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Optimization of Feeding Frequency in *Cyprinus carpio* (Linnaeus, 1758)

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Abstract: Feeds and feed delivery represent major economic costs in intensive fish culture. Juvenile fish grow rapidly during this period and their feeding preferences can often be affected by ontogeny. Feed management plays a major role in the economical and environmental status of fish farms. This study was conducted for 6 weeks in the Sijual Bony Fishes Reproduce and Cultivate Center (Bandarturkmen, Golestan, Iran). Four feeding frequencies of three (A), four (B), five (C) and six (D) times per day were evaluated as treatments in triplicate for a period of six weeks. Carp fingerlings (2.97 cm/1.5 g) stocked at 30 numbers per replicate were fed with a commercial fish diet containing 32% crude protein at 5% of the biomass daily for the culture period. Chemical factors including dissolved oxygen 5.5-6 ppm, the temperature 26±2 °C and pH 7.5 to 8 were measured during of experiment. The highest growth was recorded in treatment D, the final length (4.15±0.02 cm) and weight (3.285±0.064 g) but did not differ significantly in different treatments ($P>0.05$). According to the results of this study, it was shown that feeding frequency was not affect body weight and body length gain of carp and there is no significant differences in the rate of feed conversion ratio, body weight index and survival ($P>0.05$). The results showed that there are significant differences with regard to the amount of specific growth rate, growth rate and condition factor in different treatments ($P<0.05$). Results of this study showed that increasing of feeding frequency was not affect growth and survival in *Cyprinus carpio*.

Key words: *Cyprinus carpio* % Feeding Frequency % Growth Performance % Survival

INTRODUCTION

Fish feeding is one of the most important performances in aquaculture because of high feed costs [1]. Understanding of natural foods and dietary habits of fish culture could be an important factor in providing effective method of nutrition. Although intensive fish culture adaptability of the species with different feeding methods have been proven, but the choice of methods to provide food and nutrition in aquaculture should be considered dietary at patterns of normal behavior [2]. An appropriate feeding strategy is of paramount importance to produce quality stockable size seeds for grow-out operation. Among the different feed management practices proven to maximise the benefit of feeding, feeding frequency and ration size play an important role in regulating the feed intake, growth and waste outputs of fish [3]. Fish feeding is one of the most important factors in commercial fish farming because feeding regime may have consequences on both growth efficiency and feed wastage [4, 5]. The growth of fish at all stages is largely governed by the kind of food, ration, feeding frequency, food intake and its ability to absorb the nutrients. Among these, feeding frequency is an important aspect for the survival and growth of fish at the early stage [6]. Feeding costs contributes up to 60% of the variable costs of culture systems [3]. Optimizing feeding frequency may minimize feed wastage, leading to improvement in culture environment and or reduction in size heterogeneity [7, 8], whereas poorly timed or sporadic feeding frequency may lead to increased hunger, intra-specific aggression and increased rate of cannibalism [9, 10]. In result, understanding the nutritional qualities of fishes is very important. It is also important to establish an appropriate feeding management program, because an inadequate food supply has a direct impact on production costs [11] and water quality [12]. Optimum feeding frequency seems to be dependent on fish size and higher frequency of feeding was found to be advantageous for higher growth and survival in younger age groups. The fishes should have the access to feed up to satiation for their optimum growth. However, over-feeding leads not only to reduction in feed conversion efficiency and increase in input cost, but also accumulation of wastes

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that adversely affects the water quality [13]. Studies on feeding behavior in several fish species have shown that if feeding frequency be in accordance with natural feeding, it will increase growth and decrease FCR [14]. Moreover, knowledge of the optimum feeding rate is important not only for promoting best growth and feed efficiency, but also for preventing water quality deterioration as a result of excess feeding [11, 12, 15]. So, management of feeding is essential in fish farming due to its economic effect as well as its effect on the health of the fish. In fry production, adequate feed is essential to obtain optimum survival and growth. Feeding management and its supply is also crucial for efficient fingerling production. To improve production process experimental test evaluated the effect of feeding frequency on growth and survival of *Cyprinus carpio* fries. So, with aspect to two or three times feeding per day in farms and existing food for *Cyprinus carpio* feeding in Iran it seems essential to specify the best feeding frequency for reaching the highest rate of growth on *Cyprinus carpio*. The objective of this study was to determine optimum feeding frequency to *Cyprinus carpio* so as to improve survival and growth. The study examined appropriate feeding frequency locally prepared food to rear *Cyprinus carpio*.

