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The Effects of Starvation Duration on the Growth Performance, Feed Cost, and Water Quality in Common Carp (*Cyprinus carpio*)

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A R T I C L E I N F O

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A B S T R A C T

The present study investigated the effect of starvation periods on growth performance, feed cost, and water quality in common carp (*Cyprinus carpio*). Two different starvation methods were implemented, with an average weight of 120.69±3.47g over a 45-day trial. Group D1 was subjected to a 1-day fasting/2-day feeding regimen, whereas Group D2 adopted a 2-day fasting/1-day feeding regimen. The control group (C) was fed twice daily to satiation. At the end of the trial, the average weight of the fish was 200.88±14.62g in the control group, 189.11±21.05g in Group D1, and 130.04±10.49g in Group D2. The specific growth rates were 1.13±0.08% (C), 1.00±0.05% (D1), and 0.17±0.06% (D2), respectively. Feed conversion ratios were 1.81±0.01 (C), 1.32±0.02 (D1), and 4.43±0.05 (D2), respectively. There were significant differences between the control group and Groups D1 and D2 in terms of dissolved oxygen (mg/L) and pH values of the water. Group D2 yielded lower feed costs due to reduced feed usage. The average weight gain analysis showed that the unit feed cost of Group D2 was 3.4-fold higher than that of Group D1 and 2.5-fold higher than that of the control group. The application of starvation periods in feeding common carp had significant effects on the growth, feed utilization, water quality, and feed cost.

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Introduction

Nutrition is a crucial activity that influences all vital functions of living organisms and significantly impacts growth and associated costs. Consequently, feeding practices are vital for sustainable aquaculture systems. Fish feeding aims to achieve the desired yield weight within an optimal timeframe and minimize feed and other costs while establishing economically viable and environmentally sustainable feeding protocols (Baki et al., 2020). Accordingly, research has been conducted on the most effective feeding models that affect feed conversion and fish growth (Føre et al., 2016; Foss et al., 2009).

In nature, fish can experience periods of starvation for various reasons at certain times of the year. In aquaculture settings, they may also face short or long-term feed deprivation due to adverse environmental conditions and production-related issues. Numerous fish species have evolved remarkable resilience to endure these starvation periods (Navarro & Gutierrez, 1995). Recent studies have examined the effects of starvation periods and restricted feeding regimes on growth performance (Baki et al., 2020; Chatakondi & Yant, 2001; Chen et al., 2022; Eroldoğan et al., 2008; Fang et al., 2017; Foss & Imsland, 2002; Heide et al., 2006; Reyes & Baker, 2017; Taşbozan et al., 2014; Urbinati et al., 2014; Qian et al., 2000; Yengkokpam et al., 2013; Yılmaz et al., 2018; Zhu et al., 2001).

The present study aimed to assess the effect of starvation periods on the growth performance, feed cost, and water quality in common carp (*Cyprinus carpio*).

Material and Methods

Materials

In the study, 450 carp with an initial average weight of 120.69±3.47g and an average length of 19.04±0.16 cm were stocked into nine tanks (300 L each) with three replicates ($p>0.05$).

Methods

Two different fasting regimes were adopted for 45 days. The control group (C) was fed continuously, Group D1 was subjected to a 1-day fast followed by a 2-day feeding regimen, and Group D2 was subjected to a 2-day fasting followed by a 1-day feeding regime. All the groups were fed twice daily to satiation using a commercial carp grower feed containing 38% protein and 12% fat.

At the onset and the end of the experiment, weight and length measurements were taken for each group to determine the growth parameters of the fish (Antonelli et al., 2023; Cui et al., 2006; Skalli & Robin, 2004).

