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Frequent Feeding Improves Growth and Body Composition of Juvenile Common Carp *(Cyprinus carpio)* reared in Recirculating Aquaculture System

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Abstract

Victor David Nico Gultom, Dicky Harwanto, Sung Yong Oh, Jae Yoon Jo. 2021. Frequent Feeding Improves Growth and Body Composition of Juvenile Common Carp (Cyprinus carpio) reared in Recirculating Aquaculture System. Aquacultura Indonesiana, 22 (1): 18-23. Common carp is a major aquaculture species. Frequent feeding in aquaculture species resulted in improved growth parameters and feed conversion rate. Overfeeding cause water quality deterioration, increase labor cost, increase feed cost, and reduce profit. We examine the effect of feeding frequency on growth, feed conversion rate, and body composition of juvenile common carp. Feeding frequencies of one, three, five, six, seven, and eight meals daily were given to juvenile common carp for 60 days. Fish grew from an initial body weight of 2.4 g up to 15.2 g (one meal daily), 37.5 g (three meals daily), 50.4 g (five meals daily), 53.6 g (six meals daily), 55.4 g (seven meals daily), and 51.1 g (eight meals daily). Significantly higher final weight was exhibited by fish in groups fed six meals and seven meals daily compared to groups fed three meals and one meal daily. Lipid content of the group fed one meal daily was the lowest. No significant difference in final weight, specific growth rate, feed intake and, feed conversion rate between group fed six and seven meals daily. Feeding six meals daily is the optimum feeding frequency for juvenile common carp.

Keywords: Feeding frequency; Growth; Body composition; Common carp; *Cyprinus carpio*.

Introduction

World aquaculture production has been increasing rapidly. Production of aquatic animals grew at an average annual rate of 4.5% between 2011 to 2018. Aquaculture is dominated by finfish production with inland aquaculture contributed to 86.5% of total finfish production. Common carp recorded a 7.7% share of total finfish production and is among major aquaculture species (FAO, 2020).

In natural environment, common carp consumes mainly organic matter (43,5%) and plant (31,2%). (Naik *et al*., 2015). Common carp has no stomach and feed residence time, feed digestion, nutrient absorption process are influenced by feeding regime (Nwanna *et al*., 2012). In aquaculture, frequent feeding improves weight gain, feed efficiency (Nwanna *et al*., 2012), daily growth rate and specific growth rate of common carp (Hama Amin *et al.*, 2018), grass carp (Nekoubin and Sudagar, 2012), gibel carp (Zhao *et al*., 2016), tilapia (Alemayehu and Getahun, 2017) and river puffer (Yoo and Lee, 2016). Furthermore, frequent feeding improves body composition, increases body lipid content, and reduces moisture content in juvenile golden pompano (Hu *et al*., 2013) and juvenile flounder (Kucuk *et al*., 2014). Age should be considered when planning feeding regimen. Fish at the early stage of development must eat continuously and consume a small quantity of nutrient frequently (Esmail *et al*., 2015).

Feeding constitutes a major cost in aquaculture enterprises. Frequent feeding resulted in an increase of feed cost and labor cost. The amount of feed given to fish at a single feeding time must be consumed within 5 minutes. Uneaten feed becomes a burden to recirculation aquaculture system and impede filter performance thus contribute to water quality deterioration (Esmail *et al*., 2015).

Most of the research about feeding frequency in common carp was done in small scale with juvenile common carp in the late stage of grow-out phase (Nwanna *et al*., 2012); using glass aquaria or plastic tanks and reared in static water (Hama Amin *et al*., 2018) or flow-through system (Stankovic *et al*., 2010). There is currently no information available about the effect of feeding frequency on growth and body composition of juvenile common carp at the early stage of grow-out phase in commercial scale recirculating aquaculture system. The objective of this study is to determine the effect of feeding frequency on growth and body composition of juvenile common carp in recirculating aquaculture system.

Materials and method

Experimental system

The experiment was conducted in a tank inside a commercial-size recirculating aquaculture system (RAS). The RAS was located in outdoor facility at Pukyong National University. The experiment was conducted in 18 floating cages (0.5 x 0.5 x 0.5 m) contained in a 7.9 m (L) x 2.2 m (W) x 1.4 m (D) concrete tank. Water depth in the tank was maintained at 1.3 m, and in the cages at 0.3 m. Water flow rate in the tank was 420 L/min. Experimental fish were randomly assigned to the cages. Cages were covered with a net (0.5 x 0.5 m) to prevent fish jumping out.