MATERIALS AND METHODS

Fish Supply and Experimental Design: This study has been carried out in Sijual Bony Fishes Reproduce and Cultivate Center (Bandarturkmen, Golestan, Iran), summer 2010. This experiment was conducted for six weeks at four treatments and three replicates as follows: Treatment A: Three times a day at 08:00, 13:00 and 18:00 h, treatment B: Four times a day at 08:00, 12:00, 16:00 and 20:00 h, treatment C: Five times a day at 08:00, 10:30, 13:00, 15:30 and 18:00 h and treatment D: Six times a day for feeding at 08:00, 10:00, 12:00,14:00, 16:00 and 18:00 h. Individuals with a body weight of 1.5±0.21 g and body length 2.97±0.22 cm were selected by gravimetric measurements and acclimated five days to laboratory conditions and removing the suspected unhealthy subjects. Fish were housed in a 40 L capacity fiberglass test tank (30 fishes / aquarium) provided with aeration system. Water circulation was supported by two air pumps. *Cyprinus carpio* were fed during the experimental period with SFC feed staff containing: 8.7% moisture, 11.2% ash, 32% protein and 10.5% fat. Feeding rate which paid attention to live weight and in different times and after each two weeks biometry, equall 5% of body weight is calculated and was intered to each aquarium.

Test Water: Water chemistry characteristics of temperature, dissolved oxygen and pH were determined in all test tanks every day. Mean dissolved oxygen ranged from 5.5 to 6 mg L^{-1} during the tests. Mean water temperature ranged from 26±2EC. The mean pH during experiments ranged from 7.5 to 8. Total hardness was determined during experiments. Total hardness in all tests ranged from 370 to 378 mg L^{-1}as $CaCO_3$.

Growth Performances Assay: Fish performances were evaluated in terms of Feed Conversion Ratio (FCR), Specific Growth Rate (SGR, % d^{-1}), Body Weight Index (BWI %), Growth Rate (GR, gd^{-1}), Condition Factor (CF, g/cm) and Survival (%). These performance indices were calculated as follows [10, 16, 17]:

- FCR=total feed intake/ total biomass gain
- SGR= [(ln final weight-ln initial weight)/ rearing duration in days] ×100
- BWI= [(body weight final-body weight initial)/ body weight initial] ×100
- GR= (body weight final-body weight initial)/ rearing duration in days
- BWI= [(body weight /total length^3)] ×100
- Survival= (number of fish harvested/number of fish stocked) ×100

Statistical Analysis: For analysis of all data were used SPSS version 13 and a software program for drawing graphs of Excel 2003. All data were analyzed with one-way analyses of variance (ANOVA) and significant means were subjected to a multiple comparison test (Duncan) at $P<0.05$. When the normality of data did not present, the nonparametric test Kruskal-Wallis to compare treatments and test Mann-Whitney for paired comparison between treatments were used.

RESULTS

Final weight and length of *Cyprinus carpio* in different treatments with 3, 4, 5 and 6 feeding frequency per day are shown in Table 1. Obtained results in this study showed that increasing feeding frequency has no effect on increasing body weight and body length of *Cyprinus carpio* and there is no need full difference in this respect among considered treatments ($P>0.05$). Although, the highest growth was recorded in treatment D, the final length (4.15±0.02 cm) and weight (3.285±0.064 g), but did not differ significantly in different treatments ($P>0.05$).

Table 1: The average of body weight and body length of *Cyprinus carpio*

	Treatments	Initial weight (g)	Initial length (cm)	Final weight (g)	Final length (cm)
A	3 time feeding per day	0.21 [a]±1.5	2.97±0.22[a]	0. 37 [a] ±2.79	0.46 [a] ±3.71
B	4 times feeding per day	0.21 [a]±1.5	2.97±0.22[a]	0. 29 [a] ±2.74	0.15 [a] ±4.01
C	5 times feeding per day	0.21 [a]±1.5	2.97±0.22[a]	0.317 [a] ±3.01	0.16 [a] ±3.99
D	6 times feeding per day	0.21 [a]±1.5	2.97±0.22[a]	0.064 [a] ±3.28	0.02 [a] ±4.15

*The small Latin letters at the same column show that there are significant differences among different treatments

