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Production Systems

Growing of common carp fingerlings in net cages at different stoking densities

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Abstract. *The stocking density is one of the most important parameters of fish growth and productivity in farming activities. The aim of the study was to evaluate the effects of different stocking densities on growth rate and body indices of common carp fingerlings /Cyprinus caprio L./, reared in net cages. The trial was set up as a complete randomized design, with three different stocking densities (SD_1 – 300, SD_2 – 500 and SD_3 – 700 fish/m^3), each of them with three replications. The initial body weight of fish was 0.9 g. The size of net cages was 1.50 x 1.50 x 1.50 m, with effective depth of the mesh 1.0 m and water volume - 2.25 m³. The trial lasted 122 days. The highest final body weight was attained by fish with stocking density of 300 fish/m³ – 75.55 g. The increased stocking density resulted in lower final weight of fingerlings SD_2 and SD_3 ($p<0.05$, $p<0.001$). The higher stocking density influences substantially the exterior traits and body indices of carp fingerlings. There were statistically significant differences between mean relative body width between SD_1 and SD_3 groups ($p \leq 0.001$) as well as between relative head length group between one summer old fish from SD_1 and SD_3 ($p \leq 0.001$). The survival of fingerlings decreased as the stocking density increased, but remained within the allowed reference ranges for all three experimental variants. The fish production was the highest for carp fingerlings stocked at SD_3, but it was also associated with a large proportion of fingerlings whose size was under the fish farming standards.*

Keywords: common carp fingerlings, stocking density, net cages, intensity of growth, survival rate

Introduction

Super intensive fish farming systems (net cages or recirculation systems) are related to smaller pond areas in fish farms and higher stocking densities. The optimization of the latter is among the essential factors for obtaining high yields from rearing different fish species in net cages (Zhang et al., 1999; Brannas and Linner, 2000). It is acknowledged that as stocking density increases, the fish production per unit volume becomes higher, but the average individual weight of cultured fish decreases (Beveridge, 2002; Atanasov and Staykov, 2003). At very high stocking densities, problems with oxygenation regimen, water contamination with waste products etc. could occur, with subsequent negative impact on the growth intensity of fish (Staykov, 2001; Stuart et al., 2006; Nikolov, 2008).

A number of authors found variations in the optimum stocking density of fish in net cage systems depending on the species, age category, cage size, speed of water currents and hydrochemical parameters (Beveridge, 2002; Chua and Tech, 2002; Masser, 2004; Abdelhamid, 2011). Staykov (1990) demonstrated that the highest yields were obtained with common carp fingerlings stocked in net cages at 600/m^3. According to Das et al. (2009), the number of fish for yearling carp farming should be 500/m^3. The higher stocking density of fish increased mortality rates (Wang et al.,2013). Demétrio et al. (2012) reported a negative relationship between stocking density and growth rate of fish. Fish production increases in parallel to stocking density, but at the expense of lower individual weight of fish (Hassan et al., 2006; Nikolov, 2013). Some researchers believe that the increase in stocking density up to 400/m^3 could have a negative effect on growth intensity and alter the metabolism of fish as a result of higher stress levels (Braun et al., 2010). This could result in lower production rate and even death of the farmed species (Montero et al., 1999; Barcellos et al., 2004; Kristiansen et al, 2004; Schram et al., 2006; Boscolo et al., 2011). The analysis of literature demonstrated that the stocking density optimization is the major issue in common carp fingerlings farming in net cage systems (Stuart et al., 2006; Khatune et al., 2012).

The aim of the study was to evaluate the effects of different stocking densities on growth rate and body indices of common carp fingerlings (*Cyprinus caprio* L.), reared in net cages.

Material and methods

The experiment was conducted in the fish farm of Nomikom-N Vodenicharov Co, in the Ovcharitsa dam – a technological cooling pond of the electrical power plant Maritsa-Iztok 2, with water area of 1000 ha. The experiment lasted 122 days. The net cages used in the trial were of size 1.50 x 1.50 x 1.50 m. The effective mesh depth was 1.0 m, and cage volume – 2.25 m³. For growing common carp three stocking densities were used, each having three replications: SD_1 – 300/m³; SD_2 – 500/m³ and SD_3 – 700/m³. Fingerlings with average body weight of 0.9 g were inoculated in all net cages.

