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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

EFFECT OF FEEDING RATE ON GROWTH PERFORMANCE, FOOD UTILIZATION AND MEAT YIELD OF STERLET (*Acipenser ruthenus* Linne, 1758)

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Abstract: In this study, a 3x2 factorial feeding experiment was conducted to investigate the effect of feeding rate on growth performance, feed conversion ratio and meat yield of sterlet reared in a recirculating aquaculture system. The diet containing 45% protein 6.5% fat was offered to the sterlet with initial average weight of 187 g at three feeding rates: 1, 2 and 3% of body weight at 18.7 ±0.97°C for 60 days. SGR were 1.7 ±0.10, 2.1 ±0.11 and 2.0 ±0.11, respectively. FCR amounted as 1.8 ±0.11, 2.9 ±0.15 and 4.4 ±0.14, respectively. In terms of the hepatosomatic index, viscerasomatic index and carcass efficiency no statistic differences were found between feeding rate groups (P>0.05). Considering growth performance and FCR data, it can be concluded that the best growth of sterlet at 17-19°C was obtained in fish fed with 2% BW/day. As a result, the diet containing 45% protein and 6.5 % fat can be recommended for use at 2 % BW/day feeding rate for 150-300 g size sterlets.

Keywords: Sterlet, Feed conversion, Meat yield, Feed content

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Özet: **Yemleme Oranının Çoka Mersinlerinin (*Acipenser ruthenus* Linne, 1758) Büyüme, Yem Değerlendirme ve Et Verimine Etkisi**

Bu çalışmada, yemleme oranının kapalı devre sistemde büyütülen çoka mersininin büyüme, yem değerlendirme ve et verimine etkisini araştırmak için bir 3x2 faktöriyel besleme denemesi yapılmıştır. Ortalama ağırlıkları 187 g olan çoka mersinleri canlı ağırlıklarının %1, 2 ve 3'ü oranında, %6.5 yağ ve %45 protein içeren pellet yem ile 18.7±0.97°C su sıcaklığında 60 gün süreyle beslenmiştir. Spesifik Büyüme oranları sırasıyla 1.7±0.10, 2.1±0.11 ve 2.0±0.11 bulunmuştur. Yem Değerlendirme Oranları 1.8±0.11, 2.9±0.15 ve 4.4±0.14 hesaplanmıştır. Gruplar arasında Hepato Somatik İndeks, Viscera Somatik İndeks ve Et Verimi bakımından fark görülmemiştir (P>0.05). Büyüme ve yem değerlendirme bulguları göz önünde bulundurulduğunda, çoka mersinlerinin en iyi büyümelerinin canlı ağırlığın %2'si oranında yemlenen grupta gerçekleştiği görülmüştür. Sonuç olarak, 150-300 g ağırlıklarındaki çoka mersinlerinin canlı ağırlıklarının %2'si oranında, %6.5 yağ ve %45 protein içeren yem ile beslenebilecekleri belirlenmiştir.

Anahtar Kelimeler: Mersin balığı, FCR, Et verimi, Yem, Yağ

Introduction

The sterlet, *Acipenser ruthenus*, is a freshwater species. It originally inhabits the rivers of Eurasia, being widely distributed in rivers flowing into the Caspian, Black, Baltic, White, Barents and Kara Seas and the Sea of Azov. They reach to sexual maturity at 3-5 years in males and 5-8 years in females in nature condition (Hochleithner and Gessner, 1999).

The optimal temperature for growth of sterlet is 18-22°C in 200-250 g and its growth rate decreases rapidly below 14°C (Ponomareva et al., 2002). It is a benthos feeder and its diet changes according to season and river inhabitants, but generally includes insect larvae, small molluscs and invertebrates (Solokov and Vasiliev, 1989).

The captive breeding of sturgeons was commenced in 1869 by a Russian academician Ovsyannikov who successfully fertilized sterlet eggs using milt of the Russian sturgeon (*A. gueldenstaedtii*) and stellate sturgeon (*A. stellatus*) (Ovsyannikov, 1870, 1872, 1873).

The most commonly used species is the Siberian sturgeon (*Acipenser baerii*) which is presently reared in 22 countries reaching a total production of about 8800 tonnes per year, followed by the Russian sturgeon cultured in about 16 countries, while the sterlet is presently cultured in 15 countries (Bronzi et al., 2011).

There is a few studies dealing with the culture of sturgeon (Williot et al. 2005; Gencharov, et al., 2009; Ronyai, 2009) and new studies continue to provide experience about sterlet reproduction. As a freshwater species sterlet is one of the species identified as a leading candidate for sturgeon culture, because it reaches commercial weight (1-2 kg) and sexual maturity (3-4 years) fastly. Under recirculation system conditions it can be propagated at the age of 2-3 years with an inter-spawning period of 1 year (Ronyai, 2006a; Ponomareva and Matishov, 2006).

