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EFFECT OF STOCKING DENSITY ON GROWTH PERFORMANCE, FEED CONVERSION AND FISH PRODUCTION OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*), CULTIVATED IN RACEWAYS

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Abstract

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One of primary factors determining high yields in fish farming is the optimum stocking density. The aim of the present study was to establish the effect of stoking density of rainbow trout (*Oncorhynchus mykiss*), cultivated in raceways on growth performance, feed conversion and fish production.

For this purpose, 30 000 fish were randomly distributed in 6 raceways (5 000 fish/raceway). In the beginning of the experiment trouts weighed 21-22 g. Two different stocking densities were investigated – 150 fish/m³ (SD1) in control group (C) and 125 fish/ m³ (SD2) in experimental group (E). Each group was run in three replications. The experiment's duration was 60 days. The fish of experimental group exhibited better growth performance by 11.46% and higher fish production by 12.42%, compared to the control group ($p \leq 0.001$).

Key words: stocking density; rainbow trout (*Oncorhynchus mykiss*); FCR; growth performance

Introduction

During the last years, aquaculture as a branch of agriculture has marked a very intensive expansion at a global scale. The main purpose of aquaculture is the production of more hydrobionts per unit water area, compared to the natural production of water basins. Recently, there is a tendency for increase of aquaproduction in new intensive farms, mainly for farming of common carp and rainbow trout, as well as other economically relevant species. According to data of FAO, fish production will increase during the next years to attain about 80 million of tones in 2050.

In Bulgaria, aquaculture produce comprises mainly two fish families, common carp (*Cyprinus caprio*) and rainbow trout (*Oncorhynchus mykiss*). The data from the 2014 official statistics of the Executive Agency for Fisheries and Aquaculture (EAFA) reported 82.4% total consumption of fish, with 35.7% relative share of common carp and 17.4% of rainbow trout. Due to its rapid growth, rich and variable content of meat, rainbow trout is preferred for human consumption (Gladishev et al., 2006). Various production systems and specially designed units are currently used for rainbow trout farming. They differ by several important parameters with respect to age and categories, namely size, structure, water supply, intensity level, possibility for technological control etc.

The superintensive fish farming technologies include production in net cages, recirculation systems, tanks and other facilities, as raceway, which are associated to area reduction and increased stocking density (Brännäs and Linnér, 2000). One of essential factors for fish farming using superintensive technologies is the optimum stocking density to obtain high yields (Zhang et al., 1999; Brannas and Linner, 2000). According to several authors, the optimum stocking density varies according to fish species, age, water chemical parameters in basins (Beveridge, 2002, Chua and Tech, 2002; Masser, 2004; Sorphea et al., 2010; Abdelhamid, 2011; Pouey et al., 2011; Khatune- Jannat et al., 2012). Very high stocking

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densities are associated with poor oxygen content, pollution of water with wastes and negative effects on growth performance of fish (Stuart et al., 2006). The stocking density far from the optimum influences adversely the metabolism of fish consequently to increased level of stress (Braun et al., 2013). The high stocking density increased death rates in fish (Mazlum, 2007; Zhu et al., 2011; Wang et al., 2013). In many occasions, this could reduce fish production and results in death of farmed species (Barcellos et al., 2004; Kristiansen et al, 2004;. Schram et al., 2006; Boscolo et al., 2011).

The aim of the present study was to establish the effect of stoking density of rainbow trout (*Oncorhynchus mykiss*), cultivated in raceways on growth performance, feed conversion and fish production.

Materials and Methods

The experiment was conducted in the fish farm Ribena Ltd, Zlatna Panega. The total area of the rainbow trout farm is 100 ha, it's annual production – about 300 000 kg per year. This makes the farm a leading one for the country. Two different stocking densities were used. The control group (C) was stocked at 150 fish /m³ (SD_1) and the experimental group (E) – at 125 fish/m³ (SD_2). Each variant had three replications, respectively C_1, C_2, C_3, E_1, E_2 and E_3. A total of 30 000 fish were randomly divided into 6 raceways (5 000 fish/ raceway). In the beginning of the experiment, the weight of fish was about 21-22 g. All replicates were manually fed 6 times a day. The daily ration was divided into six parts, offered at equal time intervals: 08.00, 10.00, 12.00, 14.00, 16.00 and 18.00 h. The feed was pelleted, with 45% crude protein. The duration of the experiment was 60 days from October 14 to December 12.

