THE INFLUENCE OF GENETIC VARIABILITY ON THE GROWTH PERFORMANCE OF COMMON CARP IN A RECIRCULATING AQUACULTURE SYSTEM

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Abstract

The paper is presenting some aspects regarding the influence of size on the breeding of 14-month common carp, in a recirculating aquaculture system. The experiment lasted 38 days, in four breeding units of 500 liters in volume each. Four types of variants were compared: V_1-with a stocking density of 443 fish and a body weight of 44,45 g/fish (initial biomass of 39,38 kg/m^3); V_2-with a stocking density of 307 fish and a body weight of 63,85 g/fish (initial biomass of 39,21 kg/m^3); V_3- with a stocking density of 217 fish and a body weight of 89,98 g/fish (initial biomass of 39,05 kg/m^3); V_4- with a stocking density of 138 fish and a body weight of 141,5 g/fish (initial biomass of 39,05 kg/m^3). The technological indicators that showed up at the end of the experiment revealed the following: the biomass gain in V1 was of 9,03 kg/m^3, 9,67 kg/m^3 in V2, 12,19 kg/m^3 in V3, and 12,88 kg/m^3 in V4; the specific growth rate (SGR) was of 0,54 g%/day (V1), 0,58 g%/day (V2), 0,71 g%/day (V3) and 0,75 g%/day (V4); the feed conversion ratio (FCR) was of 2,24 g pellets/g biomass gain (V1), 2,09 g pellets/g biomass gain (V2), 1,66 g pellets/g biomass gain (V3) and 1,57 g pellets/g biomass gain (V4). The research showed that common carp has a very good technological adaptability. The best growth performance was achieved in the variant with a smaller stocking density and a higher fish size.

Key words: common carp, size, RAS

INTRODUCTION

Since there are relatively large differences between individuals in their genetically determined potential for growth, the choice for specimens with a faster growth rate is particularly important in aquaculture. It is known that a biomass crop growth performance is linked, first of all, to an efficient utilization of food. For example, the yield increase is clearly superior in carp to that of tench, and this explains the latter's low supply on the market, though it is a valuable fish, appreciated by consumers. [8]

The model developed by Iwama and Tautz [5] provides a good description of growth in the juvenile stage, but this is not sufficient to present growth of the adult individuals. It is known that the length and mass growth rate is usually lower in adult specimens. This phenomenon affects every eventual recovery processes, i.e. compensatory growth, to a significant extent. This means that the specimens not showing any response of compensatory increase can still show a recovery increase after a period of weight loss. [7]

Juvenile population, probably need more time to find food because they have less energy storage capacity and a higher specific metabolic rate. Specimens' size depends on the relationship between foraging time and its quantity. [10]

The paper presents some important issues relating to growth of juvenile carp, *Cyprinus carpio, Linnaeus*, 1758, in terms of industrial aquaculture recirculating system.

MATERIAL AND METHOD

The material facility where experimental measurements were made was the pilot recirculating system of the Department of

Fisheries and Aquaculture of the University "Dunarea de Jos". Experiments were conducted in July-August, 2010, for a period of 38 days, in four growth units with a capacity of 500 l /unit.

The configuration of the recirculating pilot system for intensive carp growth, designed and created by our specialists, involved the integration of water treatment equipment (mechanical, chemical and biological filters) with breeding units,
that had to be appropriately sized in relation to technology used (fig. 1).[2]