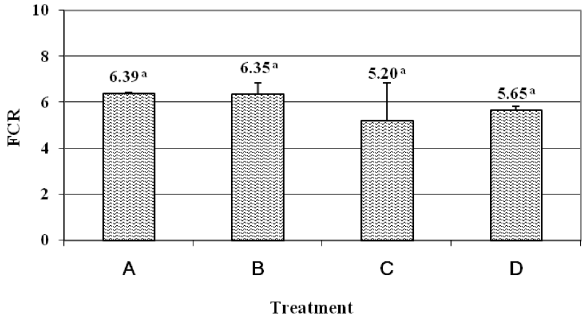

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Fig. 1: Effect of different feeding frequency on FCR in *Cyprinus carpio*

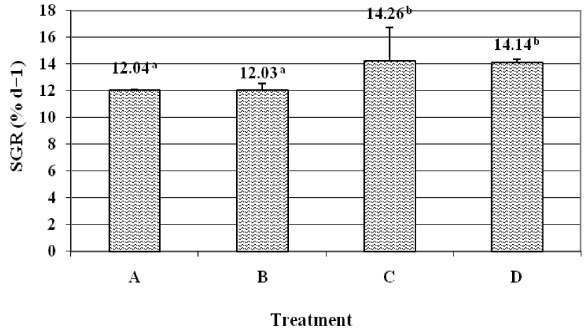

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Fig. 2: Effect of different feeding frequency on SGR in *Cyprinus carpio*

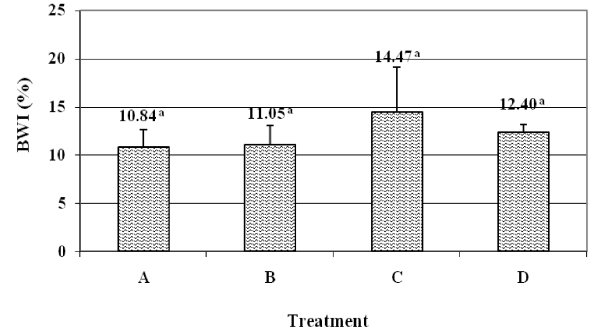

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Fig 3: Effect of different feeding frequency on BWI in *Cyprinus carpio*

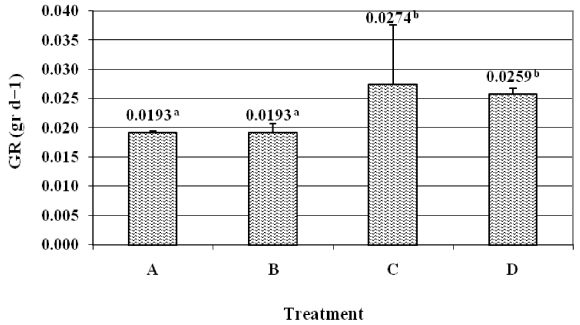

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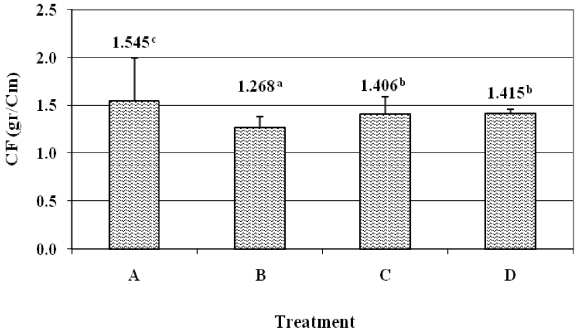
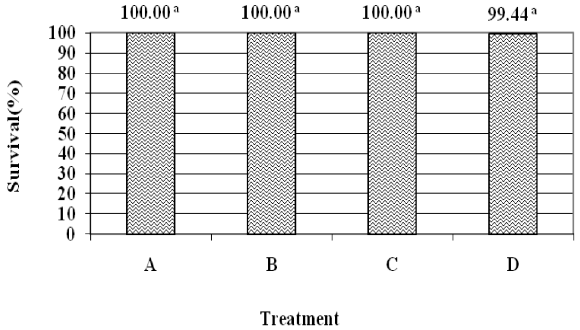
Fig. 4: Effect of different feeding frequency on GR in *Cyprinus carpio*



*The small Latin letters show that there are significant differences among different treatments

Fig. 5: Effect of different feeding frequency on CF in *Cyprinus carpio*



*The small Latin letters show that there are no significant differences among different treatments

Fig. 6: Effect of different feeding frequency on survival in *Cyprinus carpio*

Comparison average of different feeding frequency effects on FCR during culture period are shown in Fig.1. The lowest FCR was recorded in treatment C (5.20) but did not differ significantly in different treatments (P>0.05).