Experimental fish

Twenty fish were randomly assigned to each of 18 cages. Fish were given a 2 week acclimation period during which they were fed twice a day. During acclimation, fish were fed formulated feed twice daily. The composition of the feed was: protein 36.8%, lipid 5.7%, ash 7.8%, moisture 8.3%. After acclimation, fish were fasted for one day and were stocked in the cages after recording the body weight. The average initial weight was 2.5±0.01 g. The experimental period was 60 days.

Experimental design

Fish were fed from 1 to 8 meals daily according to the treatment. Treatments consist of feeding one (group 1), three (group 3), five (group 5), six (group 6), seven (group 7) and eight (group 8) meals daily. Feed was given *ad libitum* and introduced gradually until feeding began to slow.

Fish were weighed every 20 days to evaluate growth performance. All fish were deprived of feed for 1 day prior to weighing. Fish were captured, anesthetized with 60 ppm MS222 (Tricaine Methanesulfonate), and collectively weighed. The growth performance parameters being evaluated were specific growth rate (SGR), feed conversion ratio (FCR) and feed intake (FI), according to Wu *et al*. (2015).

Specific growth rate (SGR, % day^{-1}) was calculated by the following equation:

$$\text{SGR} = 100 \times [ln(W_t/N_t) - ln(W_o/N_o)]/t$$

Feed conversion ratio (FCR) was calculated by the following equation:

$$\text{FCR} = I/W_t - W_o$$

Feed intake (FI, % day^{-1}) was calculated by the following equation:

$$\text{FI} = 100 \times I/[(W_o + W_t)/2 \times t]$$

I = total amount of feed given (g)
W_o = initial body weight (g)
W_t = final body weight (g)
T = duration between two measurements (day)

Body composition analysis

Proximate analysis of fish was done at the beginning and end of each experiment. Proximate analysis of experimental fish were performed by the standard methods of AOAC (2016). Samples of fish were dried at 105°C to determine moisture content. Crude ash was determined by incineration at 550°C; crude lipid was determined by Soxhlet extraction using a Soxtec system 1046 (Foss, Hoganas, Sweden). Crude protein was measured following the Kjeldahl method (N×6.25) after acid digestion.

Statistical analysis.

Statistical analysis was employed using one-way ANOVA performed by SPSS 16 for Windows (SPSS Statistical Software, Chicago, IL, USA). Each cage was considered an experimental unit. Significant differences in means were evaluated by Duncan's multiple-range test. All statistical analysis was assessed at a significance level of $P \leq 0.05$.

Results

No mortality was observed in any group throughout the experiment. Fish weight at the beginning of the experiment was not significantly different among feeding frequency groups (2.4~2.5 g). After 60 days, significant differences ($P \leq 0.05$) were found in parameters such as final weight, feed intake, feed conversion ratio, and specific growth rate (Table 1).

Table 1. Effect of 8 different feeding frequencies on growth performance of juvenile common carp[1].

Groups	Initial weight (g)	Final weight (g)	Feed intake (g)	FCR	SGR (% day^{-1})
1	2.4±0.03	15.2±0.29^{a}	12.4±0.27^{a}	1.0±0.04^{a}	3.1±0.05^{a}
3	2.4±0.04	37.5±0.43^{b}	40.4±0.26^{b}	1.2±0.01^{bc}	4.6±0.02^{b}
5	2.5±0.02	50.4±2.07^{c}	53.3±2.26^{c}	1.1±0.01^{b}	5.0±0.06^{c}
6	2.4±0.04	53.6±0.63^{cd}	59.4±0.34^{d}	1.2±0.01^{bc}	5.1±0.04^{c}
7	2.4±0.06	55.4±0.39^{d}	60.2±0.18^{d}	1.1±0.01^{bc}	5.2±0.02^{c}
8	2.5±0.06	51.1±1.66^{c}	57.5±2.08^{cd}	1.2±0.00^{c}	5.1±0.10^{c}

[1] Values (mean±SE of triplicates) in the same column not sharing a common superscript are significantly different ($P \leq 0.05$).