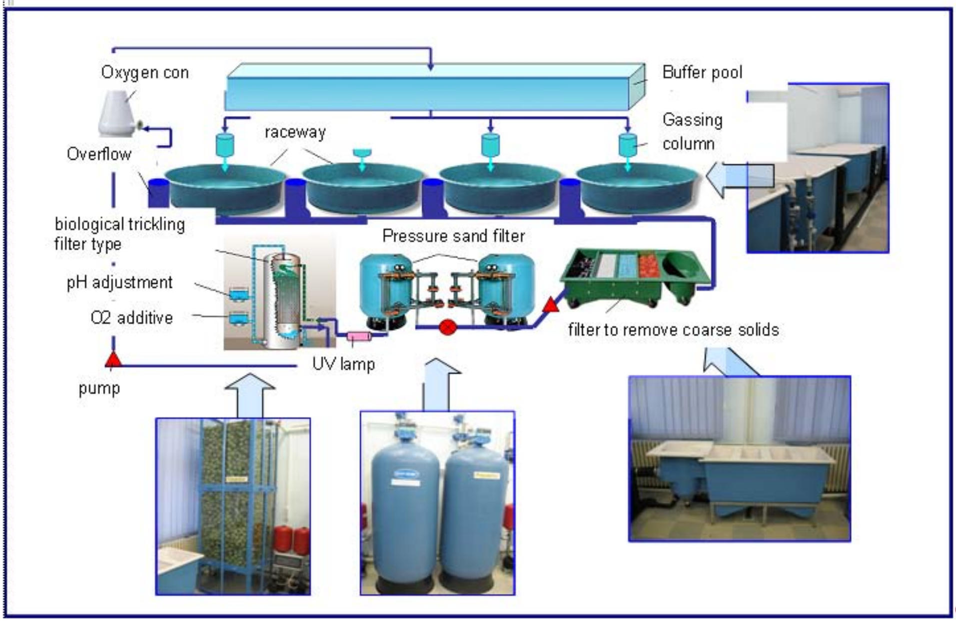

Fig 1. Recirculating System (Cristea, 2008)

The recirculating system consists of four octagonal growth tanks with geometry and hydraulics are meant to comply with the technological requirements in terms of yield rapid elimination of solids. The effluent of the 4 growth units is collected and transported to the mechanical filter (filter road), which retains solid particles and removes them regularly. The process of removing solids from the waste water continues to the next stage of mechanical filtration represented by a sand filter – active charcoal type ACLM 05 - ROMET Buzau (10 m3/h – maximum filtering speed). Water circuit between the mechanical and biological filter is provided with a recirculation pump P1, the water reaching the top of the biological filter (filter medium volume: 1.3 m^3). Gravitational water collection is done in one tank located at the bottom of the biofilter. From this point, the water is taken up by pump P2 to the denitrifier filter (organize pressure: 2.0 to 6.0 bar) and to a UV filter (wavelength: 254 nm), then transferred into breeding tanks.

The recirculating system is equipped with a sensor system that ensures monitoring of the following parameters: level, temperature and dissolved oxygen concentration in all four growth units, the supply and exhaust flow for each unit, ammonia concentration measured at two points - before and after the biofilter, the concentration of nitrite and nitrate in water, dissolved oxygen concentration measured after biological treatment of water, the pH of the drainage basin of the mechanical filter, and pH used at the supply points. The system is equipped with a control module for the following variables: dissolved oxygen concentration and water level in each basin, the pH of the mechanical tank filter. Level in the tanks is controlled by automatic valve located after the mechanical filter which is designed to supply water from the mains system. Recirculation flow is controlled by an automatic valve located after the mechanical filter which is designed to supply water from the main system. The recirculating flow is controlled by the on / off option of pump P1, respectively pump P2. The objective of the control system is to keep the prescribed values of the main parameters of water quality within the limits (inside the breeding tanks): dissolved oxygen, ammonia, nitrite, and nitrate concentration.

The recirculating flow, depending on which the components of the recirculating system were sized, is $4m^3/h$, ensuring the entire volume of water exchange of a breeding tank, every half hour.

Biological material used in the experiment is represented by juvenile carp aged 14 months, provided by Research and Development Institute of Aquatic Ecology, Fisheries and Aquaculture Galati from Brates breeding station. Sapling was obtained through artificial reproduction using breeding adults captured in the Danube.

Starting from the premise that individual size differences were due to genetic variability, respectively different feeding behaviour, carp samples were randomly distributed into four size classes, namely:

- experimental variant V1: B1-39, 38 kg/m3-443 average weight samples 44.45 g / specimen,
- experimental version V2: B2-39, 21 kg/m3-307 average weight samples 63.85 g / specimen,
- experimental variant V3: B3-39, 05 kg/m3-217 average weight samples 89.98 g / specimen,
- experimental version V4: B4-39, 05 kg/m3-138 average weight samples 141.5 g / specimen.

Somatic measurements were conducted on a sample of 10 copies of each pool, at the beginning and in the end of the experiment, determining the total length (L ± 1 mm) and body weight (W ± 1g). Length-weight correlation was determined using the formula: $W = a * L^b$ where: W- body weight (g), L-total length (cm) b-index with values ranging between 2 and 4.

