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INFLUENCE OF STOCKING DENSITY ON THE GROWTH PERFORMANCE OF RAINBOW TROUT AND BROWN TROUT GROWN IN RECIRCULATION SYSTEM

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Abstract

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Rainbow trout with initial weight 20.45 g ± 0.05 and brown trout with initial weight 18.56g ± 0.08 were grown in two stocking density 1 - 29 individual.m^{-3} and stocking density 2 - 57 individual.m^{-3}. Survival of fish was higher at lower density. The growth was significantly reduced at high density ($P<0.05$ for rainbow trout and $P<0.01$ for brown trout). Feed conversion ratio was favorable in tanks at low rearing density for two trout species ($P<0.05$). The influence of stocking density on growth and feeding ratio was higher at brown trout compared with rainbow trout.

Key words: rainbow trout, brown trout, stocking density, survival, growth, FCR
Abbreviation: SD – stocking density; FCR - feed conversion ratio

Introduction

Norwegian scientists considered that in intensive aquaculture fish were kept at too high densities. High stocking densities can have a detrimental impact on the health and welfare of rainbow trout as well. In particular, high densities can lead to:

– increased stress (Wall, 2000; Håstein, 2004)

– increased susceptibility to disease (European Commission, 2004)

– increased incidence of physical injuries (Juell et al., 2003; Turnbull et al., 2005; North et al., 2006)

– poor body condition (Ellis et al., 2002)

– reduced growth, feed intake and feed conversion efficiency (Ellis et al., 2002)

Ellis et al. (2002) reviewed the scientific literature concerning the relationship between stocking density and welfare in farmed rainbow trout. These authors examined 43 papers that studied the effects of stocking density on productivity, health, body condition and stress level. They found that commonly reported effects of increasing stocking density include an increase in fin erosion and reductions in growth, feed intake, feed conversion efficiency plus body and liver condition. They concluded that such changes are indicative of a reduced welfare status.

Many authors proved influence on stocking density on the welfare of trout fish which affects survival, growth and feeding ratio, but the dates of these studies were contradictory.

The recommended stocking density in our country for intensive cultivation of rainbow trout is between

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80 – 100 individual.m^{-3} (Zaikov, 2006). In Bulgaria there are researchers who have investigated the influence of stock density on trout grown in cages, but publications concerning that problem are almost missing on the cultivation of trout in a recirculation system.

The purpose of this research was to investigate the influence of stocking density on surviving, growth intensity and FCR of the rainbow trout and brown trout cultivated in a recirculation system.

Materials and Methods

The experiment was carried out in a 42 days period. It was conducted in the experimental base of aquaculture – Agricultural Faculty, Thracian University. For the trial were used 8 tanks conducted to recirculation system. The size of the tanks was 1/1/1 m, with working capacity of 0.7 m^3. Recirculated water was rectified by mechanical and biological filters. Fresh water was added once a day when the tanks were cleaned.

The average size of fish at the start of the experiment was:

– rainbow trout – 20.45±0.05 g
– brown trout – 18.56±0.08 g

Both fish species were randomly distributed in two experimental groups with two replications each of them (Figure 1):

– stocking density 1 (SD_1) – 29 individual.m^{-3}
– stocking density 2 (SD_2) – 57 individual.m^{-3}

Fishes were fed by hand with extruded pellets, 4 times a day. Table 1 show the diets used in these trials.

The size of the pellets was 2 mm. The daily ratio was specified as a percent of the whole biomass at different densities. The feed consumption was recorded every day and at the end of the trial the FCR was calculated.

The whole quantity of fish in different density at the start of the experiment was weighed. At the end of the trial 15 fish from each density were individually weighed.

Table 1
Content of used food

Content	%
Crude protein	44
Crude fat	13
Fibre	3.06
Phosphorus	0.84
Cuprum	5 mg.kg^{-1}
vit A	0.64 I.U. g^{-1}
vit D3	0.10 I.U.g^{-1}
vit E	176 mg.kg^{-1}

