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The effects of Rearing Density on Growth Performance and Food Conversion Ratio of Siberian Sturgeon (*Acipenser baeri* Brandt)

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Abstract

Three year old Siberian sturgeons (*Acipenser baerii*) were reared at five densities in indoor fiber-glass tanks to evaluate the effects of stocking density on growth, survival, condition, and feed efficiency. Fish (mean weight, 460±90g) were stocked into 500-L fiber-glass tanks containing 270 liters of water at rates of 6, 9, 12, 15 and 18 fish per tank (3-9 kg/m²). The growth trial was conducted over an 8-week period during which the fish were offered a 45%-protein commercial ration in slight excess. At the termination of the study, the mean weights as well as the lengths and weights of individual fish in each tank were recorded. Biometry takes place every 20 days. The final weights of the fish decreased insignificantly as density increased (p>0.05), with fish stocked at a density of kg/m² having a mean weight of 746 g and those stocked at 9kg/m² having a mean weight of 7.3 g. The percentage of weight gain and feed efficiency also decreased as stocking density increased. No significant differences in GR, SGR, BWI and FCR were found among treatments (p>0.05). The end result shows that Siberian sturgeons seem to be able to tolerate high stocking densities and this species could be easily reared in fiber-glass tanks at the rate of 10 kg.m⁻².

Introduction

Sturgeons are temperature and oxygen tolerant and they do not require specific rearing structure. In addition, the caviar market has an increasing demand that remains unfulfilled (Williot, 2001). Therefore, sturgeon farming is of great importance for those countries where wild stocks are declining or have been exterminated (Steffens et al., 1990). Siberian sturgeon (*Acipenser baeri*, Brandt) is also offering suitable prospects for aquaculture in Europe (Steffens et al. 1990) and is a commercially desirable

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aquaculture candidate (Williot, 1999). This non-migrating freshwater species has shown a good growth performance in many types of production system and in tanks of different size and shape (Williot et al., 2001; Arndt and Mieske, 1994) and is capable of reaching sexual maturity in captivity (Ronayi and Peteri, 1990; Ronayi, 1989). The results of primary research on feeding and nutritional physiology of Siberian sturgeon have also been promising (Dabrowski, 1985; Medale, and Kaushik S.J, 1989). Siberian sturgeon is also less demanding than many other cultured species e.g. rainbow trout in terms of water quality parameters (Williot et al. 1993).

Stocking density is a major factor that affects fish growth under farmed condition (Jobling, 1995; Yi et al. 1996; Hengswat et al. 1997) and in many cultivated fish species, growth is inversely related to stocking density and this is mainly attributed to social interactions (Holm et al., 1990; Haylor, 1991; Miao, 1992; Huang and Chiu, 1997; Canario et al. 1998; Irwin et al. 1999; Silva et al. 2000). However, social interactions through competition for food and/or space can negatively affect fish growth. Papst et al. (1992) suggested that in intensive aquaculture the stocking density is an important factor that determines the economic viability of the production system. Thus this study was conducted to evaluate the effects of density on growth performance, percentage of body weight, specific growth rate and food conversion ratio in order to assess the potential for introducing Siberian sturgeon to the aquaculture sector in Iran.

Materials and methods:

The experiment was carried out at the indoor installation of the International Sturgeon Research Institute in Rasht. The three year old Siberian sturgeon (imported from Hungary), were randomly separated into 15 fiber-glass tanks at five densities: 6, 9, 12, 15 and 18 fish in tank (3-9 kg/m²), with three tanks per rearing density. Rearing tanks were of equal sizes, 150 x 102 x 52 cm and held 270l of water. Total wet weight (g) and total length (cm) were measured at the beginning of the study, and repeated every 20 days. Fish were hand-fed with commercial pellets 4-times daily for 8-weeks duration. Food rate was 1-2% tank biomass (depending on water temperature). Adjustment of the amount of food was made every 20 days when the fish were measured and weighed. Fish growth and other indices were calculated with the following formulae:

Growth Rate (G R) = (BW_f - BW_i) / n (Hung et al. 1989)

Specific Growth Rate (S G R) = (lnW_t - lnW₀) / t x 100 (Ronyai et al. 1990)

Body Weight Index (BWI%) = 100 x (BW_f - BW_i) / BW_i (Hung et al. 1989)

Condition Factor (CF) = 100 x (BW / TL³) (Hung & Lutes, 1987)

Food Conversion Ratio (FCR) = F / (W_t - W₀) (Ronyai et al. 1990; Abdelghany & Ahmad, 2002)

BW_i and BW_f: Initial and final body weight (g), n: number of experiment days, TL: total length, W₀ and W_t: means of initial and final weight in each tanks, F: consumed food.

