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The effects of feeding rates on growth performance, feed conversion efficiency and body composition of juvenile snow trout, *Schizothorax zarudnyi*

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Abstract

This study was performed to investigate the effects of feeding rates on growth performance, feed conversion and body composition of juvenile snow trout (*Schizothorax zarudnyi*). For this purpose, fish with an initial body weight of 2.17±0.1 g were fed a commercial diet (40% protein, 3.8 Kcal g^{-1} diet) at five ration sizes of 2%, 4%, 6%, 8% and 10% of their body weight per day, for 60 days. The feeding trial was conducted in triplicate. Maximum weight gain, best feed conversion ratio (FCR), best specific growth rate (SGR %), highest energy retention (ERE %) and protein efficiency ratio (PER %) were evident for rations of 4–6% body weight. Second-degree polynomial regression analysis for PER, FCR and ERE indicated the break-points occurred at 4.9, 5.1 and 5.2% BW day^{-1}, respectively. Maximum body protein content was obtained for 4% and 6% rations. Body moisture, fat and ash content remained unchanged. Based on the above results, it may be concluded that the 4.9-5.2% body weight per day ration is optimal for the growth, conversion efficiencies and body composition of juvenile *S. zarudnyi* and it entails favorable economic benefits.

Keywords: Growth, Body composition, Ration, *Schizothorax zarudnyi*

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Introduction

A crucial factor in commercial aquaculture is feeding, especially when it affects growth, health of fish and production costs (Cho *et al*., 2003; Khan and Abidi, 2010; Tian *et al*., 2015). Feed costs make up a large fraction of the total fish production costs (40-50 % of production costs) (Anderson *et al*., 1997). Moreover, in practical fish farming, growth optimization is important to ensure profitability (Wang *et al*., 2009). The growth of fish at all stages in its life history is largely regulated by a number of factors, such as food type, food intake, feeding rate, feeding frequency and its ability to absorb nutrients (Gelineau *et al*., 1998; Akbulut *et al*., 2013). Among these, feeding rate is an important factor for the survival and growth of fish at the early life stages (Goddard, 1996). The influence of feeding rate on fish growth performance has received much attention (Goddard, 1996; Oberg *et al*., 2014; Luo *et al*., 2015; Li *et al*., 2016). Most studies of feeding rate have confirmed that there should be optimal feeding rates in fish culture. Determination of optimal values for this factor helps to enhance growth (Saether and Jobling, 1999) or feed utilization (Fiogbé and Kestemont, 2003); to reduce feeding costs (Silva *et al*., 2007; Luo *et al*., 2015) or to improve water quality (Allan *et al*., 1995; Zakes *et al*., 2006) and reduce fish size variations (Johnston *et al*., 2003). Consequently, for the commercial success of any aquaculture venture, it is important to have adequate knowledge of the optimal ration level.

Several studies have been conducted to evaluate the effect of feeding rate on the growth, survival, feed intake, body composition, among other parameters, in various culturable finfish species, such as common carp (Desai and Singh, 2009), mangrove red snapper (Abbas and Siddiqui, 2009), pigfish (Oberg *et al*., 2014), blunt snout bream (Tian *et al*., 2015), hybrid sturgeon (Luo *et al*., 2015). It has been shown in these studies that optimum rate might vary based on fish species, size, age, feed quality and culture system. Thus, to achieve optimum production, it is important that feeding rate be standardized for the target species in aquaculture.

It is important to choose new fish species with good potential for aquaculture to develop this growing industry. *Schizothorax zarudnyi*, also known as snow trout, is a native fish of southeast Iran and Afghanistan that belongs to the cyprinid family. In general, cyprinid species have high commercial value and their meat is appreciated by human consumers. Also, snow trout has high market value and is a promising candidate species for Iranian aquaculture diversification (Aghili, 2013; Rahdari *et al*., 2014). However, there is no information on the feeding application rates for juvenile snow trout. Therefore, the aim of this study was to assess the effects of feeding rate on the growth performance, feed conversion and body composition of juvenile snow trout, and determine the best feeding rate for this species

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under commercial production conditions. Fish nutritionists and farmers will benefit from the results of this study.

Materials and methods

This study was performed at Hamoun International Wetlands Research Institute of Zabol University. Healthy juvenile of snow trout were obtained from a local commercial fish farm in Zehak city, Iran. Fish were acclimated for 14 days before the start of the experiment. During the acclimation and experimental period, the water quality parameters were maintained as follows: temperature (22.6±1.5 °C), pH (7.6±0.3), dissolved oxygen (6.9±0.5 mg L^{-1}) and ammonia concentration was kept around zero mg L^{-1}. After the acclimation period, fish with an average initial body weight of 2.17±0.3 g (mean±SD) were distributed randomly among 15, 80 L glass tanks at the rate of 20 fish per tank. There were no significant differences in the initial weight between groups. The study design included five feeding rates (2%, 4%, 6%, 8% and 10%) with three replicates for each treatment. The daily rations were supplied each day in two equal halves, at 08.00 and 17.00 hours. Fish were weighed every 2 weeks to regulate the feeding rates. The feeding trial lasted for 60 days. The fish were offered a commercial diet (Esfahan Mokammel Company, Isfahan, Iran), containing 40% protein, 12% lipid, 9–10% moisture and 10% ash.