The hydrochemical parameters were optimal, both in net cages and the adjacent aquatory. Their changes throughout the experiment varied within the allowed ranges for the farmed species (water temperature 19.0 – 28.1°C; water pH 7.1 – 8.0; oxygen level 6.8 – 8.5 ppm).

Initially the fingerlings were fed starter feed for rainbow trout. During the first 30 days pelleted feed with 45% crude protein was used at a daily amount of 10% from the total biomass. Fish received feed five times per day. To the end of the trial period carp feed with

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31% crude protein level was offered at a daily amount of 10% of the total biomass, which was gradually decreased up to 5% at the end of the experiment.

For determining the growth intensity of carps, control catches of fish were performed at 15-day intervals. At the end of the trial, individual measurements of the following metric traits and weight of fingerlings were obtained: live body weight (g); body length (l, cm); head length (C, cm); body width (D, cm); greatest body height (H, cm); girth of body (O, cm).

The body development of one summer old fish was evaluated on the basis of numerical metric data by calculation and analysis of the following indices: relative body height, l/H; relative body width, D.100/l; relative head length, C.100/l; length-girth ratio, l/O.

For evaluation of the condition of one summer old carps, the coefficient of condition (%) was calculated as per Fulton-Polyakov:

$$K = \frac{g.100}{l^3}$$

Fish production (kg/m³) and survival rate (%) of carps were determined at the end of the experiment. Data were statistically processed with Statistica 6 software (StatSoft Inc., 2002).

Results and discussion

The hydrochemical parameters in net cages during the experiment with common carp fingerlings grown at different stocking densities are presented on Figures 1, 2 and 3. All were within the technologically allowed ranges for the species.

Table 1. Metric and weight measurements of common carp fingerlings

Exterior traits		Stocking density SD_1 n=150	Stocking density SD_2 n=150	Stocking density SD_3 n=150
Live body weight, g	Mean	$75.55^{a,b}$	$60.39^{a,c}$	$37.75^{b,c}$
	SEM	5.10	5.9	3.24
	CV	45.90	64.21	60.22
Standard length, cm	Mean	12.2^{df}	$11.08^{d,e}$	$10.32^{e,f}$
	SEM	0.33	0.39	0.28
	CV	18.55	24.33	19.00
Head length, cm	Mean	3.89^{g}	3.46^{g}	3.43^{g}
	SEM	0.11	0.14	0.15
	CV	19.44	27.46	31.07
Body width, cm	Mean	2.72^{k}	2.32^{h}	$2.17^{k,h}$
	SEM	0.08	0.08	0.05
	CV	19.45	23.81	16.74
Greatest body height, cm	Mean	$4.45^{l,m}$	4.05^{l}	3.91^{m}
	SEM	0.12	0.15	0.16
	CV	18.76	25.35	28.12
Girth of body, cm	Mean	$11.38^{n,r}$	10.59^{n}	9.81^{r}
	SEM	0.30	0.36	0.25
	CV	18.16	23.37	17.59

Equal letters within a row indicate statistically significant differences between means: a-a,e-e,d-d,g-g,h-h, n-n – $p\leq0.05$; f-f – $p\leq0.01$; b-b,c-c, l-l,m-m,r-r,k-k – $p\leq0.001$.

The cultivation of carp fingerlings at stoking densities SD1 – 300 fish/m^3; SD2 – 500 fish/m^3; and SD3 – 700 fish/m^3 showed that fish stocked at SD_1 attained the highest body weight (Table 1). In this experimental variant carp fingerlings grew most intensively and attained final live weight of 75.55 g. The comparison of the final body weight at SD_1 – 300 fish/m^3 to the other two experimental variants revealed that it was higher by 20.07% and 50.03%, respectively. The higher growth rate of SD_1 carps was probably due to the lower energy losses caused by lower feeding activity of fish resulting from the optimised stocking density. The respective losses in SD_2 and SD_3 variants were higher and were due to the enhanced competition for feed of the higher number of fish per unit volume.