Food used for culture biomass was ALLER MASTER type 3mm grain and a protein content of 35% (Tab. 1). Ration used in this experiment was 1.2% of body weight. Feed was automatically distributed through nutritious lanes with a capacity of 5 kg. Food was continuously administered in breeding units during 9AM-9 PM, so providing equal opportunities for all samples in the basins.

ALLER MASTER is know for its high energy content and is recommended for intensive production of carp.

Tab 1.Biochemical composition of the ALLER MASTER 4mm feed

Parameter	**Quantity**
Crude protein	35%
Crude fat	9 ,9%
NFE	36%
Ash	7.8%
Fibres	4.2%
Gross energy	4476/18 .7 Kcal/MJ
Convertible energy	3485/14.6 Kcal/MJ
N in dry substance	6.1%
P in dry substance	1.3%
Energy in dry substance	4865/20.3 Kcal/MJ
Vitamine A	2500(IE)
Vitamine D3	500(IE)
Vitamine E	150(mg)
Ingredients: fish flour, soybean, pea proteine, flour, rapeseed, wheat, fish oil, vegetable oil, minerals and vitamines.	

RESULTS AND DISCUSSIONS

Primary analysis of the values of performance indicators shows a better growth in experimental variant V_4B_4. In terms of water quality, during the experiment have been daily monitored the following parameters: *temperature*, ranged from 20 to 28 degrees C, the optimum spacing for growing species; *oxygen* within the range 3 to 5.8 mg/l, optimum; *nitrates* from 7.9 to 14.4 mg/l; *ammonium* ranged between 0.3 to 0.9 mg/l and *pH* between 7.1 to 7.8. Physico-chemical water parameters have been maintained at optimum spacing requirement imposed by species technology, which expresses the good functioning of the quality of water conditioning equipment.

It is known that individual growth variability rate, the reproductive capacity and other issues relating to health, are distinctive features in each species. For example, numerous studies indicate the fact that body size variability may be influenced by ecological factors, including population density and the amount of food intake.

Foraging can not ever really stop for small sapling, while the older fish can afford to avoid exposure to predators in their search for food. [3]

Dimensional variability observed in carp specimens reared under controlled conditions illustrates the increased tendency of individuals to develop and grow at different rates. This particular aspect has also been underlined by other authors [9]. If the age and origin are identical, variability can be attributed to initial size differences among specimens immediately after hatching. There can be differences in terms of future growth rate of individuals which grew up in similar eco-technological conditions, a phenomenon determined by factors such as genetics. The experiment suggestively pointed out a high variability in growth intensity.

In the four experimental variants, V_1B_1, V_2B_2, V_3B_3, V_4B_4, relatively significant gains have been achieved in survival conditions ranging between 98-100%. Following separation by size class of the biological material, at the end of the experiment, it could be observed that, in terms of technological performance indicators, V_4 version is the most powerful.

Equation biomass crop growth for the study interval is: $Wi=0{,}0197*Lt^{2{,}858}$ and $Wf=0{,}0079*Lt^{3{,}196}$ (Fig. 2), as determined by somatic measurements at the beginning and end of the experiment (Tab. 2 and 3). General characteristic of growth, defined as the coefficient "b" (bi=2,8585 şi bf=3,1957) indicate a much faster rate of weight gain in comparison with length parameters. In general, the coefficient b in the length – weight rate has ranged between 2 and 4 and it is considered a measure of the conditions offered by the environment [6]. In addition, the factor condition (b) is used to obtain information on feeding status of fish and to make comparisons between different populations living in different habitats.

The average initial weight of carp samples of the four experimental variants are as follows: 44 g / sample in V_1, 64 g /sample in V_2, 90 g / sample in the V_3 and 142 g / sample in V_4. At the end of the experiment the average weight was: 56 g / sample in V_1, 81 g / sample in V_2, 118 g / sample in the V_3 and 188 g / sample in V_4. (Fig. 3)

Tab 2. Somatic measurements at the beginning of the experiment (stocking)

Nr crt	*B1*		*B2*		*B3*		*B4*	
	L (cm)	W (g)	L (cm)	W (g)	L (cm)	W (g)	L (cm)	W (g)
1	15,5	48	18	72	19,3	98	21,8	130
2	14,2	44	16,1	55	17	78	22,1	126
3	15,4	44	16,1	53	19,5	94	20,9	126
4	14,3	42	18	72	18,2	744	23,5	158
5	14,8	46	15,5	57	19	106	21,5	124
6	15,5	52	17	72	20,1	110	23,4	164
7	16	50	17,9	71	20	106	23,5	152
8	15,7	40	17	61	20	106	21,5	146
9	15,4	50	16,4	53	19,8	106	23,6	182
10	14,2	40	18	69	20,4	104	20,9	120

