercial carp feed with pacu which was fed with the same feed show a 3.72 time increase of pacu over carp.

An important point concerning the pacu fish is its being highly sensitive to environmental factors that may be manifested in the form of severe reactions. such reactions were noticed merely under experimental condition and aquaria thus it calls for further observations and experiments to find out whether or not the dame things happen in actual farming condition (i.e. fish ponds).Given the observations and experiences gained, it can be concluded that there have been no instances of serious injuries, mortality or reactions under captivity conditions of ponds.

The specific growth rate (SGR) for carp was 1.85±0.15 and the mean value for pacu in all three treatment was2.8±0.12.this apparent difference shows the significant superiority of pacu over carp in terms of growth rate, the FCR for carp and pacu over carp in terms of growth rate. The FCR for carp and pacu which were fed by commercial feed also suggest a meaningful difference, showing that the feed/flesh conversion of carp is slower that than of pacu with similar diet.

The results obtained in the second of experiments showed the greater lipid content of tissues in 10and12% feeding rate and lower amount of tissues lipids with 8% feeding rate nevertheless, concerning the protein level of tissue, the first and third treatments resulted in increased tissue protein while the second treatment (i.e. 12% feeding rat) was associated with decreased tissue protein (Table 6). Obtained results indicate that the weight gain of pacu with 10% feeding rate was high which showed a downward trend in the third treatment. A considerable point to mention is that the weight gain was conventionally at 25±5g level but from this range upward, a noticeably greater growth rate was noticed in all three treatments.

Changes of studied factors during the biometric stage in treatments 1-3 at second experiment summarized at Table 7. The research findings showed that the 10% feeding rate caused a better total body length in pacu as compared with the rest of treatment. Meanwhile, the best FDR was related to 10% feeding rate. In general, the first treatment (The 10% feeding rate) induced the highest and the best growth rate, condition factor and protein efficiency ratio thus making it best treatment in this research. It is too early in the study to draw conclusions. Fish are feeding well and water quality should improve as the addition of organic material in the form of excess feed and fish feces accumulates in the ponds. More detailed production cost data are being collected.

DISCUSSION

The obtained results were indicative of superior pacu growth rate over carp the FCR comparison of P1 and P2 for pacu failed to show any noticeable difference. Thus, it can be maintained that the preference of one type of feed over the other is determined by the price which makes P1more advantageous because of cheaper price [5]. In addition feeding the fish up to satiation limit showed the pacu fish meet their nutritional requirements as much as possible. Lee *et al*. [9] showed that fish diet containing 14% fat enjoy nutritional efficiency over those with 7% fat can tent in terms of both PER and PPV which can be attributed to energy requirement for protein production.

The results also depict a meaningfully higher protein efficiency ratio for pacu over carp explaining the reason why the growth rate of pacu is better than that of carp. Table 5 illustrates the measured growth factors across different treatments, gain showing the absence of any meaningful difference of various feed on pacu across different treatment.

Scorvo Filho *et al*. [10] verified that the average price of 1000 pacu juveniles in ranged from US$ 50.26 in February to US$ 54.65 in November. Some other studies on fry production have revealed a significant participation of live food in the composition of costs. Kam and Leung [11] reported that live food corresponded to 20% of the costs of Polydactylus sexfilis fry production. Salles [3], evaluating the use of *Brachionus plicatilis* rotifers in the intensive larviculture of curimbata Prochilodus scrofa, verified that it represented 63% of the total cost. One issue that should be considered with regard to the use of Artemia in intensive larviculture is the availability of cysts in the international market. According to Lavens and Sorgeloos [12] the price of cysts has increased considerably since the 1970s because of the demand for the production of shrimp and fish juveniles, the decrease in cyst harvest in the Great Salt Lakes (USA) and the possibility of stocking cysts, which is done by companies that explore the product. Variations in Artemia cyst prices presented a linear relationship with production costs of P. sexfilis fry [11] and this effect becomes even more evident if a large-scale production is taken into consideration [13].

Despite of the fact of iso-nitrogenous nature of the diets, availability of carbohydrates added in the form of dextrin or as part of soybean products might have led to differences in available energy. However, if present, this effect was manifested in pacu. Therefore, it was concluded that the same diet enhanced the growth rate of pacu and may have been a result of positive effect on protein utilization [13].

The development of aquaculture techniques for the culture of *Piaractus brachypomus* will benefit many sectors throughout the Iran. Sustainable aquaculture offers rural farmers an alternative source of food and/or income in addition to agricultural production and will provide a steady supply of high quality protein in the marketplace. *Piaractus brachypomus*, a novel species, play a crucial role in disseminating seeds in the flooded rainforests. The culture of this species should relieve some commercial fishing pressure.

On the other hand, the demonstrated short culture cycle allows for the production of two crops of pacu per pond during a single growing season in the appropriate temperate climate. Stocking of 150-g advanced fingerlings, which can be produced in year one of a two-year production cycle, would permit two fish harvests at 55 days per production cycle, with 10 days between crops for harvesting the first crop and preparing ponds for the second crop.

Of course Lee *et al.* [14] verified that the cost of production per 1000 milkfish fry in the semi-intensive system in Taiwan was lower than the cost in the intensive system. However, the technique employed by the authors in each rearing system differed from the technique used in the present study, as well as the time the larvae remained in the laboratory.

The results of this study may contribute to improve the productivity of fish farms, encouraging producers to adopt more efficient rearing techniques. In addition, this information could be important for other countries in Iran where pacu and related species are reared seldom. Under a commercial point of view, further studies are recommended to maximize laboratory use, especially to evaluate the possibility of increasing larval stocking density in the laboratory, since rearing at higher densities would increase the productivity of the system [15].

It can be concluded that considering the superior growth rate of pacu over carp, it is possible to suggest that carp can be replaced by pacu for farming together with the rest of warm water fish species or be used mainly in ponds for sport fishing.

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