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Influence of Feeding Frequency on Growth performance and Body Indices of Goldfish *(Carrassius auratus)*

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Abstract

A total of forty goldfish *(Carrassius auratus)* with an average weight of 20 g per fish were stocked in individual glass aquaria having 50-L water holding capacity. There were 4 experimental feeding regimens A, B, C, and D having once twice, thrice and four times per day, respectively. All the groups received Nova Aquarium Fish Food @ 2% bodyweight which was equally spaced in treatment groups. The body weight, body and caudal lengths, and girth were recorded at the start of the experiment. The trial continued for 8 weeks. Group B yielded the maximum weight gain whereas group D yielded lowest weight ($P<0.05$). Feed Conversion Ratio (FCR) was better in Feed A and depreciated with increasing frequency ($P<0.05$). Caudal fin showed significant correlation with weight (+ 0.548; $P<0.001$) and length (- 0.792; $P<0.0001$). A positive correlation of dissolved oxygen (DO; $P<0.001$) and salinity ($P<0.0001$) showed with temperature. Salinity showed positive significant correlation with temperature ($P<0.05$). Consequently, feeding frequency twice per day is better for maximum body weight gain however better feed efficiency can be obtained at feed frequency once per day. However goldfish require genetic improvement for its rearing at commercial scale.

Keywords: Feeding frequency; Growth performance; Body measurements; Goldfish

Introduction

Ornamental fish culture is an important primary industry [1]. Ornamental fishes are often referred as alive jewels due to their beautiful colors, their body shape and natural behavior. They are very gentle, generally tiny, charming colors and could be easily accommodated in confined spaces. Modern ornamental fish culture and breeding operations have been intensified both vertically and horizontally, necessitating a continuous supply of nutritionally balanced, cost-effective feed [2].

The goldfish (*Carrassius auratus*) belongs to the family Cyprinidae and is the most popular variety of ornamental fish. It was one of the earliest fish to be domesticated, and is one of the most commonly kept aquarium fish [3,4]. Like other fishes its growth and reproduction is influenced by numerous factors. Feed quality, quantity, composition and ingredient size, and feeding frequency are among the most important [5-7]. Though frequent feeding improves fish growth [8,9] increasing feeding frequency beyond a particular level may lead to feed wastage and increase production costs [10]. Identification of the optimal feeding frequency helps to reduce feed wastage and maximize growth and reproduction.

Many authors studied the effect of feeding frequency on feed intake and growth in edible fishes [10-13]. Wang et al. [14] found that increased feeding frequency decreased inter-individual size variation among treatments. However, Zhou et al. [15] did not observe any effect of varying feeding frequency in juvenile gibel carp, *Carrassius auratus gibelio,* did some work on the influence of nutrition on growth and reproduction of ornamental fishes [16-18] but little attention has been paid to the impact of feeding frequency on growth and reproductive performance in ornamental fishes. Therefore, the present study was conducted to determine the effect of varying feeding frequency on growth and various body indices of goldfish, *Carraius auratus*.

Materials and Methods

The experiment was conducted at the Department of Fisheries and Aquaculture, University of Veterinary and Animals Sciences, Ravi Campus, Pattoki.

Management and feeding

A total of 40 Goldfish (*Carassius auratus*) was procured from Poonch Market, Choburgi Lahore-Pakistan weighs on average 20 g each. All the 40 individuals were divided equally into 20 tanks, with five replicates having 2 fish per replicate. Each tank has 10-L water holding capacity. There were 4 dietary groups, A, B, C and D. Group A served as a control and was fed once a day. Group B, C and D were fed twice, thrice and four times a day respectively. Time of feeding to different groups is followed as; Group A was offered feed at 0800, Group B was offered feed at 0800 and 1200, Group C was offered at 0800, 1200 and 1600, and Group D was offered feed at 0800, 1200, 1600 and 2000. A standard commercially available Nova Aquarium Fish Food was offered @ 2% bodyweight (g/g) split in equal parts as per requirement of each replicate. The amount of feed offered to the fish was close to the maximum daily ration consumed as per the local recommendations. The feeding trial lasted for 8 weeks. Faecal matter and unconsumed feed, if any, were siphoned before feeding. The unconsumed feed was filtered over a screen soon after the active feeding, dried and weighed to

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measure the amount of feed consumed. Proximate composition of this feed has been given in Table 1.