Body composition analysis

Before the start of the experiment, 20 stocked fish were killed and analyzed for initial body composition. At the end of the experiment, ten fishes from each replicate were sacrificed for the analysis of proximate composition of whole body. The ash, moisture, crude protein and lipid contents of fish were estimated by AOAC (2000).

Growth parameters

The growth parameters were evaluated as follows: Survival (%) (Survival%=100×(final fish number/ initial fish number), Weight gain rate (WGR=100×(average final body weight−average initial body weight)/average initial body weight), Feed conversion ratio (FCR=total feed intake/total weight gain), Specific growth rate (SGR=100×(ln final mean weight−ln initial mean weight)/days), Energy retention efficiency (ERE=100×(energy gain/total energy in the diet), Protein efficiency ratio (PER=100×(weight gain/protein fed) (Tacon, 1990; De Silva and Anderson, 1995; Khan and Abidi, 2010).

Data analysis

Data were analyzed by one-way (ANOVA) using SPSS, version 16 for Windows, and Duncan's test was used to compare differences between the means at 5% probability. All experimental values are expressed as mean ± SD. The estimation of optimum feeding rate for growth and feed conversion efficiency of snow trout was carried out using second-degree

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polynomial regression analysis ($Y=aX^2+bX+c$) (Zeitoun *et al.*, 1976).

Results

Growth performance and feed conversion efficiencies of juvenile *S. zarudnyi* subjected to different feeding rates are presented in Table 1. All fish survived throughout the trial. Maximum weight gain rate (%) was recorded with a diet of 6% BW day^{-1}. Best FCR, and highest specific growth, Energy retention efficiency (ERE) and Protein efficiency ratio (PER) where obtained for fish fed by 4-6% ration. Feed conversion ratio (FCR) decreased as the ration rose up to 6%. No significant ($p>0.05$) improvement in FCR was seen for fish fed with the 8% ration and increasing the ration further indicated in no improvement or even poor FCR. In order to obtain more exact information on the ration level, second-degree polynomial regression analysis was conducted for the growth parameters. Using the second-order polynomial regression analysis model, the optimal feeding rate for juvenile snow trout based on PER, FCR and RER was estimated to be 4.9, 5.1 and 5.2 % BW day^{-1}, respectively (Figs. 1, 2 and 3).

Table 1: Growth, conversion efficiencies and nutrient retention efficiency of juvenile *Schizothorax zarudnyi* fed at different feeding rates.

Parameters	**Feeding rate (%weight day^{-1})**				
	2	**4**	**6**	**8**	**10**
Initial body weight (g)	2.21±0.07	2.13±0.10	2.14±0.17	2.20±0.06	2.09±0.06
Final body weight (g)	2.75±0.07^{a}	3.73±0.24^{b}	4.36±0.14^{c}	4.09±0.19^{c}	3.48±0.15^{b}
Weight gain (%)	54±3.46^{a}	152±15.39^{b}	222.33±4.50^{d}	188.6±22.23^{c}	139±19.15^{b}
Feed conversion ration	4.82±0.49^{b}	3.48±0.24^{a}	3.47±0.35^{a}	5.67±0.83^{c}	9.13±1.36^{d}
Specific growth rate (%)	0.36±0.02^{a}	0.86±0.05^{b}	1.19±0.08^{c}	1.02±0.10^{bc}	0.84±0.10^{b}
PER (%)	52.49±0.05^{b}	71.27±0.05^{c}	73.79±0.04^{c}	42.63±0.09^{b}	27.87±0.04^{a}
ERE (%)	16.19±0.01^{b}	21.46±0.02^{c}	22.31±0.005^{c}	14.51±0.01^{b}	8.76±0.01^{a}

Mean value±SEM from three replicate analyses; mean values with the same superscript are not significantly different ($p>0.05$)