The studies on the nutritional requirements of the sturgeons are mostly related to white sturgeon (*Acipenser transmontanus*) and Siberian sturgeon (Moore et al., 1988; Hung et al., 1989; Kaushik et al., 1989; Xu et al., 1993; Deng et al., 1998; Stuart and Hung, 2003; Şener et al., 2005). The previous literature for some cultured sturgeon species was revived and summarized by García-Gallego et al. (2009). In published literature plenty of studies exist on rearing of sturgeon species. Some of those studies focus on growth rates of white sturgeon (Stuart and Hung, 2003), Siberian sturgeon (Ronyai et al., 1989a; Rad et al., 2003; Adámek et al., 2007), sterlet (Ronyai et al., 1989b; Jecu, et al., 2008; Feledi et al., 2011; Prokes et al., 2011) and Russian sturgeon (Çelikkale et al., 2002; Memiş et al., 2009), some of them are about feeding rates or frequency of feeding of white sturgeon (Hung and Lutes, 1987; Hung et al., 1993), Siberian sturgeon (Ronyai et al., 1989b; Ronyai et al., 1999; Köksal et al., 2002), Russian sturgeon (Memiş et al., 2009), great sturgeon, *Huso huso* (Mohseni et al., 2006), juvenile Atlantic sturgeon (*Acipenser oxyrinchus*) and shortnose sturgeon, *A. brevirostrum* (Giberson and Litvak, 2003). There are also a number of publications dealing with a stock density for white sturgeon (Gershanovich and Taufik, 1992). However, studies on the feeding rate of sterlet and its effects on growth performance and feed utilization are scarce (Ronyai et al., 2006; Feledi et al., 2011).

In intensive fish farming operational cost mostly depends on the feed because it accounts for 60-80 percent of total production costs (Hasan et al., 2007). Therefore feeds will continue to dominate fish farming needs. On the other hand, growth performance and food utilization are major variables in fish culture and mostly related to water temperature. The aim of any fish farming is using low cost feeds and obtaining better growth performance.

There were also several studies about meat yield of different fish species (Macias 2004; Samsun et al., 2005; Duman and Dartay, 2007; Şebnem et al., 2011) and effects of cultivation practices on it (Cibert et al., 1999).

The objective of the present study is to investigate the effect of different feeding rates with a low fat diet containing appropriate protein on growth performance, food utilization and meat yield of sterlet reared in a recirculating aquaculture system.

Materials and Methods

The fish used in the experiment hatched in April 2011 and raised in the Research Institute for Fisheries, Aquaculture and Irrigation (HAKI) in Szarvas, Hungary. The experiment was conducted in January-Ferbuary 2012. Prior to measurement the fish was anaesthetized with clove oil (Akbulut et al., 2011). 120 fish with an average weight of 187 g were individually weighed to nearest 0.1 g and randomly placed into six tanks (1.1x1.1 m) in 2 subgroups. Water depths in the tanks with a middle outflow were set up to 25 cm with a 10 L/minute flow rate.

Six groups composing 20 sterlets each were fed with a commercial (3-3.5 mm) sunken pellet feed (Halpad Ltd. Szarvas, Hungary) with 45% protein and 6.5 % fat content. Three feeding rates were applied: 1, 2 and 3% of total body weight per day (BW/day), and the daily rations were calculated with expecting 0.6 SGR (%). The amounts of feed were correlated by weight measurements every 20 days. The feeding commenced at 08:00 every day at belt feeders set for 12 hours and lasted for 60 days. During the experiment water quality parameters were also checked, including daily temperature records with a minimum of 16.6°C and a maximum of 19.9°C (average temperature was 18.7±0.97°C). The other measurements varied as follows: oxygen concentration 7.9-9.4 mg/l and saturation 81-99%.

Following variables were calculated:

Feed Conversion Ratio

$FCR=F/WG$

Feed Intake

$FI=F/\text{number of fish}$

Specific Growth Rate

$SGR \text{ (in \% of W)}=((\ln W_f - \ln W_i)/t)x100$

Weight gain

$WG=(W_f - W_i)$

Daily Weight Increase

$DI=WG/t$,

Percentage relative change in weight was also used: $RW \text{ change } (\%)=100 \times (W_f–W_i)/W_i$ where t is the number of experiment days. W_i *and* W_f are the initial and final weights (g), F is the cumulative food consumption of fish in each tank.