Water analyses

Water parameters were closely monitored and were kept within safe limits by regular flow management. The water parameters were evaluated in terms of pH, temperature, dissolved oxygen (DO) and salinity. Water was analyzed for its pH by pH metre (LT-Lutron pH-207 Taiwan), dissolved oxygen (DO) by DO metre (YSI 55 Incorporated, Yellow Springs, Ohio, 4387, USA). Moreover, temperature was recorded by the Combo meter (H M Digital, Inc. CA 90230). These observations were recorded twice (morning and noon) daily from different replicates.

Growth and body indices

Growth and morphometric parameters were carefully examined to predict daily feed ration. Each fish was individually weighed and all the other morphometric parameters were measured before the start of the trial and then in the lapse of every 2 weeks. The fish was removed from the tank individually and placed on laminated graph paper. Length from the mouth to the caudal peduncle and depth from the deepest point of the body to the base of the dorsal fin was measured (mm). Fish were then placed in a tarred beaker of tank water on an analytical balance for body weight measurements and then returned to their respective holding tank. The duration of study was 8 weeks.

Statistical Analysis

Data was subjected to One-way ANOVA Technique under completely randomized design. To determine significant differences ($P<0.05$) among the treatments means, Duncan's multiple range test was employed. Pearson correlation was applied to find out the correlation between the studied parameters. The level of significance was <0.05 or otherwise stated.

Results

Body weight and body indices of all the groups are shown in Table 2. Significantly higher initial body weight was observed in fish allocated to feed B followed by feed A, C and D, respectively ($P<0.05$). All the fish allocated were of equal length, means horizontal growth was not unlike among the various treatments ($P>0.05$). Caudal length was found to be significantly higher in group C, followed by B, D, and A ($P<0.05$). More than 10% increase in caudal length has been observed in fish allocated to feed C as compared to feed A. The girth of fish allocated to group A and B was highest while the lowest response was observed in feed C and D ($P<0.05$).

The observations of weight gain and feed conversion ratio (FCR) are shown in Table 3. The weight gain was improved in group B (68.5 g) while the better FCR was noticed in group A (1.28). Feed B showed 2.5 times improvement in weight gain as compared to feed D (68.5 vs. 29.0 g) while feed A responded almost 5 times better than feed D (1.28 vs. 9.66).

The correlation between weight, length, caudal fin, girth, pH, temperature, DO and salinity is shown in Table 4. The caudal fin of fish showed a highly positive correlation (+ 0.548) with weight ($P<0.01$) and a negative correlation (-0.792) with length ($P<0.001$) whereas the water DO showed a positive correlation (+ 0.538) with water temperature ($P<0.001$). The salinity of water is positively correlated (+ 0.729) with temperature ($P<0.05$).

Discussion

The positive correlation of the caudal fin with weight and length leads to the fact that the measurement of caudal fin could be a good criteria to estimate the weight of the fish. Increase in water temperature reduced the water DO and salinity so it also needed to maintain an optimum temperature for better dissolved oxygen and salinity level. There are some physicochemical viz. Temperature, Salinity, Conductivity, Dissolved Oxygen (DO), and pH which are considered to be important and critical water quality parameters in aquaculture [19,20]. Each water quality factor interacts with and influences other parameters, sometimes in complex ways [21]. Brian [22] and Ita et al. [23] noted that increased DO level is needed to support an increase in metabolic rates and reproduction. McElwee [24] described that temperature has an influence on salinity tolerance since they fluctuate together in nature and these fluctuations may positively or negatively influence growth and reproductive performance of cichlids. Watanabe et al. [25] observed that growth and survival in fish are not affected at different salinity levels when temperature exceeds 27°C but salinity has pronounced effect at temperatures below 25°C.

The initial observations in the present study did not affect further growth responses (on percent basis). In the present study the higher body weight was observed in fish fed to a frequency of two times per day. Similar results were observed by James and Sampath [26] in Red Swordtail (*Xiphophorus helleri*) which indicated that feeding twice a day resulted in the highest growth and reproductive success of this specie in a cultured system, when compared with 4 alternative feeding regimens

Nutritional compositional (g/kg)	
Crude Protein	170.0
Crude Fiber	45.0
Crude Fat	30.0
Moisture	100.0

Table 1: Proximate Composition of Nova Aquarium Fish Food.

