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Determination of optimum feeding rate for growth of Caspian carp, *Cyprinus carpio* (Linnaeus, 1758) fingerlings

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Abstract. One of the important issues in aquaculture, need to achieve a balance between growth rate and optimal use of fish meal is provided. This study was conducted for 6 weeks in the Sijual Bony Fishes Reproduce and Cultivate Center (Gorgan, Golestan, Iran). Experiments were done 4 treatments and 3 replicates as follows: treatment A = 2.5 % body weight per day, treatment B = 5 % body weight per day, treatment C = 7.5 % body weight per day and treatment D = 10 % body weight per day. Aim to this purpose Caspian carp fingerlings with an average weight of 1.5 ± 0.145 g and average length of 2.97 ± 0.154 cm were distributed in 12 fiberglass tanks (30 number fish per tank) and were cultured for 6 weeks in the same conditions and fed with SFC diet (content: 8.7 % moisture, 11.2 % ash, 32 % protein and 10.5 % fat) four times a day. Results showed that hadn't significant effects in Specific Growth Rate (SGR), Body Weight Index (BWI %), Growth Rate (GR) and Condition Factor (CF) ($P<0.05$) but hadn't significant effects in Feed Conversion Ratio (FCR) and survival ($P>0.05$). The results show that there are significant differences with regard to the amount of body weight and body length of fingerlings in different treatments ($P<0.05$), so that the maximum body weight and body length of carp fingerlings is 7.5 % body weight per day.
Key Words: feeding rate, growth, survival, *Cyprinus carpio*.

Introduction. Fish is a primary source of protein for more than one billion people around the world (Rameshguru et al 2011). 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 (Mohammad Nejad Shamoushaki 2012). One of the most significant attainments in aquaculture is fish feeding due to the high cost of feeding (Aydin et al 2011). Feeding rate, water temperature, and fish size have a significant effect on the fish growth; in particular, the optimum feeding rate has to be found in order to achieve a successful aquaculture operation (Yuan et al 2010). Optimum feeding rate differ according to fish species, size, and rearing system (Cho et al 2003). In addition, feeding rate affects the usage of the nutrients in the feed (Mihelakakis et al 2002). Knowledge of the optimum feeding rate is important to improve best feed efficiency resulting better growth and production (Cho et al 2003; Eroldogan et al 2004). Moreover, knowing of the optimum feeding rate helps to prevent water quality degradation which overfeeding causes (Ng et al 2000; Mihelakakis et al 2002; Webster et al 2002; Eroldogan et al 2004). Feeding rate is especially important for larval fish since they are vulnerable to over- and under-feeding. Therefore, over- or under-feeding causes an increase in disease and mortality (Deng et al 2003). Feeding costs contributes up to 60% of the variable costs of culture systems. Therefore, it is essential to provide a proper and applicable feeding management program. In fact, an inadequate food supply directly affects production costs and water quality (Silva et al 2007; Mihelakakis et al 2002; Ng et al 2000). Overfeeding mostly causes feed spillage,

decreasing in feed efficiency, and polluting the environment. Similarly, underfeeding results in decreased feed efficiency as well as degraded growth (Dediu et al 2011). Therefore, it is essential, in terms of both economy and biology, to determine the optimum feeding rate for growth (Aydin et al 2011). It should be noted that optimal feeding rate is essential not only because of promoting best growth and minimizing feed conversion rate (FCR), but also for economic and environmental aspects, preventing water quality degradation (Yuan et al 2010).

Caspian carp, *Cyprinus carpio* belongs to *Cyprinidae* is one of the most economically important and valuable telostei in the Caspian Sea. Currently, there is no published information on the effects of feeding rate on growth of Caspian carp fingerlings. It is necessary to have a better understanding of the optimum feeding rate of this species. The objective of the this study was to determine optimum and maintenance feeding rate and the effects of the feeding rate on growth performances and survival for Caspian carp, *C. carpio* fingerlings.