Water quality, including water temperature, dissolved oxygen and pH as were measured every day at 08:00 am. Statistical analyses were conducted using the "Statistic" program for Windows Ver. 10.0. One-way ANOVA test was computed to evaluate the differences in terms of mean body weight, total lengths, SGR, GR, BWI, CF and FCR between replicates. When significant differences were detected, the Duncan test was applied to compare the means.

Results and Discussion

Water quality, including water temperature, dissolved oxygen and pH were measured daily. These parameters in high stocking densities were significantly lower than low stocking densities ($P < 0.05$).

Table 1. Range of physico-chemical water parameters during trial

Blood	Stocking density(fish in tank)				
	6	9	12	15	18
DO	6.21±0.1	6.18±0.4	5.97±0.1	6.08±0.2	5.87±0.5
pH	7.57±0.04	7.56±0.09	7.52±0.08	7.55±0.06	7.46±0.6

Water quality has a complex side effect on high stocking density. Miao (1992) found that higher stocking density was accompanied by lower pH and dissolved oxygen, and resulting changes in water quality might play an important role in affecting growth and survival of fish. The stocking densities may be the cause of stress because of deterioration in water quality (Barton & Iwama, 1991).

The mean standard length and mean body weight of fish at five densities at the beginning of the experiment (Week 0) and end of the experiment (Week 8) are shown in Table 2. At the beginning of the experiment, mean length and mean weight were not significantly different between the densities ($P > 0.05$).

In the present experiment, attempts were made to estimate the influence of stocking density on the growth indices of Siberian sturgeon reared in 500L fiber-glass tanks. The results showed that the different growth parameters were affected by stocking density. It was also noticed that fish growth was negatively affected by stocking density. The maximum growth was obtained in low density (6fish in tank) whereas the lowest growth

was obtained in moderate density (12fish in tank). Maximum increase in weight and length were observed at lowest density. Differences between mean values of length and weight in different stocking density were statistically significant ($P < 0.05$) but weight in different stocking density was insignificant ($P > 0.05$).

Table 2. Mean values of weight and length changes of Siberian sturgeon during trial

Density (fish in tank)		Stocking density(fish in tank)			
		Biometry 1st	Biometry 2nd	Biometry 3rd	Biometry 4th
6	W (g)	461.8±51.6	515±75.9	595.3±89.3	746±109.6
	TL(cm)	49.8±4.45	52.5±3.4	55.6±8.1	57.8±3.3
9	W (g)	482±16.6	510.5±80	601.4±100.56	713±127
	TL(cm)	51±2	51.6±2.6	51.3±2.6	55.7±3
12	W (g)	448.5±83.8	511.68±79.3	571±98.6	664.7±117
	TL(cm)	50.6±3.34	51±2.8	52.6±2.6	55±2.7
15	W (g)	465.8±84	513±97	571±105	680.4±127.6
	TL(cm)	50.5±2.9	51.6±2.5	52.9±2.9	55.5±3
18	W (g)	465.8±126.8	512±127	565±141	664.5±146.2
	TL(cm)	51.7±4.4	51.7±4.4	52.9±4.5	55.9±4.2

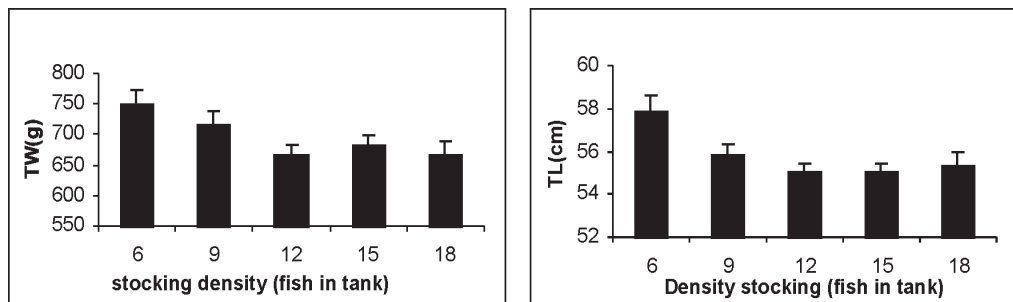


Figure 1, 2- Mean (\pm SE) length and weight of Siberian sturgeon at five rearing densities at end of the experiment.