During the experiment, water chemical parameters were monitored. Samples of water were obtained at 50 cm below the water surface. They were analysed at 3-day intervals for amount of dissolved oxygen (ppm); water pH and temperature (°C). The growth performance of rainbow trout from control and experimental groups was monitored through control catches of 40 fish from each group in the beginning, middle and end of the trial. At the end, feed conversion ratio (FCR), fish production (kg/m³) and mortality rate (%) of fish were calculated for all replications.

Results and Discussion

Water temperature

During the experiment. the water temperature in raceways varied within the optimum range for rainbow trout (from 12 to 17°C, Figure 1).

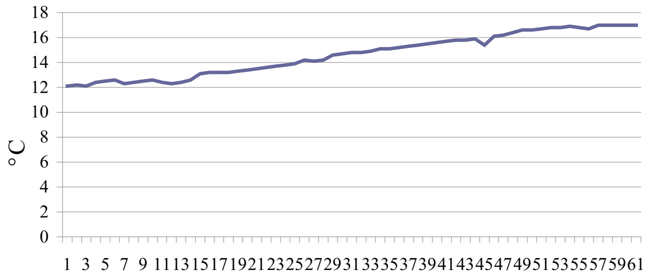

Fig. 1. Water temperature

Water pH

The water pH in the fish farm was optimal for the farmed species – from 6.7 to 8.0 (Fig. 2).

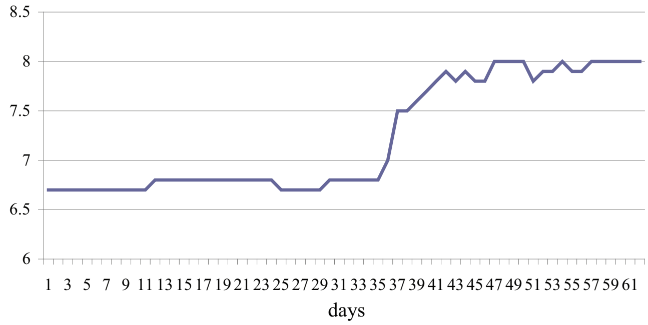

Fig. 2. Water pH

Water oxygen content

The amount of oxygen dissolved in water during the experimental period varied within the allowances of the species: 8.0 – 8.5 ppm (Figure 3).

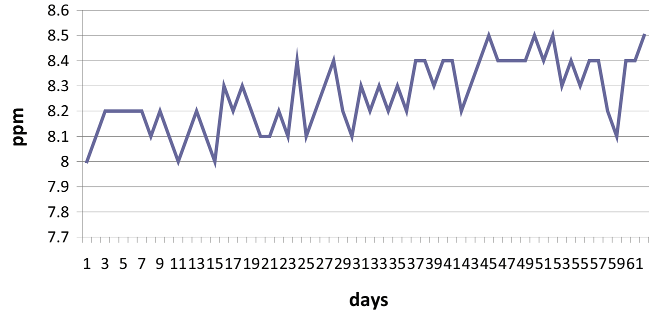

Fig. 3. Water oxygen content

Feeding of rainbow trout

During the experiment, fish were fed daily extruded feed and the ration was divided into 6 equal parts. Fish from all groups, control and experimental, were weighed at 15-day intervals and their daily ration was corrected as percentage of the total biomass. The feed conversion ratio of rainbow trout from all experimental replications were substantially lower as compared to fish from control replications ($p < 0.05$) (Figure 4).

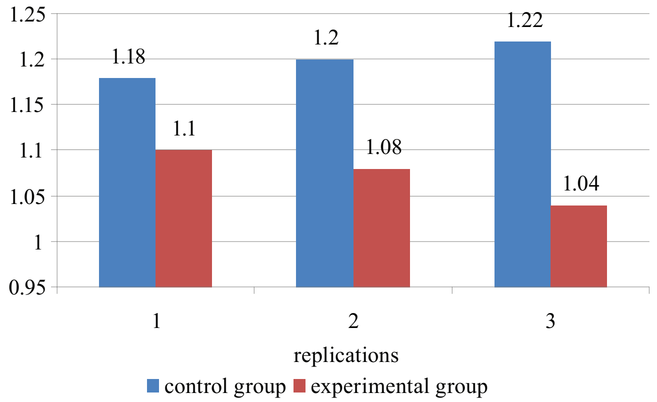

Fig. 4. Feed conversion ratio

Growth performance of rainbow trout

Average initial body weight of rainbow trout from all control and experimental replications were similar: 21.2 – 21.9 g, without significant differences ($p > 0.05$) (Table 1, Figure 5).