Parameters	Feed-A[1]	Feed-B[2]	Feed-C[3]	Feed-D[4]
Body weight (g)	12.26 ± 0.40^{ab}	12.45 ± 0.36^{a}	11.01 ± 0.54^{bc}	10.29 ± 0.49^{c}
Body Length (cm)	7.45 ± 0.09^{a}	7.57 ± 0.09^{a}	7.37 ± 0.16^{a}	7.27 ± 0.10^{a}
Caudal length (cm)	2.71 ± 0.07^{b}	2.88 ± 0.06^{ba}	3.10 ± 0.11^{a}	2.86 ± 0.06^{b}
Girth (cm)	7.82 ± 0.13^{a}	7.65 ± 0.11^{a}	7.17 ± 0.18^{b}	6.95 ± 0.13^{b}

[a,b,c]Data figures with different superscript letters across the rows are significantly different from each other at P<0.05
[1]Feeding frequency is once per day
[2]Feeding frequency is twice per day
[3]Feeding frequency is thrice per day
[4]Feeding frequency is four times per day

Table 2: Growth and length of goldfish at the start of feeding trial.

Feed	Weight Gain (g)[1]	FCR (g:g)
A	64.95 ± 0.06^{a}	1.28 ± 0.04^{a}
B	68.47 ± 0.04^{b}	2.63 ± 0.02^{b}
C	58.47 ± 0.09^{c}	3.94 ± 0.06^{c}
D	29.02 ± 1.00^{d}	9.66 ± 0.03^{d}

[a,b,c,d]Data figures with different superscript letters across the rows are significantly different from each other at P<0.05
[1]Weight gain was calculated by dividing average weight of 10 fish minus the initial weight
[1]Feed A means feeding frequency is once per day
[2]Feed B means the feeding frequency is twice per day
[3]Feed C means the feeding frequency is thrice per day
[4]Feed D means the feeding frequency is four times per day

Table 3: Weight gain and FCR of goldfish reared under various feeding frequency regimes

Correlation	Weight	Length	Caudal Fin	Girth	pH	Temp.	DO	Salinity
Weight	NS	NS	NS	NS	NS	NS	NS	NS
Length	NS	NS	NS	NS	NS	NS	NS	NS
Caudal Fin	0.548**	-0.792***	NS	NS	NS	NS	NS	NS
Girth	NS	NS	NS	NS	NS	NS	NS	NS
pH	NS	NS	NS	NS	NS	NS	NS	NS
Temp	NS	NS	NS	NS	NS	0.729***	NS	NS
Do	NS	NS	NS	NS	NS	0.538*	NS	NS
Salinity	NS	NS	NS	NS	NS	NS	NS	NS

NS- Non-significant; * P<0.05; ** P<0.010; *** P<0.001

Table 4: Pearson Correlation between weight, length, caudal fin, girth, pH, temperature, dissolved oxygen, and salinity

(once, thrice, once and twice a day). James and Sampath [26] had similar findings in Siamese fighting fish (*Bettas plendens*. Regan) who showed that fish fed twice a day to satiation elicited maximum growth and reproductive output when compared with its counterparts (1 meal in 3 d, 1 meal in 2 d, 1 meal/d, and 3 meals/d). Contrary to our results commercially cultured fish species such as Black Rockfish (*Sebastes schlegeli*) suggested that feeding to satiation once a day resulted in optimum growth [27]. Gibel Carp (*Carrassius auratus gibelio*), showed a significant surge in growth rate and feed efficiency when feeding frequency increased from 2 to 3, 4, 12, and 24 feedings per day, with the recommendation of 24 feeding times per day for this species [15]. The difference in results might be due to the fact that goldfish is not usually reared for commercial purpose. Moreover, this fact also leads to the fact that there is a need to improve the genetic potential of goldfish if we want to rear it for commercial reasons. In the present study, the maximum weight gain was observed in the feed (B) and the same result was observed in Siamese fighting fish (*Betta splendens*. Regan) which showed that 2 meals per day fed to satiation are sufficient to support the maximum growth. Further it has been reported that ornamental Red Swordtail (*Xiphophorus helleri*) fed 2 meals per day resulted in the greatest growth [28]. But contrary to present study the juvenile Atlantic Halibut (*Hippoglossus hippoglossus*) displayed improved growth rates when fed on satiation 5 times per day, compared with one time per day [29], and African Catfish (*Clarias gariepinus*) exhibited greater growth rates when fed to satiation twice compared with 3 times per day [30]. In the present study the better feed conversion ratio (FCR) was observed in Feed (A) but contrary to present study best FCR were observed for the Goldfish fed 4 times per day, indicating that this frequency of feeding was optimal, suggesting that both growth and feed utilization are more efficient at this feeding frequency [31].

Conclusion

It is inferred that frequency feeding has profound effects on growth of goldfish. However two times per day feeding frequency is better choice for maximum body weight gain but the efficiency of feed could be improved if feed frequency remained once per day. Moreover, for rearing goldfish at commercial level it is recommended to geneticist and breeders to improve its genetic potential.

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