The coefficient of variation (CV) was used to examine an inter-individual weight variation among the fish in each group: *CV (%)=100xS.D./mean weight* of the fish in each tank. Percentage relative was calculated as: $CV \text{ change } (\%)=100*(CV_f–CV_i)/CV_i$.

At the end of experiment five fish from each tank were randomly sampled for indices estimations. Body weights, livers and viscera were individually weighed for calculation of hepatosomatic index (HIS), viscerasomatic index (VSI) and carcass efficiency (CE). Viscera included a liver and a gastrointestinal tract from esophagus to anus. Carcass weight (CW) was determined by subtracting viscera, head and fins from body weight.

The following variables were calculated: hepatosomatic index *HSI= [liver weight(g)/body weight (g)] x 100*, viscera somatic index *VSI=[viscera weight (g)/body weight (g)] x 100)* and carcass efficiency *CE= [Carcass weight (g)/body weight (g)]x100*.

Statistical tests were carried out using the SPSS software package for Windows. All data were subjected to one-way analysis of variance

(ANOVA) and differences between means compared by the Tukey test at a 95% confidence interval (P<0.05).

Results and Discussion

Feeding rate affected the growth of the fish. Feeding rate for maximum growth was 2% of BW/day. Mean weight gains were 75.4±4.95 g, 98.7±6.40 g, and 94.1±5.76 g for fish in the 1, 2 and 3% of BW/day groups, respectively. The mean weight increase in the 1 % group was significantly lower than the other groups (P<0.05). Growth trend of fish during the course of the experiment is shown in Figure 1. The specific growth rates (SGR%) were significantly higher (P<0.05) in the 2 and 3% feeding rate groups than in 1% group (Table 1). Statistically significant differences were found in FCR between the 1, 2 and 3% of BW/day groups (P>0.05). The feeding rate did not influence neither the hepatosomatic index (HIS), nor viscerasomatic index (VSI) and carcass efficiency (CE) (P>0.05). The final meat yield parameters of sterlet are represented in Table 2.

Table 1. Growth performance, feed utilization and survival rates of juvenile sterlets fed at different feeding rates. Values (mean ± SD) with different superscripts in the same row are significantly different at the 5% level.

	Feeding rates (% of BW/day)		
Parameters	**1**	**2**	**3**
Initial weight (g)	186.9±0.99	187.4±0.28	187.8±0.14
Weight gain (g)	75.4±4.95^{a}	98.7±6.40^{b}	94.1±5.76^{b}
Relative W change (%)	40.4±2.86^{a}	52.7±3.49^{b}	50.1±3.18^{b}
SGR (% day)	1.7±0.10^{a}	2.1±0.11^{b}	2.0±0.11^{b}
Daily weight increase (g)	3.8±0.25^{a}	4.9±0.32^{b}	4.7±0.30^{b}
Coefficient of variation (CV)	16.3±1.73	15.1±0.69	14.4±1.07
Relative CV change (%)	-5.9±1.12^{a}	16.6±19.98^{b}	25.6±3.12^{c}
Survival rate (%)	100±0.00	100±0.00	100±0.00
Feed conversion ratio (FCR)	1.8±0.11^{a}	2.9±0.15^{b}	4.4±0.14^{c}
Feed intake (FI)	131.6±0.18^{a}	282.2±3.25^{b}	413.8±12.86^{c}

Table 2. Meat yield parameters of juvenile sterlets fed at different feeding rates.

	Feeding rates (% of BW/day)		
Parameters	**1**	**2**	**3**
Average weight (g)	268.8±56.02	281.3±74.23	260.4±59.45
Average total length (cm)	41.2±1.77	41.6±2.77	40.4±2.30
Hepatosomatic index (HIS)	2.2±0.36	2.5±0.68	2.2±0.49
Viscerasomatic index (VSI)	8.1±1.19	8.9±1.37	8.2±1.36
Carcass efficiency (CE)	68.2±1.67	68.8±1.34	69.3±1.49