The results of SGR are shown in Fig. 2. The results showed that there are significant differences with regard to the amount of SGR in different treatments (P<0.05). The lowest SGR was recorded in four times feeding per day and the highest SGR was recorded in five times feeding per day (Fig. 2).

Also, the results showed that there isn't any meaningful difference in BWI % in different treatments (p > 0.05). The highest BWI % was recorded in treatment C (14.47%), but did not differ significantly in different treatments (Fig. 3).

Obtained results in this study showed that the lowest growth factor (GR) is in three and four times feeding per day and the highest GR is in five times feeding per day (Fig. 4). The results showed that there are significant differences with regard to the amount of GR in different treatments (P<0.05).

The results showed that there are significant differences with regard to the amount of condition factor (CF) in different treatments (P<0.05). The lowest CF was recorded in four times feeding per day (1.268 g/cm) and the highest CF (1.545 g/cm) was recorded in three times feeding per day (Fig. 5).

The results of survival are shown in Fig. 6. The results showed that increasing of feeding frequency there isn't effect on survival in *Cyprinus carpio* (P>0.05). The highest survival was recorded in treatments A, B and C (100%).

DISCUSSION

Growth of fishes is affected by biotic and abiotic factors. Among them, food is probably the most potent one. Feeding can have a significant impact on the success of fish culture [18]. The determination of the optimal feeding schedule of fish is needed for their efficient production, because their nutrient requirements are largely influenced by feed allowance [19, 20]. The proper feeding frequency for maximum growth of fish may differ by fish species, fish size, dietary protein and energy contents and feed allowance in previous feeding and so on [21-23]. Ishiwata [24-25] showed that the daily feed intake of fish changes with feeding frequency and improves the growth of fish to some extent. However, weight gain of rainbow trout fry fed to satiety three meals a day was better than one meal a day or six meals a day [26]. Increasing the feeding frequency has been reported to improve the growth of fishes. In filefish, puffer, yellowtail and rainbow trout, the daily food ration changed directly with the frequency of feeding [24-25]. Similar results have been reported in other species of fish [27-30]. Also, in experimental rearing, Lee *et al*. [31] suggested that an increase of feeding frequency (the daily ration was provided between three and five times per day) stimulated the intake of artificial diet in juvenile cuttlefish, the results of this study is not the same. The results obtained in this study show that growth is not influenced by feeding frequency. The amount of food consumed by carp fed by increasing feeding frequency no difference in growth was observed. No improvement of weight gain was obtained in the fish fed in different feeding frequency. The frequency of feeding did not induce any change of survival of carp fry. Also, FCR and BWI were not affected by increasing feeding frequency.

Some studies showed that two or three feedings a day have been found to be sufficient for maximum growth of a number of species such as yellowtail [25], channel catfish [29], grouper *Epinephelus tauvina* [32], as well as sea bass *Dicentrarchus labrax* [4] and rainbow trout [26]. The results of this study are the same. In other studies the results was different. Ruohonen [33] reported that the average growth rate increased and size variation decreased in a group of juvenile Atlantic salmon when they were fed up to 60 times a day. Shelbourn *et al*. [34] reported that sockeye salmon fry showed significantly higher growth rate when fed continuously for 15 h a day in comparison to being fed to satiation three times a day. For larger Atlantic salmon, Thomassen and Fjaera [35] found no effect of feeding frequencies of 3, 9 or 27 times in a day [36]. Booth *et al*. [37] noted that 1 to 4 feeding frequency per day may have the best function for increasing growth in *Salmonidae* and Australian snapper, the results of this study is not the same. Johansen and Jobling [38] have reported that feeding frequency increase, fish swimming activity increase too and so energy consuming will be more and growth will be less. The highest growth in the low frequency of feeding occurs [4]. Tyler and Dunn [39] found, at lower feeding frequencies growth by winter flounder *(Pseudopleuronectes americanus)* increased directly with feeding frequency [26]. Lee *et al*. [40] suggested that feeding frequency of one meal every 2 days at satiation would be proper for Korean rockfish grown from 25 to 60 g than one meal a day or two meals a day. It is concluded that a feeding frequency of one meal a day till satiation is proper for the improvement of weight gain in juvenile Korean rockfish [41].

As is clear, research results showed that the feeding frequency and growth rate are different in different species.

So, as for two or three times feeding per day in farms and existing food for *Cyprinus carpio* feeding in Iran fish farms seems two- times feeding per day for reaching the highest rate of growth on *Cyprinus carpio* is good.

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