In the middle of the trial, the live weight of rainbow trout from the three experimental replications was statistically significantly higher than that of control fish ($p<0.001$) (Table 1, Figure 6).

The final live body weight of rainbow trout is presented on Figure 7.

Fish from all experimental replications exhibited a more intensive growth and higher body weight than control fish ($p < 0.001$) (Table 1, Figure 7).

The fish production of all experimental rainbow trout replications stocked at SD_2 was considerably higher than that in controls ($p<0.01$) (Figure 8).

Fish production increased parallelly to stocking density, but on the account of individual live weight of fish.

Table 1
Growth performance of rainbow trout (g)

Group		C_1	C_2	C_3	E_1	E_2	E_3
		n=40	n=40	n=40	n=40	n=40	n=40
Initial body weight, g	$\bar{x}$	21.4	21.7	21.9	21.3	21.7	21.20
	$S\bar{x}$	1.96	1.91	1.52	1.64	1.87	1.44
	Cv	3.84	3.65	2,30	2.68	3.50	2.06
Middle body weight, g	$\bar{x}$	65.1 a	67.2 в	68 c	70 a	72.4 в	74.8 c
	$S\bar{x}$	3.99	3.53	4.13	3.26	2.93	3.19
	Cv	15.88	12.48	17.07	10.68	8.61	10.16
Final body weight, g	$\bar{x}$	145.20 d	146.70 e	143.4 f	161.40 d	163.10 e	160 f
	$S\bar{x}$	7.62	6.77	5.96	5.10	5.46	5.77
	Cv	58.11	45.90	35.48	26.04	29.78	33.34

The difference among mean values within a row marked with the same letters are statistically significantly different: a-a; b-b; c-c; d-d; e-e; f-f $p \leq 0.001$