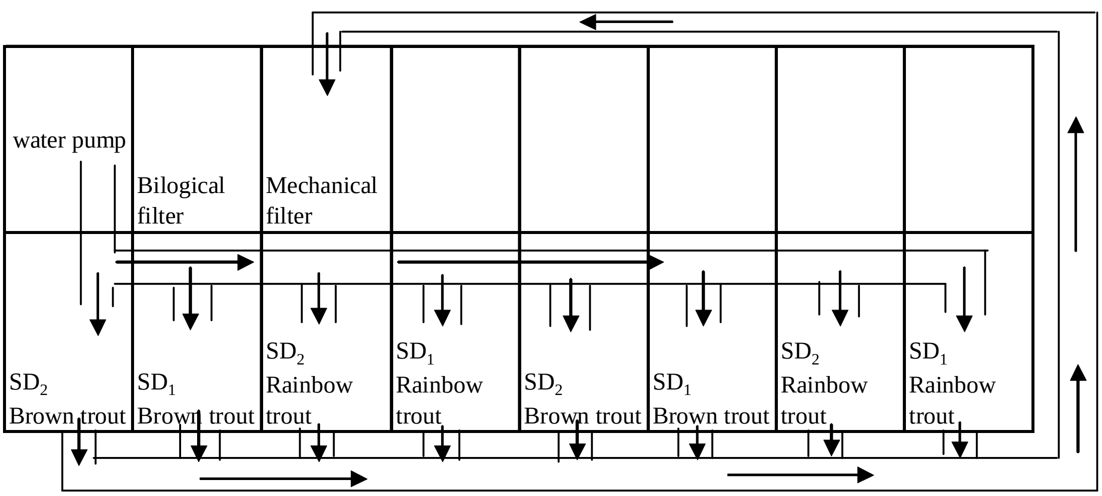

Fig. 1. Scheme of the experiment

During the experiment hydro chemical parameters were measured: temperature (C°), oxygen (mg $O_2.l^{-1}$), ammonia, nitrite and nitrate ($mg.l^{-1}$). They were measured according to generally accepted methods.

At the end of the experiment were calculated:

– fish survival (%)
– body weight – (g)
– individual growth rate – (g)
– weight gain (g)
– relative weight gain - %
– food conversion ratio

All the data was analyzed by descriptive statistics and single –factor ANOVA, describing the effects of density.

Results and Discussion

Water temperature ranged from 13.4 - 16.2°C during the trial period. Oxygen concentration in water varied between 8 and 9 mg $O_2.l^{-1}$. Ammonia was not found, nitrites and nitrates varied respectively 0.003 – 0.01mg.l^{-1} and 8 – 10 mg.l^{-1}.

Fish survival was higher 2.5% in SD_1 compared to that in SD_2 for the two cultivated species but this difference was not a significant evidence of influence of this indicator on the examined density.

Average body weights of the two trout species didn't show differences at the start of the trial (Table 2).

In the recirculation system, at the end of the 42 days trial period the final weight of rainbow trout at SD_1 was 1.403 g higher than that of the trout from the lowest stocking density (Table 2).

This tendency of average final body weight to decrease with the increasing of stocking density was valid for the trial of brown trout too. The advantage in final body weight was on the hand of trout from low stocking density (Table 2).

Average individual growth rate of rainbow trout from SD_1 was higher with 6.32% higher than that of trout of high stocking density and for the brown trout this difference was 24.25 % (Table 3).

In our trial the influence of stocking density to weight gain was better manifested in brown trout than in rainbow trout. The brown trout from SD_1 had with 24.46 % higher weight gain than that of the fishes from SD_2. This difference in weight gain of rainbow trout between the 2 densities was 6.27 % (Table 3).

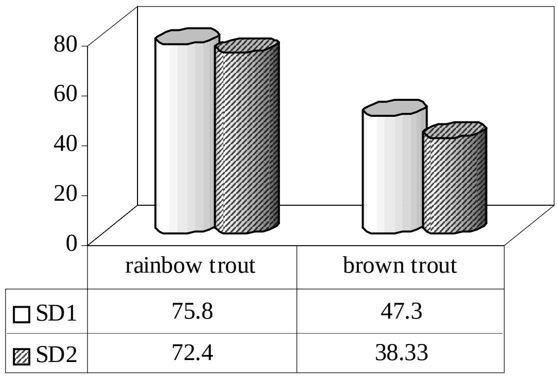

Fig. 2. Relative weight gain of rainbow trout and brown trout

Table 2

Body weights (g) of rainbow trout and brown trout

Rainbow trout	Start of trial		End of trial	
	SD_1	SD_2	SD_1	SD_2
x ±Sx	20.38±0.0705	20.53±0.083	45.26±0.392	43.86±0.434
l-l1	20-21.8	20-21.8	42-49	40-49
P	P>0.05		P<0.05	
Brown trout	start of trial		end of trial	
	SD_1	SD_2	SD_1	SD_2
x ±Sx	18.68±0.139	18.45±0.106	30.26±0.420	27.2±0.564
l-l1	17.3-20.8	17-19.2	24.3-34	23-32
P	P>0.05		P<0.001	