Tab 3. Somatic measurements at the end of the experiment (harvesting)

Nr crt	B1		B2		B3		B4	
	L (cm)	W (g)	L (cm)	W (g)	L (cm)	W (g)	L (cm)	W (g)
1	16,3	56	17,8	72	20,4	142	25,4	260
2	15,2	42	19,1	88	19,1	93	23,7	239
3	17,3	66	18,7	89	19,8	111	23,6	218
4	15,9	62	19,2	92	19,7	109	24,3	222
5	16,1	62	16,1	58	19,4	100	20,9	135
6	17,3	70	19,4	103	21,6	139	20,8	167
7	17,4	66	16,8	69	20,4	105	24,5	212
8	16,7	72	17,2	61	20,6	110	27,5	270
9	16,3	66	18,4	90	22,7	146	22,9	174
10	16,5	66	19,6	83	18,8	94	27,9	215

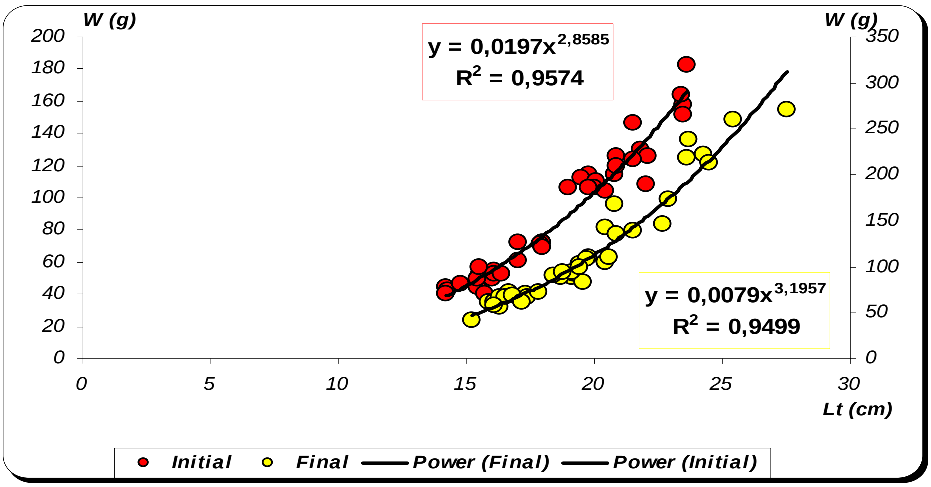

Fig 2. Length-weight correlation with carp

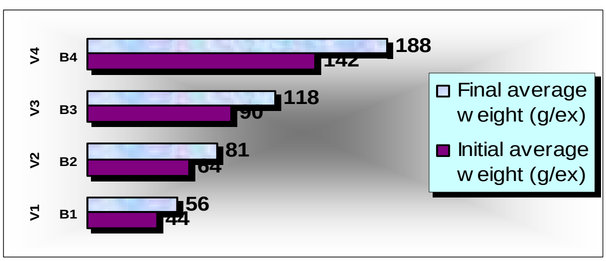

Fig 3. Evolution of average individual weight

Crop biomass increase recorded in the experimental variants is: 9,03 kg/m^3 in V_1 and 9,67 kg/m^3 in V_2, 12,19 kg/m^3 in V_3, and 19,88 kg/m^3 in V_4. Growth rate (GR) - technology indicator showing linear growth of the fish – which is supposed constant, was 118.76 g / day in V_1, 127.24 g / day in V_2, 160.42 g / day in V_3 and 169.45 V3 g / day in V_4.

Tab 4. Technological indicators of common carp breeding.