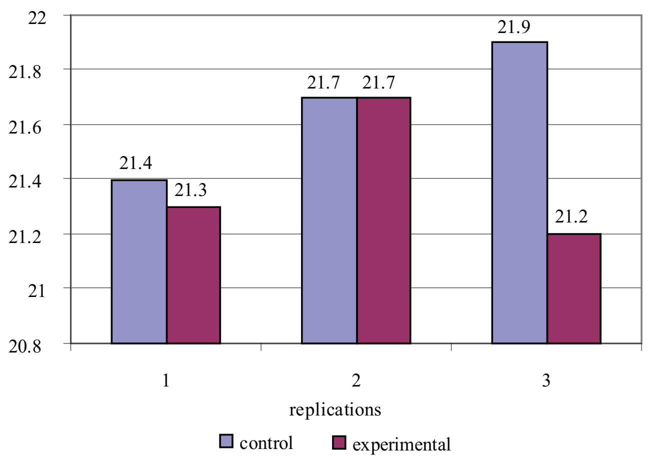

Fig 5. Live body weight at the beginning of the experiment

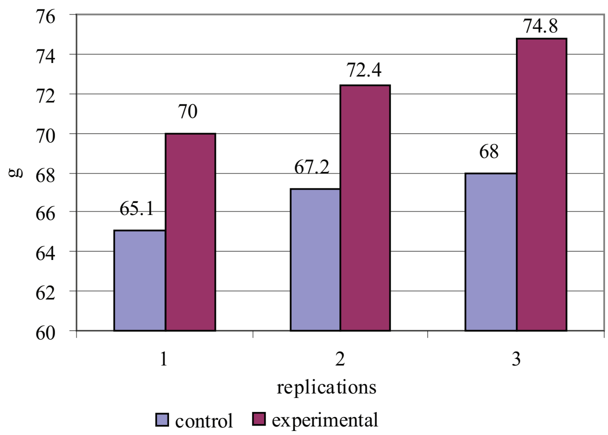

Fig 6. Live body weight of rainbow trout in the middle of the experiment

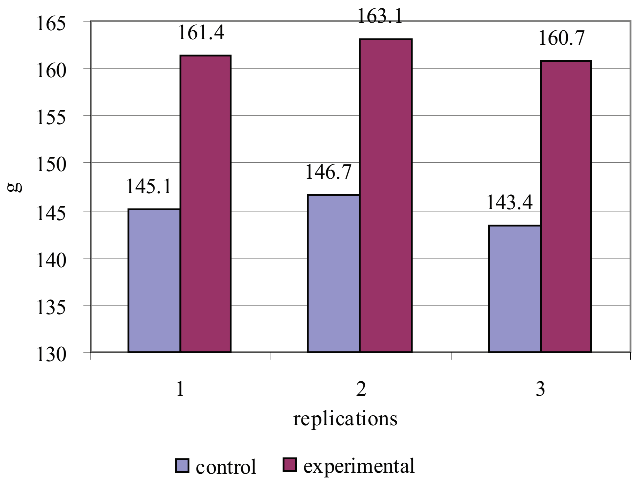

Fig. 7. Live body weight of rainbow trout at the end of the experiment

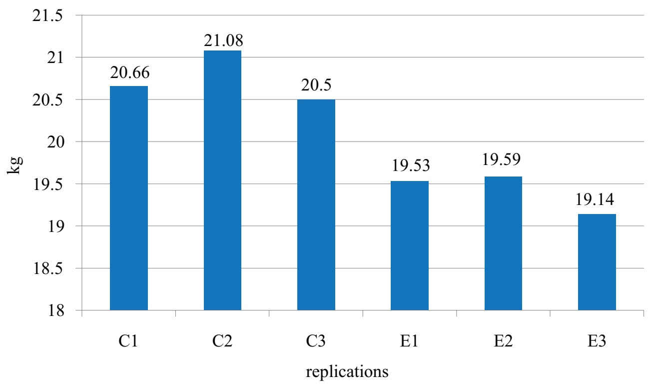

Fig. 8. Fish production

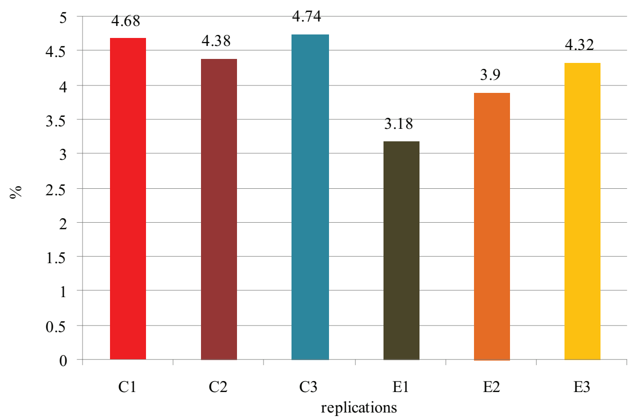

Fig. 9. Mortality rate of rainbow trout

Similar results were reported by other researchers in studies on optimisation of fish stocking densities (Hassan et al., 2006; Rowland et al., 2006; Khatune et al., 2012).

Mortality rate of rainbow trout

The mortality rate of rainbow trout from the experimental replications was consdierably lower ($p < 0.001$) than this one of fish from control group at SD_1 (Figure 9).

Conclusions

The farming of rainbow trout at stocking density of 125/m^3 had positive effects on production traits of the farmed fish species as followed:

increased growth performance by 11.30 %;

reduced FCR by 10.84%;

reduced mortality rate by 17.39%.

The total fish production was by 6.47% higher at stocking density of 150 fish/m^3 although the production traits of fish were better at stocking density of 125 fish/m^3

References

Abdelhamid, A., 2011. Intensive Rearing of Mono-Sex Nile Tilapia and Silver Carp Under Mono-or Poyculture Systems at different Stocking Densities in Floating Net Cages. http://en.engormix.com/MA-aquaculture/

Barcellos L, L. Kreutz, R. Quevedo, I. Floreze, L. Cerlcato, B. Soso, M. Fagundes, J. Conrad, R. BaldIssera, A. Bruschl and F. Ritter, 2004.Nursery rearing of jundiá, Rhamdia quelen (Quoy & Gaimard) in cages: cage type, stocking density and stress response to confinement. Aquaculture, 232: 383-394.

Beveridge, M, 2002. Overview of cage culture. In: K. Woo, W. Bruno and S. Lim (Eds.), Diseases and Disordersof Finfish in Cage Culture. *CABI Publishing*, Oxon, pp. 41-59.

Boscolo, C., R. Morais and E. Gonçalves-de-Freitas, 2011. Same-sized fish groups increase aggressive interaction of sex-reversed males Nile tilapia GIFT strain. *Applied Animal Behavior Science*, 135: 154-159.

Branas, E. and J. Linner, 2000. Growth effects in Artic charr reared in cold water: feed frequency, access to bottom and stocking density. *Aquaculture International*, 8: 381-389.