Fish grew from the initial body weight of 2.5±0.01 g to 15.2 g (group 1), 37.5 g (group 3), 50.4 g (group 5), 53.6 g (group 6), 55.4 g (group 7), and 51.1 g (group 8) after 60 days. The highest average final weight was achieved in the group 7 (55.4 g), but that was not significantly different from the average final weight in group 6 (53.6 g). The group with the least frequent feeding (group 1) had the lowest final weight (15.2 g). There were three-fold differences between the group with the lowest final weight (group 1) and the group with the highest final weight (group 6 and group 7). Fish in group 6 and group 7 grew more than 20-fold while fish in group 1 grew only six-fold from initial weight.

The highest feed intake was achieved in group 6 (59.4 g) and group 7 (60.2 g), but that was not significantly different from the average feed intake in group 8 (57.5 g). Group 1 consumed the least feed (12.4 g), followed by group 3 (40.4 g) during this period. There were five-fold differences between fish in the groups with the lowest feed intake (group 1) and fish in the group with the highest feed intake (group 6 and group 7).

The best FCR was achieved in group 1 while the worst FCR was achieved in group 8. There was no significant difference in FCR between group 3~7. Group 5~8 have significantly higher SGR than group 1 and 3. Group 1 has the lowest SGR compared to all groups.

Daily feed intake decreased gradually in all groups from Period 1~3 (Table 2). The decrement of daily feed intake was larger from Period 2~3 against Period 1~2. The daily feed intake of group 8 (7.25%) was the highest compared to each group in Period 1. In period 2, group 6 has the highest daily feed intake (4.93%). Surprisingly, group 8 has the lowest daily feed intake compared to each group in the last period.

Table 2. Daily Feed intake (% body weight day^{-1}) for juvenile common carp under 1~8 feeding frequency

Groups	Period		
	Period 1 (Day 0-20)	Period 2 (Day 20-40)	Period 3 Day (40-60)
1	2.84	3.01	2.35
3	5.84	4.49	2.85
5	6.67	4.61	2.45
6	7.12	4.93	2.58
7	6.87	4.81	2.40
8	7.25	4.87	2.33

Group 1, the least fed group, had the highest moisture content, while the fish in group 5~8 showed the lowest moisture content (Table 3). Group 6, 7 and 8 had significantly higher crude lipid content in comparison with group 1, which had the lowest crude lipid content. There was no significant difference of body composition between groups fed six, seven and eight meals daily. Group 1, the least feed group, had the highest ash content. The ash content of fish in group 3 was significantly lower than that of fish in group 1. More frequently fed groups (5~8) had significantly lower crude ash content.

Table 3. Effect of 1~8 feeding frequencies on body proximate composition of juvenile common carp[1] (%, wet weight basis)

Groups	Moisture (%)	Crude protein (%)	Crude lipid (%)	Crude ash (%)
1	75.5±0.38[c]	15.2±0.26[b]	6.4±0.12[a]	2.6±0.07[c]
3	72.9±0.38[b]	14.3±0.27[ab]	10.8±0.12[b]	2.0±0.05[b]
5	70.9±0.78[a]	14.2±0.42[a]	12.9±0.66[c]	1.8±0.05[a]
6	70.2±0.65[a]	14.0±0.11[a]	13.9±0.55[cd]	1.9±0.03[ab]
7	70.4±0.29[a]	14.2±0.14[a]	13.9±0.18[cd]	1.9±0.06[ab]
8	69.5±0.69[a]	14.1±0.35[a]	14.2±0.23[d]	1.9±0.03[ab]
Initial	83.9±0.02	11.4±0.05	1.07±0.05	2.72±0.02

[1] Values (mean±SE of triplicates) in the same column not sharing a common superscript are significantly different ($P \leq 0.05$)

Discussion

Feeding frequency affected the total amount of food consumed, which thereafter affected the growth rate and weight gain of common carp (Hama Amin *et al*., 2018) and gibel carp (Zhao *et al*., 2016). An increase in feeding frequency improved growth of fish reared for commercial purpose such as river puffer (Yoo and Lee, 2016), golden pompano (Wu *et al*., 2015) and grass carp (Nekoubin and Sudagar, 2012). Contrary to our findings, fish reared for ornamental purposes, such as goldfish (*Carassius auratus*), have better weight gain when fed less frequently. The result might be caused by rearing for ornamental purpose rather than for commercial purpose and by lack of improvement in genetic potential (Hafeez-ur-Rehman *et al*., 2015).