SGR (%, day) = 100 × (lnWf × lnWi) / t

Daily Growth Coefficient = (Wf – Wi) / t

Growth Ratio on Feeding Day = (Wf – Wi) / tf

FCR = Feed Intake (g) / Weight gain (g)

SFR (%, day) = (Food ingested (g) / day/fish weight) × 100

FCR= (Daily Feed Consumption / W, g) × 100

PER= [(Wf – Wi) / Protein intake] × 100

Condition Factor = W/L^3 × 100

Feed cost (USD) = Cost diet × Fi

FCG= Total feed cost / Total weight gain (kg).

Wf = Final Weight (g),
Wi = Initial Weight (g),
FCR = Feed Consumption Ratio
PER = Protein Efficiency Ratio
FCG = Feed cost/kg gain (USD)
W = Fish weight (g),
L = Fish length (cm),
t = days,
tf =The number of feeding days,
Cost diet = the cost of one kg of each diet
Fi = total feed intake (kg) during the experimental period (days).

Statistical Analysis

The data obtained from the research were analyzed using one-way ANOVA with SPSS 21 statistical software. Differences between the values were compared using Tukey's multiple comparison tests at a significance level of $p<0.05$.

Results and Discussion

Growth parameters determined in the study are given in Table 1.

At the end of the study, the average weights of the fish were found to be 200.88±14.62g (C), 189.11±21.05g (D1), and 130.04±10.49g (D2), with specific growth ratio (%) of 1.13±0.08 (C), 1.00±0.05 (D1), and 0.17±0.06 (D2) ($p<0.05$). Group D1 exhibited the highest weight gain and growth values following the control group. Also, according to the growth calculations based on the number of feeding days, Group D1 had the best growth ratio value (2.28±0.25) ($p>0.05$).

The groups subjected to starvation had lower final weight, specific growth ratio, and daily growth coefficient values compared to the control group, indicating that the duration of starvation significantly affected growth. Previous studies have reported that starvation has a significant effect on growth values (Abdel-Tawwab et al., 2006; Akpınar & Metin, 1999; Baki et al., 2013; Einen et al., 1998; Nikki et al., 2004; Tian & Qin, 2004), with significant reductions in specific growth values observed under starvation conditions (Kocabaş et al., 2013; Sevgili, 2007).

In terms of the feed conversion ratio (FCR), which expresses the efficiency of converting feed into biomass, the best value was in Group D1 (1.32±0.02) ($p>0.05$). In contrast, the lowest value was in Group D2 (4.44±0.05) ($p<0.05$). Regarding the specific feeding ratio (SFR), no significant differences were found between the control group (20.82±0.81) and Group D1 (20.75±0.78) ($p>0.05$), whereas the difference between these groups and Group D2 (25.75±1.53) was significant ($p<0.05$).

The study revealed that the average feed consumption during feeding days varied depending on the number of starvation days, with the best value in Group D1, and the difference between this group and the control group was not significant ($p>0.05$). In contrast, the difference with the D2 group was significant ($p<0.05$). Other studies have reported that fish experiencing starvation consume more feed compared to continuously fed fish (Bull & Metcalfe, 1997; Eroldoğan et al., 2006a, 2006b; Miglavs & Jobling, 1989; Nikki et al., 2004; Sevgili, 2007).

Table 1. Growth parameters obtained from the study

Group	Control	D1	D2
Final Weight (g)	200.88±14.62	189.11±21.05	130.04±10.49
Biomass	3013.22±158.26	2836.58±110.10	1950.62±127.30
SBO (%, day)	1.13±0.08	1.00±0.05	0.17±0.06
Daily Growth Coefficient	1.78±0.13	1.52±0.17	0.21±0.02
Growth Ratio on Feeding Day	1.78±0.13	2.28±0.25	0.62±0.05
FCR	1.81±0.01	1.32±0.02	4.43±0.05
SFR (%, day)	20.82±0.81	20.75±0.78	25.75±1.53
Feed cost (USD)	3.17±0.22	1.98±0.21	0.91±0.08
Feed cost/kg gain (USD)	0.04±0.01	0.03±0.01	0.10±0.01
Feed Consumption Ratio	1.60±0.13	1.59±0.17	2.13±0.18
Protein Efficiency Ratio	211.03±15.36	180.05±20.04	24.61±1.99
CF (%)	1.94±0.14	1.85±0.21	1.68±0.14

The each value means mean±standard error. Values expressed with different exponential letters on the same line are statistically different from each other ($p<0.05$); a, b, c: The differences between the means with different letters on the same line within the group are statistically significant ($p<0.05$).