Braun N, A. Dafre, R. Lima, L. Beux, F. Brol and A. Nuñer, 2013. Growth and stress of dourado cultivated in cages at different stocking densities. *Pesq. Agropec. Bras.*, Brasília, 48 (8): 1145-1149.

Chua, E. and E. Tech, 2002. Introduction and history of cage culture. In: K. Woo, W. Bruno, S. Lim (Eds.), Diseases and Disorders of Finfish in Cage Culture. *CABI Publishing*, Oxon, 1-39.

Gladishev, M. I., N. N. Sushchik, G. A. Gubanenko, S. M. Demirchieva and G. S. Kalachova, 2006. Effect of way of cooking on content of essential polyunsaturated fatty acid in muscle tissue of humpback salmon (*Oncorhynchus gorbuscha*).

Food Chem., 96: 446-451.
Hassan, S., A. Hassan and H. Mahmoud, 2006. Effect of stocking rate and organic fertilization on the growth performance of tilapia aurea (Oreochromis aureus). *Journal of Agricultural Sciences*, **31** (2): 617-625.
Khatune, J., M. Rahman, A. Bashar, N. Hasan, F. Ahamed and Y. Hossain, 2012.Effects of Stocking Density on Survival, Growth and Production of Thai Climbing Perch (*Anabas testudineus*) under Fed Ponds. *Sains Malaysiana*, **41** (10): 1205-1210.
Kristiansen, S., A. Ferno, C. Holm, L. Privitera, S. Bakke and E. Fosseidengen, 2004. Swimming behaviour as an indicator of low growth rate and impaired welfare in Atlantic halibut (*Hippoglossus hippoglossus* L.) reared at three stocking densities. *Aquaculture*, 230: 137-151.
Masser, P., 2004. Cages and in-pond raceways. In: C. S. Tucker and J. A. Hargreaves (Eds.), Biology and Culture of Channel Catfish. *Elsevier*, Sydney, 530-544.
Mazlum, Y., 2007. Stocking density affects the growth, survival, and cheliped injuries of third instars of narrow-clawed crayfish, Astacus leptodactylus Eschscholtz, 1823 juveniles. *Crustaceana*, 80: 803-815.
National Statistical Institute, 2014. Report for the annual consumption of fish and other aquatic organisms by households and their production in Bulgarian in 2013. *National Statistical Institute*, Department of Income, Expenses of Households and Quality of Life, Sofia.
Pouey, J. L. O. F., S. R. N. Piedras, C. B. Rocha, R. A. Tavares, J. D. M. Santos and A. C. P. Britto, 2011. Productive performance of silver catfish, Rhamdia quelen, juveniles stocked at different densities. Ars Veterinaria 27: 241-245.
Rowland, J., C. Mifsuda, M. Nixona and P. Boydb 2006. Effects of stocking density on the performance of the Australian freshwater silver perch (*Bidyanus bidyanus*) in cages. *Elsevier*, 301-308.
Schram, E., W. Van der Heul, A. Kamstra and M. C. J. Verdegem, 2006. Stocking densitydependent growth of Dover sole (*Solea solea*). *Aquaculture*, 252: 339-347.
Sorphea, S., T. Lundh, T. R. Preston and K. Borin, 2010. Effect of stocking densities and feed supplements on the growth performance of tilapia (Oreochromis spp.) raised in ponds and in the paddy field. *Livest. Res. Rural Dev.*, 22: 227.
Stuart, J., J. Rowlanda, C. Mifsuda, M. Nixona and P. Boydb, 2006. Effects of stocking density on the performance of the Australian freshwater silver perch (*Bidyanus bidyanus*) in cages. *Elsevier*, 301-308.
Wang, X., W. Dai, M. Xu, B. Pan, X. Li and Y. Chen, 2013. Effects of stocking density on growth, nonspecific immune response, and antioxidant status in African catfish (*Clarias gariepinus*). *The Israeli Journal of Aquaculture* – Bamidgeh, 6.
Zhang, T., Z. Yang, R. Sun, 1999. Effect of *Common carp* culture in small cages and its relation with rearing density. *Journal of Fishery Sciences of China*.
Zhu, Y. J., D. G. Yang, J. W. Chen, J. F. Yi, W. C. Liu and J. H. Zhao, 2011. An evaluation of stocking density in the cage culture efficiency of Amur sturgeon Acipenser schrenckii. *Journal of Applied Ichthyol.*, 27: 545-549.

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