Table 3
Individual growth rate (g) and weight gain (g) of rainbow and brown trout

Individual growth rate, g		
Rainbow trout	SD_1	SD_2
x ±Sx	0.592±0.009	0.555±0.010
l-l1	0.507-0.690	0.452-0.666
P	P<0.05	
Brown trout	SD_1	SD_2
x ±Sx	0.275±0.009838	0.208±0.01253
l-l1	0.15-0.366	0.1-0.3142
P	P<0.001	
Weight gain, g		
Rainbow trout	SD_1	SD_2
x ±Sx	24.883±0.395	23.322±0.449
l-l1	21.3-29	19-28
P	P<0.05	
Brown trout	SD_1	SD_2
x ±Sx	11.584±0.413	8.75±0.526
l-l1 /	6.3-15.4	4.2-13.2
P	P<0.001	

Brown trout from SD_1 had an 8.97 % higher relative weight gain than fish from lower stocking density. The situation with rainbow trout was the same, but the difference was just 3.4 % to the advantage of the trout from SD_1 (Figure 2).

The influence of stocking density on average values of feed conversion ratio was significantly manifested in brown trout. The fish from SD_2 had a 31.7% lower FCR compared to brown trout from SD_1 (P<0.05). This difference in rainbow trout was significantly too but just 9 % to the advantage of FCR of trout from the lowest stocking density (P<0.05).

The temperature at the time of our trial was in optimal borders for the two cultivated species. Ammonia and nitrites had optimal values for the cultivated fish, but nitrates had high rates, because recirculation system we use does not have a denitrification block that would have decreased high nitrate levels.

Survival is a key indicator of health status. Fish survival was high in our trial, but the differences were not significant evidence that surviving of trout is affected by stocking density. Wallat et al. (2004) reported that average survival was 96.7% for the low density and 94.2 % for the high density for trout cultivation in cages. Bircan (1997) obtained similar to our data for trout survival in his trial. Some studies showed opposite results to those obtained by us, high survival of trout cultivated at high stocking density in differences at low stocking density in which fish survival was lower (North et all., 2003).

Many authors (Bojard et al., 2002; Melotti et al., 2004; Wallat et al., 2004; Rasmussen et al., 2007) remarked the influence of stocking density on the growth of trout. Reduced growth and an increase food conversion ratio with the increasing of stocking density were found in 70% of the studies investigated by Ellis (2002). Rainbow trout growth and feeding ratio was better at low stocking density compared to the growth and feeding ratio of fish at high stocking density in our trial. Brown trout in our study showed higher differences of growth and feeding ratio at the examined density than these of rainbow trout to the advantage of fish at low stocking density too. Some studies reported that high densities lead to aggression and some welfare problems that authors suggest may be due to the existence of a dominance hierarchy (North et al., 2006). We didn't investigate the behavior of cultivated fish species especially, but when we observed them we didn't see so many cases of aggression and we considered that the general reason for high survival, growth and feeding ratio in tanks at low density is a result of better quality of the water in them. Ellis et al. (2004) concluded that stocking density is "an important factor for fish welfare, but cannot be considered in isolation from other environmental factors", which is our opinion too. We suggest that level of removal waste products was higher in tanks of high stocking density and combination with high level of nitrates in used recirculation system decreased growth of fishes and assimilation of food much more in tank with high density than this tank with low density. The most important reason for us that the influence of stocking density on growth and feeding intake of brown trout is higher than in the trial with rainbow trout is the higher sensitiveness of brown trout to environmental conditions. The high number of individual.m^{-3} which reduced the ability of fish to see and access food is another possible reason for the low growth and high feeding conversion ratio of fish in high stocking density. Cooke et al. (2000) reported that rainbow trout oxygen consumption was 12% higher at 60 kg.m^{-3} than at 30 kg.m^{-3}, the loss of energy for breathing of the fish is higher at high stocking density. We suppose it is possible that the energy loss of other vital functions was higher at high stocking density and this leads to low growth and worse food assimilation.

Conclusion

The increasing of stock density of rainbow and brown trout leads to the decreasing of growth rate. Body weight of fish from SD_2 is respectively 6.32% and 24.25% lower than that of individuals from SD_1 ($P<0.05$). The influence of stocking density on growth performance and feeding conversion ratio was higher in the tanks with brown trout ($P<0.001$) compared to the tanks in which we grew rainbow trout ($P<0.05$).

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