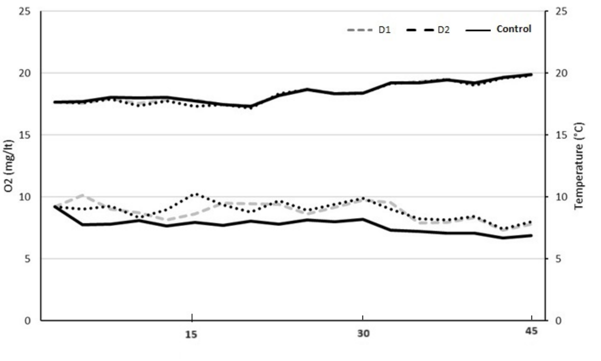

Figure 1. Dissolved Oxygen and Temperature Values

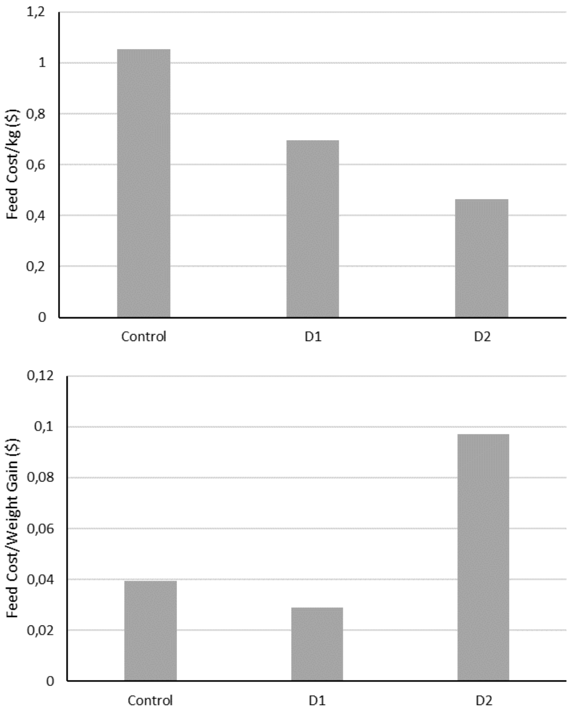

Figure 2. Feed Cost and Feed Cost/Weight Gain Values.

Regarding the protein efficiency ratio, the control group had the best performance, with significant differences from the other groups ($p<0.05$). Other studies have reported no significant changes in the protein efficiency ratio between starvation and feeding groups (Sevgili, 2007). Heide et al. (2006) reported that the protein efficiency ratio in the control group was higher than in the starvation group.

In terms of the condition factor, the difference between the control group and Group D1 was not significant ($p>0.05$), whereas the difference between the control group and Group D2 was significant ($p<0.05$).

The water temperature values throughout the research ranged from 17.19 to 19.88°C, with an average of 18.45±0.19°C in the control group, 18.42±0.19°C in Group D1, and 18.35±0.20°C in Group D2 Group ($p>0.05$). The dissolved oxygen values ranged from 8.70 to 12.27 mg/L, with an average of 7.70±0.14 mg/L in the control group, 8.81±0.18 mg/L in Group D1, and 8.79±0.19 mg/L in Group D2. The difference in dissolved oxygen values between Group D1 and Group D2 was not significant ($p>0.05$), whereas the differences between the control group and the other groups were significant ($p<0.05$) (Figure 1).