Several authors have demonstrated that stocking density is a major factor that affects fish growth under farmed condition (Jobberling, 1995; Yi et al., 1996; Hangswat et al., 1997). Increased density has been shown to have negative effects on the growth of several other species (Holm et al., 1990; Soderberg et al., 1993; Yi et al 1996). Papst et al., (1992) suggested that in intensive aquaculture the stocking density is an important factor that determines the economic viability of the production system but it appears that there is no general agreement regarding the effects of stocking density on growth,

size variation, survival and production of fish (Haug & Chiu, 1997). Stocking density, besides genetics, food supply and environmental condition, is an important factor affecting growth and maturation of wild and farmed fish. As population density increases, competition for food and living space usually intensifies, providing one of the most effective controls on animal population (Haug & Chiu, 1997). In this study, the similar negative relationship was found between stocking density and growth of size of Siberian sturgeon.

The mean values of SGR, GR, BWI, CF and FCR obtained at each stocking rate are given in Table 2. Best specific growth rates ($1.13\% \text{ day}^{-1}$), body weight index (25.4%) and food conversion ratio (1.6) were measured at lowest stocking density. Best condition factor were measured in treatment containing 9 and 15 fish (0.41). Differences between mean values of specific growth rate, body weight index, and condition factor and food conversion ratio obtained at different stocking rates were statistically insignificant ($P > 0.05$).

Table 3. Mean values of SGR, GR, BWI, CF and FCR obtained at each stocking rate for Siberian sturgeon.

Index Experimental fish.tank ⁻¹	Growth Rate (g.day ⁻¹)	Specific Growth Rate (% in day)	Body Weight Index (% in total duration)	Condition Factor (CF)	Food Con- version Ratio (FCR)
6	7.59±0.7	1.13±0.05	25.4±1.2	0.38±0.01	1.6±0.09
9	7.58±0.9	0.85±0.036	18.63±0.85	0.41±0.01	2.18±0.1
12	4.65±0.66	0.75±0.085	16.24±4.98	0.39±0.01	2.54±0.32
15	5.32±1.12	0.84±0.15	18.5±3.5	0.41±0.01	2.47±0.32
18	4.97±0.04	0.81±0.003	17.6±0.08	0.39±0.01	2.19±0.07

In our experiment three year old Siberian sturgeon with a mean initial weight of 460 ± 90 g reached the mean final weight of 668.8g in 61 days. The specific growth rate (SGR) values obtained in our trial are 1.13 ± 0.05 and 0.81 ± 0.003 in lowest and highest stocking density respectively. Medale and Kaushik (1989) reported the SGR values for 3 and 10-months-old Siberian sturgeon juveniles as 1.54 and 1.03 ($\% \text{ day}^{-1}$) respectively in 17.5 ± 1 °C. While Köksal et al. (2000) observed that, Siberian sturgeon with body weight above 20-30 g performed a SGR of 2.90-2.8 ($\% \text{ day}^{-1}$). However, specific growth rate decreased with increasing age and the SGR value in the last experimental period was found to be 1.30 ($\% \text{ day}^{-1}$).

The value of body weight increase (BWI) reported by [Kaushik et al. \(1989\)](#) at 17.5 ± 1 °C for Siberian sturgeons with an initial mean weight of 90 g using concrete tanks (1.5x1.5x0.3m) was 179%. [Köksal et al., \(2000\)](#) observed that, Siberian sturgeon with body weight above 20-30 g performed BWG of 122% but in this experiment BWI were $25.4 \pm 1.2\%$ and $17.6 \pm 0.08\%$ in lowest and highest stocking density respectively. Feed Conversion Rates ranged from 1.6 - 2.54 with fish at the lowest density being more efficient at converting feed to flesh than other treatments. [Ferit Rad et al., \(2003\)](#) investigated the effects of different daily feeding rates on the specific growth rate and food conversion ratio of Siberian sturgeon in order to determine the optimum daily feeding rate for fish with an initial mean weight of 1736 ± 37 g. Mean specific growth rate and food conversion ratio values were found to be significantly different ($P < 0.05$) between the four treatments. The means of specific growth rate and food conversion ratio for fish fed at 0.75%, 1.00%, 1.25% and 1.50% body weight/day were computed as 0.47, 0.88, 0.89 and 0.64% day⁻¹ and 1.71, 1.25, 1.40 and 2.43, respectively. They found at 19-22 °C the optimum daily feeding rate for Siberian sturgeon of 1736 g was determined to be 1.00% body weight.day⁻¹ but in our experiment, daily feeding rate was 2.00% body weight/day to ensure that all treatment were fed to satiation.