There was a trend for higher standard body length in SD_1 fish – 12.2 cm, compared to that of SD_2 group – 11.08 cm and SD_3 group –

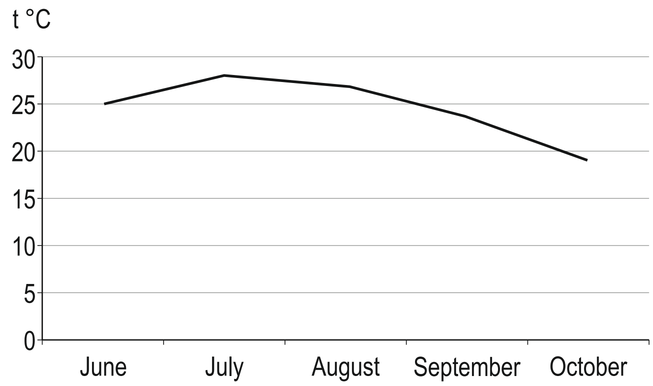

Figure 1. Water temperature in net cages

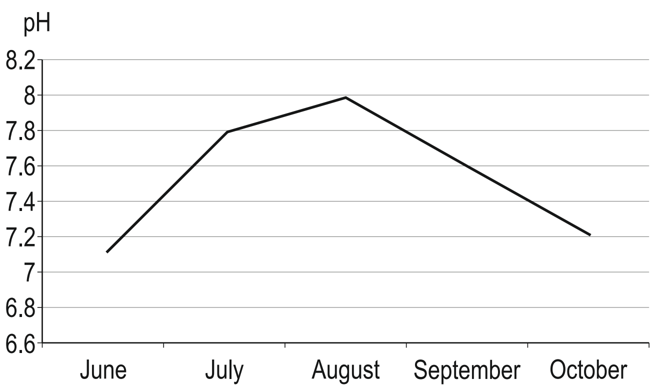

Figure 2. Water pH

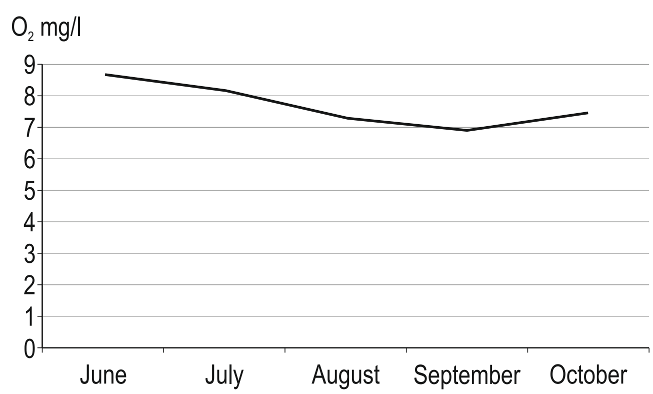

Figure 3. Dissolved oxygen in water

Table 2. Body indices

Features			SD_1	SD_2	SD_3
			n=150	n=150	n=150
Indices of relative body height	Mean SEM	±	2.69±0.03	2.74±0.02	2.66±0.03
	CV		0.12	0.15	0.14
Indices of relative body width	Mean SEM	±	22.1a±0.14	20.94±0.15	20.89a±0.19
	CV		0.87	0.79	0.95
Indices of relative head length	Mean SEM	±	31.70a±0.31	31.23±0.29	33.01a±0.34
	CV		2.75	2.98	3.01
Indices of length-girth ratio	Mean SEM	±	1.08±0.07	1.05±0.06	1.05±0.06
	CV		0.07	0.04	0.05

Equal letters within a row indicate statistically significant differences between means: a-a – $p\leq0.001$

Table 3. Fattening coefficients of one summer old carps, reared at different stocking densities