Materials and Methods. This study has been carried out in Sijual Bony Fishes Reproduce and Cultivate Center (Gorgan, Golestan, Iran) in 2011 summer. Initial body weight and length average were 1.5 ±0.145 g and 2.97 ±0.154 cm. Given the importance of the physical and chemical performances and their impact on water supply and ultimately the fish growth, these performances were so controlled through the experiment that the amount of dissolved oxygen was fixed on 5.5 - 6 ppm, the temperature 26±2^{0}C and pH 7.5 to 8. Fish were fed SFC (starting food carp) commercial food during (6 weeks) of the study. The feed was administered only during daylight hours. Pertinent characteristics of this feed were: 32% crude protein; 10.5% crude fat; 11.2% ash and 8.7% moisture. This study was operated as long as 6 weeks and in 12 tanks with 30 numbers fish in each tank, with 4 treatments and 3 replicate as: treatment A = 2.5 % body weight per day — BW d^{-1}, treatment B = 5 % body weight per day — BW d^{-1}, treatment C = 7.5 % body weight per day — BW d^{-1} and treatment D = 10 % body weight per day — BW d^{-1}. Daily treatments were fed four times a day (equal meals at 08:00, 11:00, 14:00 and 17:00 h) by hand according to feeding rates, making sure that no feed was left uneaten. Fish were sampled every 2 weeks to evaluate growth in weight and length, for this purpose 10 numbers of fish in each tank were captured, weighed and measured. After each sampling period the amount of feed given was adjusted according to mean weight in each aquarium. From results of the last sample fish performances were evaluated in terms of Feed Conversion Ratio (FCR), Specific Growth Rate (SGR, % d^{-1}), Body Weight Index (BWI %), Growth Rate (GR, g d^{-1}), Condition Factor (CF, g/Cm) and Survival (%). These performance indices were calculated as follows (Hung et al 1989; Ronyai et al 1990; Biswas et al 2010):

- 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

SPSS version 13 and a software program for drawing graphs of Excel 2003 have been used to analys all data. 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 (Mohammad Nejad Shamoushaki 2012).

Results and Discussion. Final body weight and body length of *C. carpio* in different treatments are shown in Table 1. Obtained results at the end of this study showed that feeding rates had significant effects on body weight and body length of *C. carpio* ($P<0.05$). Also, results show that maximum body weight and body length were in 7.5% BW d^{-1}.

Table 1

The average of body weight and body length of *C. carpio* in different treatments

	Treatments	Initial weight (g)	Initial length (cm)	Final weight (g)	Final length (cm)
A	2.5 % BW d^{-1}	1.5 ± 0.145	2.97 ± 0.154	2.046 ±0.076 [a]	3.327 ± 0.097[a]
B	5 % BW d^{-1}	1.5 ± 0.145	2.97 ± 0.154	2.875 ± 0.212[b]	3.34 ± 0.566[a]
C	7.5 % BW d^{-1}	1.5 ± 0.145	2.97 ± 0.154	3.337 ± 0.085[c]	4.357 ± 0.365[b]
D	10 % BW d^{-1}	1.5 ± 0.145	2.97 ± 0.154	3.14 ± 0.07[d]	4.297 ± 0.091[c]

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

Comparison average of different feeding rate effects on *C. carpio* growth performances during culture period are shown in Table 2. Results showed that hadn't significant effects in BWI, SGR, GR and CF ($P<0.05$) but hadn't significant effects in FCR and survival ($P>0.05$).

Table 2

Effects of different feeding rate on growth performances in *C. carpio*

Indicators	Treatment A	Treatment B	Treatment C	Treatment D
FCR	4.65 ± 2.438 [a]	5.106 ± 1.768 [a]	7.737 ± .205 [a]	7.465 ± 0.375 [a]
SGR (% d^{-1})	7.24 ± 3.45 [a]	13.83 ± 2.85 [b]	14.64 ± 0.19 [c]	16.37 ± 0.61 [d]
BWI (%)	7.78 ± 3.18 [a]	14.96 ± 7.43 [b]	13.17 ± 0.31 [b]	18.79 ± 2.08 [c]
GR (g d^{-1})	0.011 ± 0.004 [a]	0.026 ± 0.001 [b]	0.0277 ± 0.0007 [b]	0.035 ± 0.003 [c]
CF (g/cm)	1.36 ± 0.12 [a]	1.94 ± 0.44 [b]	1.32 ± 0.24 [a]	1.26 ± 0.046 [c]
Survival (%)	100 [a]	100 [a]	100 [a]	100 [a]