Best mean values of SGR, GR, BWI, and FCR obtained were measured at lowest stocking density and with increased density, these factors were declined. The lowest mean values of SGR, GR, BWI, CF and FCR obtained were measured at groups containing 12 fish in tank. But differences between mean values of these factors in all treatment were insignificant ($P > 0.05$), indicating that the stocking density has no significant effect on growth indices of Siberian sturgeon reared in 500L fiber-glass tanks.

Siberian sturgeons seem to be able to tolerate high stocking densities. However, this figure should not be regarded as an upper limit and is specific to the total biomass at the 61st day of our experiment and to 668 g fish. [Köksal et al., \(2000\)](#) applied population densities of 30 to 35 kg.m⁻² for larger fish (0.5 to 1.0 kg) in shaded outdoor fiberglass tanks (2x 2x1 m) and each supplied with spring water at a constant flow rate of 2l.sec⁻². Water temperature ranged between 19.0 and 22.0 °C throughout the experiment with the mean being 21.7 °C. [Steffens et al. \(1990\)](#) and [Ronayi et al. \(1997\)](#) reported 25 kg.m⁻² as an acceptable population density for the white sturgeon. The results of our experiment in terms of growth performance and feed conversion efficiency indicate that the Siberian sturgeon could be regarded as a potential candidate for species diversification in the Iran aquaculture sector.

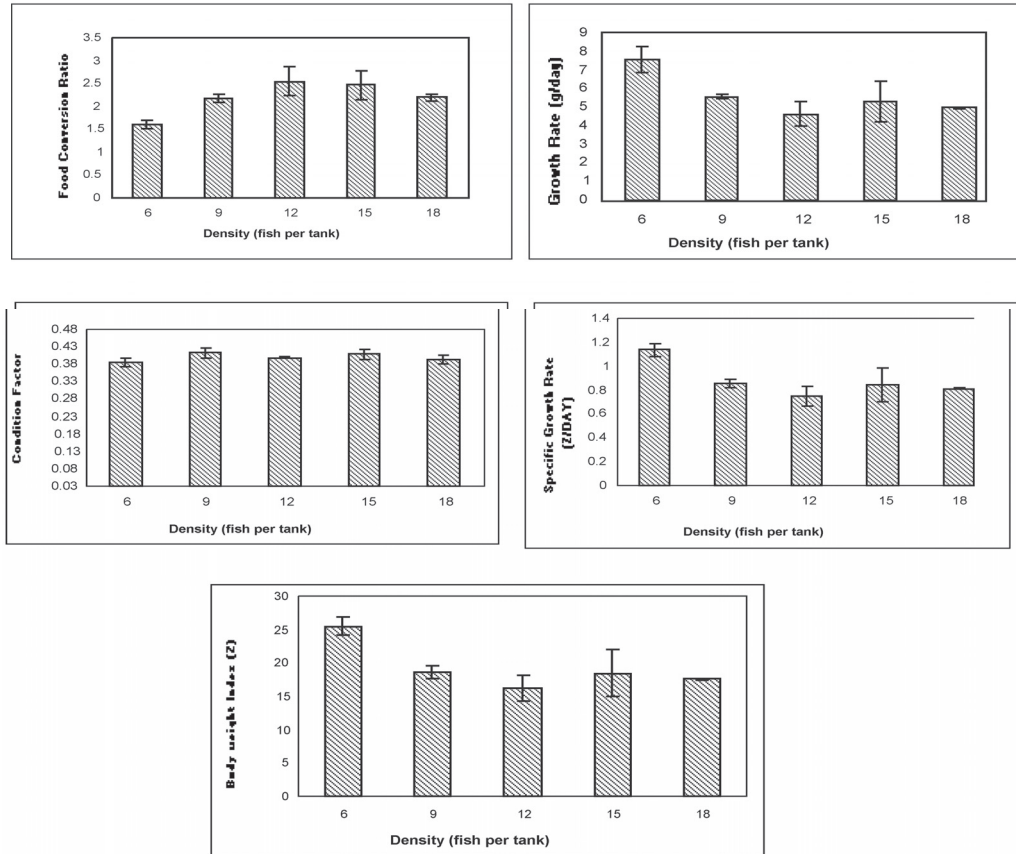


Figure 3. mean body weight, total lengths, Specific Growth Rate (SGR), Growth Rate (GR), Body Weight Index (BWI %), Condition Factor (CF) and Food Conversion Ratio (FCR) of *Acipenser baerii* in different stocking density. * Significant differences ($P < 0.05$)

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