Daily feed intake decrease gradually throughout the experiment in each groups. Other than feeding frequency, feeding regimen is influenced by age (Lawrence *et al*., 2012), season and food availability (Naik *et al*., 2015; Stankovic *et al*., 2010), temperature (Song-bo *et al*., 2012) and dietary protein level (Zhao *et al*., 2016).

The best feed conversion ratio was achieved in group 1. FCR in group 3~8 was higher than group 1, but there was no significant difference between them (Table 1). FCR increased with increasing feeding frequency. Similar result was achieved in Hama-amin *et al*. (2017) and (Hafeez-ur-Rehman *et al*., 2015). Higher FCR indicate that fish fed more frequently utilize feed less efficient, retain less nitrogen and excrete more nitrogen (Kucuk *et al*., 2014).

The highest SGR (5.0~5.2%) was achieved in group 5~8. SGR of the fish in group 3 was 4.6%, and in group 1 was 3.1% per day (Table 1). The growth rate of fish increased with increasing feeding frequency. This result was similar to other reports (Nekoubin and Sudagar 2012; Wu *et al*., 2015; Rahim *et al*., 2017; Hama Amin *et al*., 2018). However, there was no further improvement of SGR if optimum frequency was reached. At optimum frequency, growth was enhanced but waste output was stable (Wu *et al*., 2015). This result was in accordance to Jegepede and Olorunfemi (2013). Feed intake was an important factor that limited growth. Optimum feed intake will ultimately result in maximum growth. Optimum frequency was influenced by size, age, temperature and food quality (Lawrence *et al*., 2012; Song-bo *et al*., 2012; Zhao *et al*., 2016). Frequent feeding increased food intake and growth. However, at a certain limit, more frequent feeding did not induce more feed intake (Kucuk *et al*., 2014; Wu *et al*., 2015; Yoo and Lee, 2016; Thongprajukaew *et al*., 2017). The lowest frequency at which there is no further increase of feed intake may be called the “optimum” feeding frequency. There was no further increase of feed intake in groups fed seven and eight meals daily. More frequent feeding resulted in partial consumption (Abbas *et al*., 2015), less effective digestion (Biswas *et al*., 2010), feed wastage and water deterioration (Jobling, 2012). These results confirm that 6 meals daily is the optimum feeding frequency for juvenile common carp.

There was a trend that as feeding frequency increased, moisture content decreased (Table 3). This result is similar to experiments conducted by Kucuk *et al*. (2014) and Wu *et al*. (2015). There was an indication that as feeding frequency increased, crude lipid content increased. This result is similar to the experiment conducted by Hossain *et al*., (2018), who found an increase in crude lipid content along with an increase in feeding frequency in Thai pangas. Fish fed more frequently tend to have higher lipid deposits than fish fed less frequently (Abbas *et al*., 2015; Wu *et al*. 2015). Lipid deposition in fish tissue caused by excessive feeding cannot be utilized as energy reserve if a certain point is reached but excreted (Kucuk *et al*., 2014). Jobling (2012) suggested that overfeeding caused indigestion and gut problem.

There was some indication that ash content increased when fish were fed less frequently (Wu *et al*., 2015). Therefore, it is clear that fish provided with adequate food exhibited lower ash content in the whole body (Kucuk *et al*., 2014; Wu *et al*., 2015; Zhao *et al*., 2016).

Conclusion

Fish grew from the initial body weight of 2.4 g to 15.2 g (group 1), 37.5 g (group 3), 50.4 g (group 5), 53.6 g (group 6), 55.4 g (group 7), and 51.1 g (group 8) after 60 days, and significantly higher body weight were recorded for group 6 and group 7 compared to the group 3 and group 1. Feeding more than seven meals daily resulted in lower final weight. The moisture and crude ash content of group 1 was significantly higher than the other groups. The lipid content of the group 1 was lowest followed by group 3 and the remaining groups. There was no significant difference of growth parameters and body composition between groups fed six and seven meals daily. According to the result of this experiment, a feeding frequency of 6 meals daily is recommended for juvenile common carp to achieve maximum growth.

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