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

Fish requires a daily ration for maximum growth (Chua & Teng 1982; Kaiser et al 2012). Fish feeding is one of the most important performances in aquaculture because of high feed costs. Overfeeding causes degradation of water quality; consequently, the fish growth reduces and cost increases. On the other hand, underfeeding is undesirable. Therefore, it is critical to find the optimum feeding rate from both economical and biological point of view (Aydin et al 2011). In this work, maximum growth of Caspian carp fed at 7.5% BW d^{-1}. The optimal feeding strategies augment growth performance, survival, and food conversion ratios. Additionally, it contributes to minimize food wastage, reduce size variation, and accordingly, increase production efficiency (Goddard 1996; Kubitza & Lovshin 1999). In his study, significant differences in BWI, SGR, GR and CF ($P<0.05$) were observed among treatments (see Table 2). The SGR and GR increased with increasing feeding rate to 10% BW d^{-1} ($P<0.05$) but best CF were observed in 7.5% BW d^{-1} ($P<0.05$). The highest growth in the present study typically occurred in the 7.5% BW d^{-1} group. A similar result was also found in sea bass (Russell et al 1996) and *Rachycentron canadum* (Sun et al 2006). The best growth found at the 7.5% and 7% BW d^{-1}.

The quantity and quality of the ration have a significant effect on growth rate, efeciency of feed utilization and chemical composition (Juell & Lekang 2001; Abdelghany & Ahmad 2002; Rowland et al 2005; Bureau et al 2006; Yuan et al 2010). Therefore, it is necessary to determine the optimal feeding rate for different species. Results of other studies are different in various species. Studies with several fish species have revealed that with increasing feeding rate, the growth increases at higher ration levels and decreases at lower ration levels (De Silva & Anderson 1995; Hung & Lutes 1987; Hung 1991; Xiao-Jun & Ruyung 1992; Adebayo et al 2000; Ng et al 2000; Mihelakakis et al 2002; Rosenthal 2000; Tsevis et al 1992). The discrepancies between the results of this study and the findings of others could be explained by size and/or age differences of fish

and experimental conditions such as feeding regimes (Brett 1979; Webster et al 2002; Fiogbe & Kestemont 2003). For instance, Hung et al (1993) observed that optimum feeding rate for striped bass fingerlings (initial body weight 38 g) was 1.0–1.5% BW d^{-1}. In similar size, optimum feeding rate was suggested to be 2.0 BW d^{-1} for the same species (>27 g) kept by Piper et al (1982). It is well known that feeding rate and feed consumption in relation to body weight decreases as fish grow (NRC 1993; Ng et al 2000; Webster et al 2002). A feeding rate of 4.0% BW d^{-1} for gilthead sea bream at 3g initial average weight but 6.0% BW d^{-1} at 1g initial average weight was suggested to be optimal (Kalogeropoulos et al 1992; Alexis et al 1999; Eroldogan et al 2004). Also, another study, Silva et al (2007), showed that increasing feeding rate on *Colossoma macropomum* with 10% BW d^{-1} results in more growth. Also, studies on other fish such as *Mystus nemurus* (Ng et al 2000), *Dicentrarchus labrax* (Eroldogan et al 2004), *Ictalurus punctatus* (Robinson & Li 1999) and *Piaractus mesopotamicus* (Borghetti & Canzi 1993) showed that feeding rate with 10% BW d^{-1} fish growth was better.

Conclusions. The result of this research on the effects of the fish feeding rate has been different from other studies. However, research results show that the feeding rates and growth rate are different in different species. Based on growth performance, the highest growth was obtained with fish fed 7.5% BW day^{-1}, in the present study. It appears that, feeding 7.5% BW day^{-1} to satiation may be accepted as sufficient for on growing of Caspian carp under the conditions of this experiment.

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