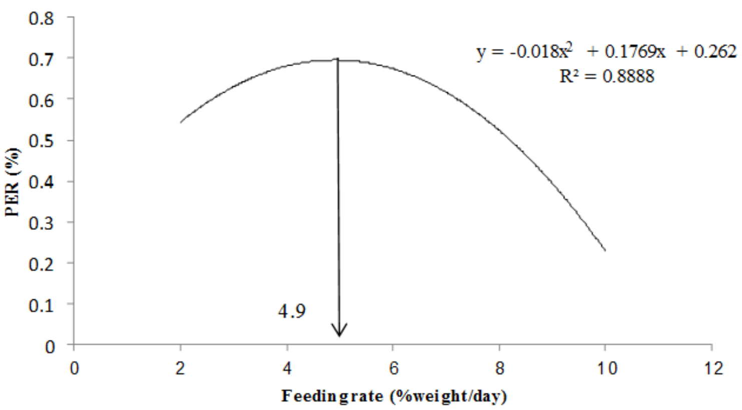

Figure 1: Second-order polynomial fitting of protein efficiency ratio to feeding rate of *Schizothorax zarudnyi*.

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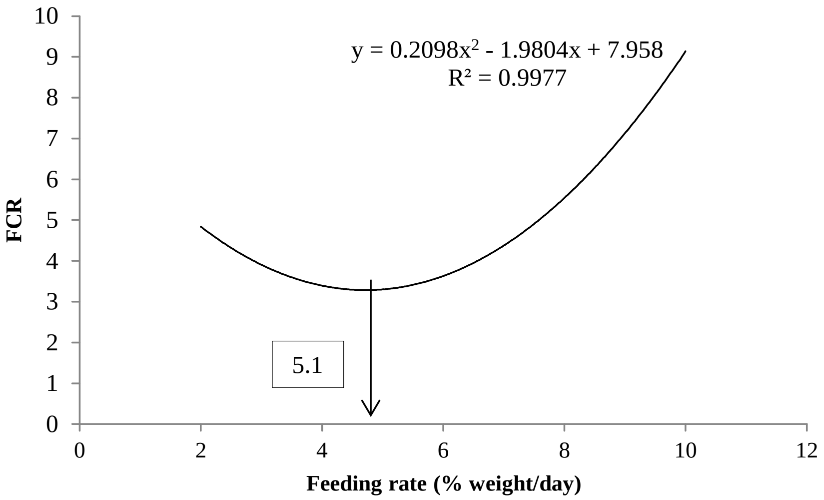

Figure 2: Second-order polynomial fitting of feed conversion efficiency to feeding rate of *Schizothorax zarudnyi*.

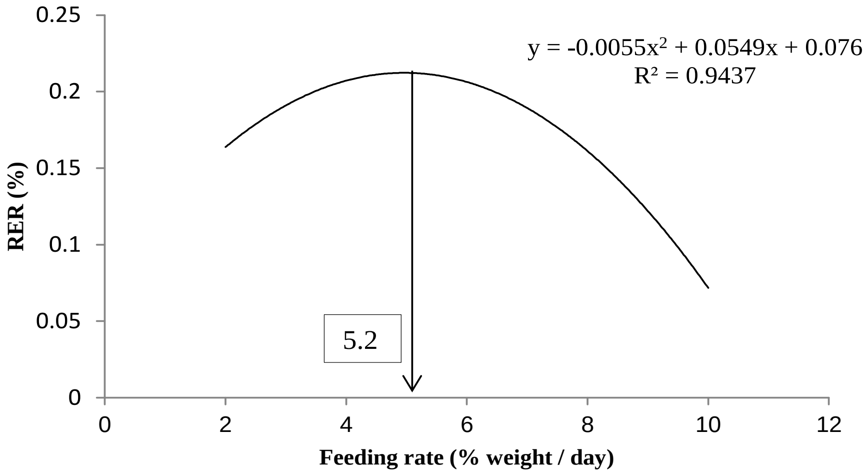

Figure 3: Second-order polynomial fitting of energy retention to feeding rate of *Schizothorax zarudnyi*.

Whole-body composition of juvenile snow trout is shown in Table 2. Whole-body protein content was found to be significantly higher (p<0.05) for 4% and 6% rations compared with fish fed with other rations. Body ash, fat and Moisture did not differ among fish fed with different rations.

Table 2: Whole body composition of juvenile *Schizothorax zarudnyi* fed different feeding rates

Parameters	Feeding rate (%weight/day)				
	2	4	6	8	10
Moisture (%)	76.41±0.52	76.85±0.28	76.12±0.20	77.41±0.63	77.90±0.46
Protein (%)	66.79±1.25[a]	69.58±1.09[bc]	71.24±1.38[c]	68.14±1.2[ab]	68.38±1.03[b]
Fat (%)	9.78±0.33	9.74±0.42	9.49±0.11	9.16±0.82	9.38±0.16
Ash (%)	3.01±0.19	2.86±0.26	2.80±0.19	2.63±0.27	2.79±0.12

Mean values±SEM from three replicate analyses; mean values with the same superscript are not significantly different (p>0.05)

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Discussion

Feeding rate is an important factor affecting growth in fish. Determination of optimal values for this factor is necessary to the success of aquaculture production. In the present study, ration levels had significant effects on the growth, SGR, FCR, ERE and PER of *S. zarudnyi*. Similarly, studies by Ahmed (2007) on *Labeo rohita*, Khan and Abidi (2010) on *Heteropneustes fossilis* and Oberg *et al*. (2014) on pigfish reported that ration levels very often affect the growth performances, survival, feed intake and conversion efficiencies of cultured fish.