Stocking density	Fattening coefficient			
	n	Mean	SEM	Cv
SD_1	150	4.09^a	0.05	0.15
SD_2	150	4.44	0.07	0.21
SD_3	150	3.37^a	0.06	0.23

Equal letters within a row indicate statistically significant differences between means: a-a – $p\leq0.001$

Table 4. Survival of one summer old carps reared at different stocking densities, /%/

Stocking density	Number at the beginning of the experiment	Number at the end of the experiment	Survival
SD_1	1800	1746	97.0%
SD_2	3000	2904	96.8%
SD_3	4200	4015	95.6%

10.32 cm (by 3.28% and 12.2%). The width of the body and the girth of the body differed between SD_1 and SD_3, both at $p\leq 0.001$. This tendency was preserved also for other body dimensions of SD_1 fish. The result of other researchers reporting significant influence of the number of cultured fish per unit volume on the growth norm which decreased in parallel to increasing stocking density were comparable to ours (Brannas and Linner 2000, Wallat et al., 2004).

Table 2 presents the body indices of one summer old carps reared at different stocking densities. The calculated indices were within the reference ranges, as follows: relative body height – from 2 to 3, relative body width – over 16, relative head length – from 24 to 37. Only the length-girth ratio was higher than the reference value of 1.0 and higher. There were statistically significant differences between mean relative body width between SD_1 and SD_3 groups ($p\leq 0.001$) as well as between relative head length group between one summer old fish from SD_1 and SD_3 ($p\leq0.001$).

Table 3 presents the data about fattening coefficients of fish reared at the different stocking densities. As stocking density increased, the fattening coefficients went down. In fish stocked at SD_1, the coefficient was higher than in SD_2 and SD_3 groups. The average fattening coefficient of fish from the SD_1 group was statistically significantly higher than that of the SD_3 group ($p\leq0.001$).

Table 4 depicts the survival rate of carps reared at different stocking density. Survival was the highest in the SD_1 group – 97.0%, followed by SD_2 – 96.8 % and the lowest in SD_3 – 95.6%. The analysis showed that fish survived better at lower stocking densities and that the increase in the latter resulted in higher mortality in one summer old carps.

Fish production in the different groups at the end of the experiment was as follows: SD_1 – 13.80 кg/m^3, SD_2 – 29.80 кg/m^3, SD_3 – 36.71 кg/m^3. With increasing stocking density the results indicated increase in fish production, but at the expense of lower individual weight of fish, as also confirmed by the studies of other authors (Hassan et al., 2006; Nikolov, 2013). This fact allowed recommending the use of stocking density of 300 fish/m^3 in net cages. At this stocking density, good performance results are obtained, the production costs are optimum, including lower costs for feed. The latter is a prerequisite for maintaining the ecological equilibrium in waters where net cages for cultivation of this aquaculture species are located.

Conclusions

The highest final body weight was attained by fish from the SD_1 group – 75.55 g. It was higher compared to SD_2 and SD_3 groups by 20.07% and 50.03%, respectively.

The higher stocking density influences substantially the exterior measurements of carps, but not body indices, which remained within the optimal reference ranges of the species. There was a trend for higher standard body length of fish from SD_1 (12.2 cm), compared to that of SD_2 group (11.08 cm) and SD_3 group (10.32 cm), by 3.28% and 12.2%, respectively. This tendency was preserved also for other body dimensions of SD_1 fish.

The survival of fingerlings decreased as the stocking density increased, but remained within the allowed reference ranges for all three groups. Survival rate was the highest in the SD_1 group – 97.0%, followed by SD_2 – 96.8 % and the lowest in SD_3 – 95.6%. The conclusion is that fish survived better at lower stocking densities and that the increase in the latter resulted in higher mortality in one summer old carps.

The production of carps reared at SD_2 and SD_3 was higher than that of fish stocked at SD_1 by 54% and 63%, respectively. However, this was associated with lower body weights of SD_2 and SD_3 specimens as they did not attain the optimum weights as required by aquaculture technology.

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CONTENTS

CONTENTS

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