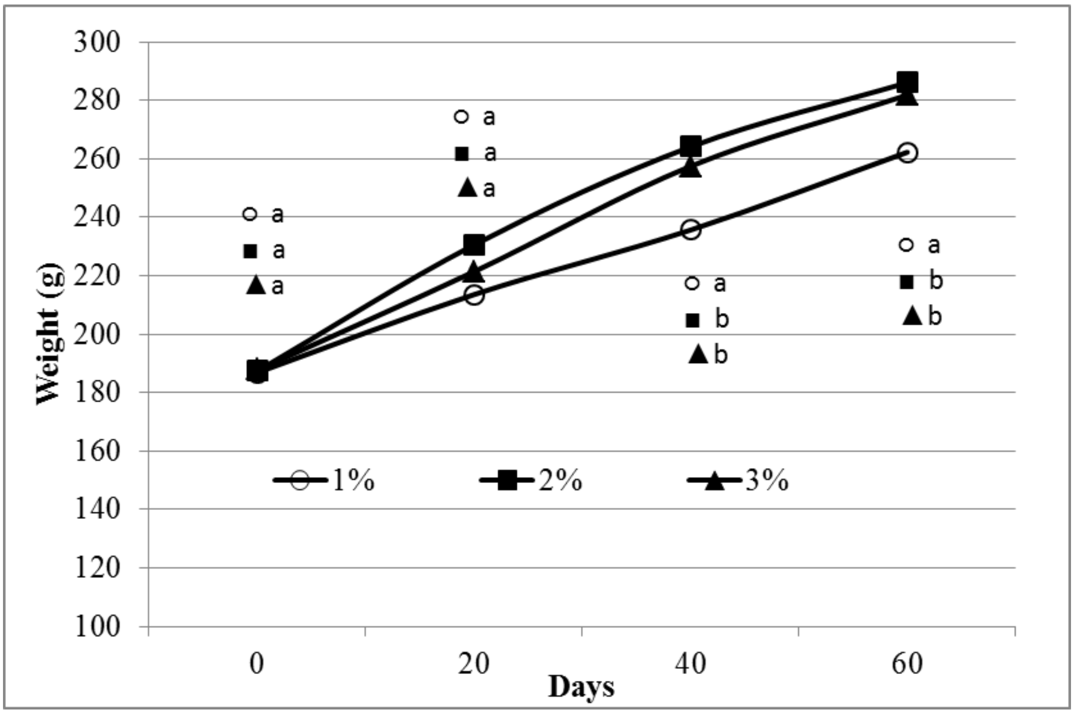

Figure 1. Average weight of juvenile sterlets fed with 1, 2 and 3 percent of BW/day.

In sturgeon culture, feeding rates vary according to the purpose and stage of rearing systems (Ronyai, 2006a; Chebanov and Galich, 2010; Prokes et al., 2011). Besides, different diet content is recommended for sturgeon feeding depending on the fish size and species (Hung and Deng, 2002; Chebanov and Galich, 2010).

The results obtained in the present study were similar to those in the study by Şener et al. (2006) where a feeding rate of 2% body weight was used at 16°C for Russian sturgeon with average weight of 144 g and studies of Sion et al. (2011) who used a 41 g sterlet fed with 30-46% crude protein at the 1.5% BW/day feeding rate at 19.1-24.6°C temperature.

Our SGR results in all the experimental groups were higher than results of lower temperature studies of Memiş et al. (2006) who found SGR as 0.16 for Russian sturgeon fed with a carp diet containing 35% protein and 10% crude fat, and Akbulut et al. (2010) where SGR was found as 0.36 for 0.5-2.2 kg juvenile beluga fed with raw fish at 13°C.

Filipiak et al. (1999) reported that SGR and FCR were 3.03 and 1.57 for 25 g sterlet reared in cages at 12.2-23.0 °C with feeding a diet containing 41.3% protein and 23.3% fat. Feledi et al. (2011) found SGR and FCR as 5.39 and 3.23 in 77 g sterlet reared in the tanks at 24.0-25.6 °C feeding with a diet containing 45% protein and 6.5% fat at feeding rate of 10% BW. According to Prokes et al. (2011), during the subsequent part of juvenile period of sterlet, from the 6th day after hatching and up to the age 5+ the SGR values subsequently diminish from 7.00 to 0.05 under farm conditions, and SGR summers in 0.88, 0.73 and 0.59, FCR in 1.35, 1.39 and 1.42, with daily feeding rates 1.6, 1.7 and 2.1 % for 99.5 and 71.2 g juvenile sterlets, respectively.

When comparing growth and feed utilization of sterlet with other sturgeon species, it can be seen that growth rate of sterlet was a little bit slower but feed utilization was similar to those of the other sturgeons. In the case of meat yield of sterlet there are no published data, but there are some numbers for Russian sturgeon, for example, Sener et al. (2005 and 2006) who reported that dietary lipid effected on values of HIS and VSI in Russian sturgeon. Akbulut et al. (2013) calculated HIS, VSI and CA as 3.28, 8.18 and 65.14 for 400 g Russian sturgeon and 2.97, 9.03 and 65.40 for stellate sturgeon.

Conclusion

Consequently determining the optimal feeding rates for sterlet is important to the success of its culture. Meat yield may also be helpful to determine a daily feed amount of food in sturgeon culture.

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