Experimental variant	V1	V2	V3	V4
Indicator/tank	**B1**	**B2**	**B3**	**B4**
initial biomass (kg)	19,690	19,604	19,527	19,527
initial biomass (kg/m^3)	39,38	39,21	39,05	39,05
final biomass (kg)	24,203	24,439	25,623	25,966
final biomass (kg/m^3)	48,41	48,88	51,25	51,93
increase biomass growth (kg)	4,513	4,835	6,096	6,439
increase biomass growth (kg/m3)	9,03	9,67	12,19	12,88
initial number of fish	443	307	217	138
final number of fish	435	301	217	138
survival (%)	98	98	100	100
initial average weight (g/eg)	44	64	90	142
final average weight (g/eg)	56	81	118	188
growing days	38	38	38	38
GR (daily growth rate) (g/day)	118,76	127,24	160,42	169,45
SGR (%/day)	0,54	0,58	0,71	0,75
Individual growth gain (g)	14	15	28	47
total amount of feed distributed (g)	10094	10094	10094	10094
FCR (g feed/g gain biomass)	2,24	2,09	1,66	1,57
daily biomass (% biomass)	1,2	1,2	1,2	1,2
Crude protein feed (PB %)	35,0	35,0	35,0	35,0

Technological indicators of juvenile carp growth obtained at the end of the experimental period are summarized in Table 4 and graphically presented in fig. 4 and 5. The following is a critical analysis of the most significant technological indicators, namely, specific growth rate (SGR) and feed conversion ratio (FCR).

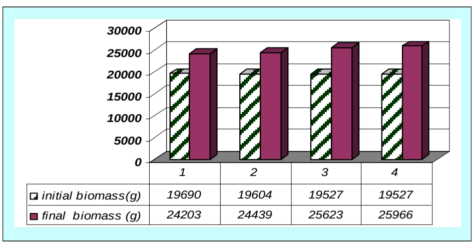

Fig 4- Evolution of growth

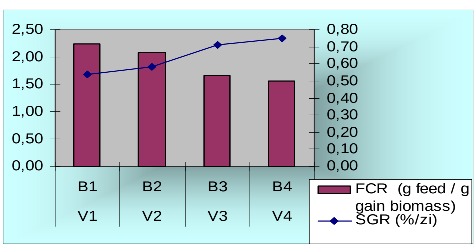

Fig 5- Changes in feed conversion ratio and specific growth rate

Technological indicators resulted at the end of the experiment had the following values: specific growth rate (SGR) was 0.54 g%/day (V1), 0.58 g%/day (V2), 0.71 g%/day (V3) and 0.75 g%/day (V4), feed conversion factor (FCR) was 2.24 g feed /g gain biomass (V1), 2.09 g feed/g gain biomass (in V2), 1.66 g feed / g gain biomass (in V3) and 1.57 g feed / g gain biomass (in V4).

Both indicators were higher in V_4. Figure 5 shows inverse correlation that exists between SGR and FCR development, namely: a low FCR is always obtained when the SGR increases (Fig. 5).

Initial storage density was relatively constant in the four experimental variants, ranging in an extremely small deviation, i.e. 39.38 kg/m3 in the first variant, 39.05 kg/m3 in the fourth variant. Final biomass varied in direct proportion to the size of fish, from 48,41 kg/m^3 V_1, 48,88 kg/m^3 in V_2, 51,25 kg/m^3 in V_3up to 51,93 kg/m^3 in V_4. This indicates an increase in biomass with 22.93% of initial biomass in V_1 and an increase of 32.98% in V_4. Variant V_4, the most powerful, indicates an increase in final biomass compared with 7% in V_1.

CONCLUSIONS

Recirculating systems allow a high degree of biomass intensity production by an advanced control of physico-chemical parameters of the breeding system in accordance with the quantity and biochemical structure of the feed administered, and the demands imposed by ensuring optimal hygienic conditions for fish growth. [1] Intensive recirculating systems allow fish growth in every region, and provide complete control over the growing medium. They also allow a large percentage of water reuse. [12]

Genetic factors are of vital importance in achieving descendants with a high growth potential. Some genetic characters such as: growth rate, disease resistance, viability, variability, etc. are important for fish breeders. Variability in size (length, weight, ratio, shape, etc.) can provide clues about how species interact and how environmental conditions affect growth and survival, in general, indicating, for example, the intensity of feeding competition [11]. Environmental and genetic factors may play an important role in the dynamics of individual development [4].

At the end of the experiment, crop biomass growth equation ($W= a*l^b$) for the carp population during the study shows an increase in weight faster than the increase in length, condition factor (b) being used to obtain information about the status of fish feeding.

The research showed that common carp has a very good technological adaptability in all experimental variants, but in terms of technological performance, indicators show that the larger samples can lead to better gains of biomass. The results obtained can lead to the conclusion that dimensional variability of carp samples, reared under similar conditions, is due to genetic variability, the final biomass being directly proportional to the size of fish.

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