Our study revealed that growth in terms of final weight and other weight related indices SGR and WGR in juveniles of snow trout could be improved when they were reared with increasing feeding ration up to a certain level as was observed in *Cirrhinus mrigala* (Khan and Abidi, 2004) and hybrid sturgeon (Luo *et al*., 2015). However, significant growth improvement was recorded with increasing rations up to 6%, and was not significantly different from that achieved by fish fed at 4% BW day^{-1}. This indicates that feeding fish in the range of 4–6% BW day^{-1} results in maximum utilization of food for growth. On subjecting PER, FCR and RER data to second degree polynomial regression analysis, however, break-points occurred for rations of 4.9, 5.1 and 5.2%, respectively. These break-points show that rations in the range 4.9–5.2% BW day^{-1} are optimal for growth of snow trout. This enables producers to grow healthy fish as quickly and/or efficiently as desired and using optimal ration prevents overfeeding, which is costly and reduces water quality. The above range is higher than the ration allocation reported for grass carp, *Ctenopharyngodon idella* (1.97%) (Du *et al*., 2006), Atlantic salmon, *Salmo salar* (2%) (Austreng *et al*., 1987), Nile tilapia, *O. niloticus* (2%) (El-Saidy and Gaber, 2005), European sea bass, *Dicentrarchus labrax* (3–3.5%) (Eroldogan *et al*., 2004), hybrid sturgeon (3.7%) (Lue *et al*., 2015), in the range determined for big head carp, *Aristichthyes nobilis* (2-5.7%) (Opuszynski and Shireman, 1991), and lower than the values for *H. fossilis* (5.9-6.8%) (Khan and Abidi, 2010), Common carp, *Cyprinus carpio* (6%) (Desai and singh, 2009), Indian major carp, *Labeo rohita* (6.5-7%) (Ahmed, 2007), African catfish, *Clarias gariepinus* (6%) (Al-Hafedh and Ali, 2004), white sturgeon, *Acipenser transmontanus* (6%) (Deng *et al*., 2003), Tambaqui, *Colossoma macropomum* (10%) (Silva *et al*., 2007), clownfish, *Amphiprion percula* (10.26%) (Johnston *et al*., 2003) and brown trout, *Salmo trutta* (11.3%) (Elliot, 1975). Thus, the difference in nutrient requirement could also be related to species and age of fish, composition of the diet, stock density and water quality.

In this study, poor growth and FCR for fish fed lower rations of 4% BW day^{-1}, lower rations than the optimum, suggests these rations approximate to maintenance requirements only and that most of the ingested nutrients are used

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to maintain life and a small portion probably remained for growth. The present findings on snow trout also seem to be in agreement with the observations of Khan *et al*. (2004) on *C. mrigala*. Moreover, poor FCR for higher rations can be due to loss of nutrients and waste of food, because it takes longer for fish to consume food to reach satiation. Similar results were also reported in *Heteropneustes fossilis* (Khan and Abidi, 2010), *Labeo rohita* (Ahmed, 2007) and *Acipenser transmontanus* (Hung and Lutes, 1987).

The whole-body composition of fish is known to indicate the fish quality. Many studies have confirmed that body composition is significantly affected by feeding rate (Ahmed, 2007; Desai and Singh, 2009; Khan and Abidi, 2010). The findings of the present study showed that ration significantly affects whole-body protein content. The highest protein contents were observed at 4%-6% feeding ration. Similar observations were made by Khan *et al*. (2004) in *C. mrigala*. Also in the present study, ash, fat and moisture were not significantly influenced by ration level. This is in agreement with results of Desai and Singh (2009) who reported that ash and moisture content remained insignificantly different among the ration levels in common carp. Generally, lack of difference between fish fed with 4% and 6% ration indicates that all fishes in these treatment groups were adequately fed.

In conclusion, results of the present study show that a feeding rate of 4.9-5.2% BW day^{-1} is the most efficient feeding strategy for juvenile snow trout, because it results in greater growth and production. Therefore the application of this feeding rate for juvenile *Schizothorax zarudnyi* would insure optimum feed consumption with minimum waste, improve nutritional efficiency and food conversion efficiency, decrease production cost and reduce water pollution.

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