Dissolved oxygen is crucial for all aquatic organisms and is of great importance for aquaculture. Its value is inversely proportional to temperature values. The dissolved oxygen values in the groups in the present study did not fall below the critical level. However, the continuously fed control group had lower dissolved oxygen values than the starvation group.

The pH values in the study ranged from 7.12 to 7.63, with an average of 7.33±0.02 in the control group, 7.44±0.03 in Group D1 group, and 7.43±0.03 in Group D2. The difference in pH values between Groups D1 and D2 was not significant ($p>0.05$), whereas the differences between the control group and both other groups were significant ($p<0.05$). The oxidation-reduction potential (ORP) values during the study ranged from 204.9 to 270.4, with an average of 231.28±4.13 in the control group, 234.44±4.18 in Group D1, and 231.88±4.62 in the D2 ($p>0.05$).

Feed costs constitute a significant portion of the total costs in fish production (Baki & Yucel, 2017; Das et al., 2018; Uddin et al., 2022). Therefore, in aquaculture, it is essential to evaluate the growth characteristics of the feed and the amount of feed given and to calculate the feed costs in production. In the present study, the total feed cost over 45 days was $3.17 for the control group, $1.98 for Group D1, and $0.91 for Group D2. Examining the feed cost per unit fish weight (kg), the value for the control group was $1, $0.70 for Group D1, and $0.47 for Group D2 (Figure 2).

In Group D2, less feed was used due to the hunger application, resulting in lower feed costs. However, when evaluated in conjunction with average weight gain, the unit feed cost was 3.4 times higher compared to Group D1 and 2.5 times higher compared to the control group.

Conclusion

Developing feeding strategies that can reduce production costs without compromising the growth performance of fish is crucial for the aquaculture industry. Also, ensuring the sustainability of these activities is equally important. The present study examined the effects of different fasting periods on the growth performance, feed cost, and water quality of common carp (*Cyprinus carpio*). Accordingly, temperature, dissolved oxygen, saturation percentage, and pH values were examined. Among these parameters, temperature is particularly vital as it can affect vital functions in aquatic environments and influence parameters like dissolved oxygen. Therefore, it requires regular monitoring. No significant changes were observed in temperature, dissolved oxygen, saturation percentage, and pH values throughout the study.

Examining the effect of fasting periods on growth parameters, the groups subjected to fasting had lower final weight, specific growth ratio, and daily growth coefficient values compared to the control group. Fasting periods have an effect on growth.

Starvation periods have been known to affect the growth performance of fish negatively. Also, a low feed conversion ratio (FCR) is targeted. In the present study, it was observed that Group D1 had the best FCR value, whereas longer periods of fasting, as indicated by D2, would have a negative effect on feed utilization.

Intermittent fasting and refeeding can be implemented in aquaculture practices, reducing labor and feed costs while minimizing feed waste. However, it is worth noting that improved protein retention rather than improved protein digestibility was attributed to compensatory growth in gibel carp (*Carassius auratus*), as Qian et al. (2000) reported.

Yengkokpam et al. (2013) stated that a 2-3 day fasting period per week with Labeo rohita fingerlings could induce some level of stress. Reduced feeding can lead to the depletion of organ antioxidant stores and increased oxygen free radicals in organs.

In conclusion, the practice of feed restriction in fish feeding activities does not necessarily compensate for the effects of prolonged fasting periods during subsequent feeding activities. This leads to a prolonged period of time for fish to reach market weight and affects the feed conversion ratio and feed costs.

Declarations

Ethical Approval Certificate

The experimental procedures of this study were approved by the Local Animal Care and Ethics Committee of Sinop University, 30.03.2023 (Approval date and number: 2023/03).

Author Contribution Statement

Dr. Birol Baki: Data collection, investigation, formal analysis, and writing the original draft

Dr. Oylum Gökkurt Baki: Data collection, investigation, methodology, review and editing

Dr. Gülşen Uzun Gören: Data collection and investigation

Conflict of Interest

The authors declare no conflict of interest.

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