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THE EFFECT OF HETEROSIS IN INTER-LINE CROSSING OF COMMON CARP

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A B S T R A C T. Three inter-line crossbred populations of common carp were compared with their parent lines during three years of rearing. The effect of heterosis was assessed in the growth rate, survival and share of slaughter yield. Positive effects of heterosis in growth rate and survival of all carp crosses were observed. Share of flesh in the whole body weight was higher only in one group comparing to both parent lines.

Key words: HETEROSIS, CROSSING, COMMON CARP

INTRODUCTION

In animal breeding, the effect of heterosis is usually defined as a phenotypic expression of heterozygosity of inherited features causing increased viability, improved productivity, and other characteristics compared to parental lines. Mechanism of heterosis has not been definitely explained, although all the theories confirm that heterozygous genotypes are more valuable than homozygous ones.

The Institute of Ichthyobiology and Aquaculture of the Polish Academy of Sciences in Gołysz deals with this problem for over 20 years. The aim of the studies is to create as high as possible number of crossbred populations and to test their productivity. Polish and foreign common carp lines are used for cross-breeding (Włodek, Matlak 1978, Białowas 1991).

The aim of the present study was an assessment of the effect of heterosis in carp crossbred populations, and of the differences in the blood parameters between crossbred fish and their parental lines.

MATERIAL AND METHODS

Two males and two females of each of Polish carp lines 3 and 6 (Irnazarow, Białowas 1994), and of Hungarian line 8 (Irnazarow, Białowas 1995) were used as the broodstock. Spawning took place on May 18, 1993, after hypophysation in two intramuscular injections: 24 and 12 hours before spawning. A dose of 0.9 mg of pituitary homogenate per 1 kg of fish weight was administered. The eggs were fertilised and incubated according to the modified Woynarovich (1962) method. Fertilised eggs were incubated in Weiss apparatuses, at the temperature of 20-22°C.

The eggs from two females of each line (100 g from each female) were fertilised with the sperm of two males of each line (0.5 cm³ from each male). A breakdown of one apparatus resulted in low number of larvae of 3x3 group (471 individuals).

The assessment of productive potential of each crossbred population was done in three-year rearing cycle, typical for Polish common carp pond culture. Due to the impossibility of marking newly hatched larvae, each group of fish in the first year was reared in separate small ponds, 670 m² each, under the same environmental conditions (Białowas 1991), in three replicates for each group. Stock density was 2500 individuals per pond. In the pond with 471 individuals of 3x3 group, the fish stock was supplemented with 2029 individuals of full-scaled carp larvae. In autumn, 400 randomly harvested individuals of each group (and 168 individuals of 3x3 group) were marked using liquid nitrogen, and placed in one pond. Fish were fed wheat grain, distributed manually over the feeding areas. Fish were harvested every spring and autumn. Fish numbers and weight were assessed. The final harvest took place on October 2, 1995. All fish were counted and weighed. Thirty individuals of each group (and 22 fish of 3x3 group) were separately measured and weighed. Then, the fish were dissected to determine sex, and to weigh head, flesh, internal organs and gonads. Percentage of flesh (edible parts) was estimated in the whole body weight.

Blood samples were taken from 7-8 individuals of each group. The following parameters were estimated in blood: hematocrite (Ht), red blood cell numbers (Erc), cell precipitation index (OB) after 20 and 40 minutes, haemoglobin concentration (Hb), and density (d). Total protein concentration and total lipid concentration were measured in the blood serum according to Łysak (1961) and Svobodova et al. (1986). Water temperature during blood sampling was 6-9°C.

One and two-factor ANOVA analysis, and Bonferroni test (SYSTAT 1992) were used to check the significance of differences between the groups and sexes. Correlation coefficients were calculated between blood parameters.

Values of the effect of heterosis were calculated for survival, growth rate and share of flesh in whole body weight by comparing crossbred fish to both parental lines, and to a better parental line.

RESULTS

Figure 1 shows survival of crossbred fish and of pure lines during the 3 year rearing period. In the first season, high mortality was observed in all groups. In the second and the third season, survival was similar for all groups. Survival of parental lines within a 3 year cycle was 4.7-14.8%, and of crossbred populations 19.6-31.9% (Tab. 1). Figure 2 shows growth of fish during the rearing period. Mean final fish weight of parental lines ranged from 1136 to 1293 g, and of crossbred fish 1292-1595 g (Tab. 1). Only 6x8 group (the heaviest) differed significantly from other groups ($p < 0.001$). Share of flesh in body weight of the fish from parental lines was 60.9-62.0%, and in crossbred fish 61.1-63.1%. Significant differences were observed between 3x8

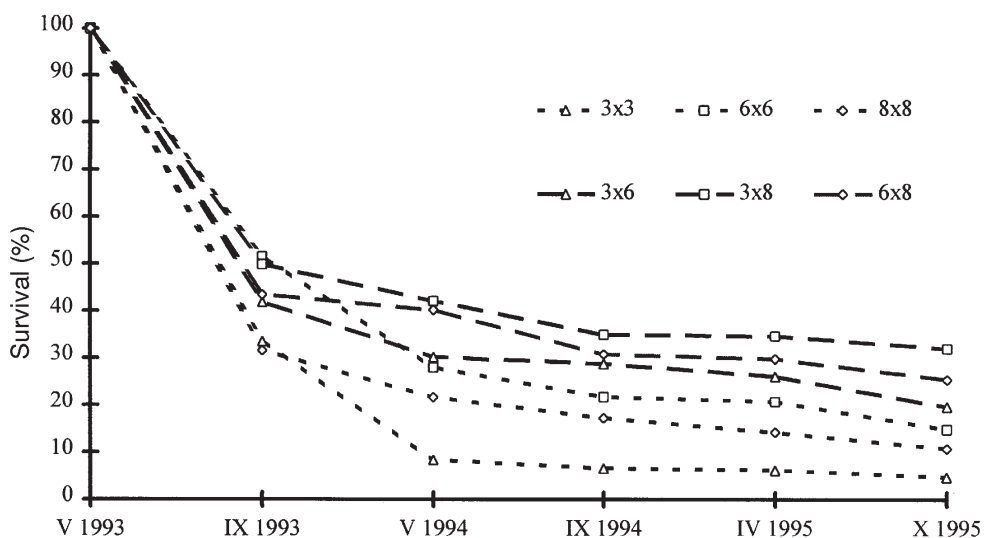


Fig. 1. Survival of crossbred carps of 3x6, 3x8, and 6x8 groups, and of their parental lines: 3x3, 6x6, and 8x8 during 3 year rearing period.

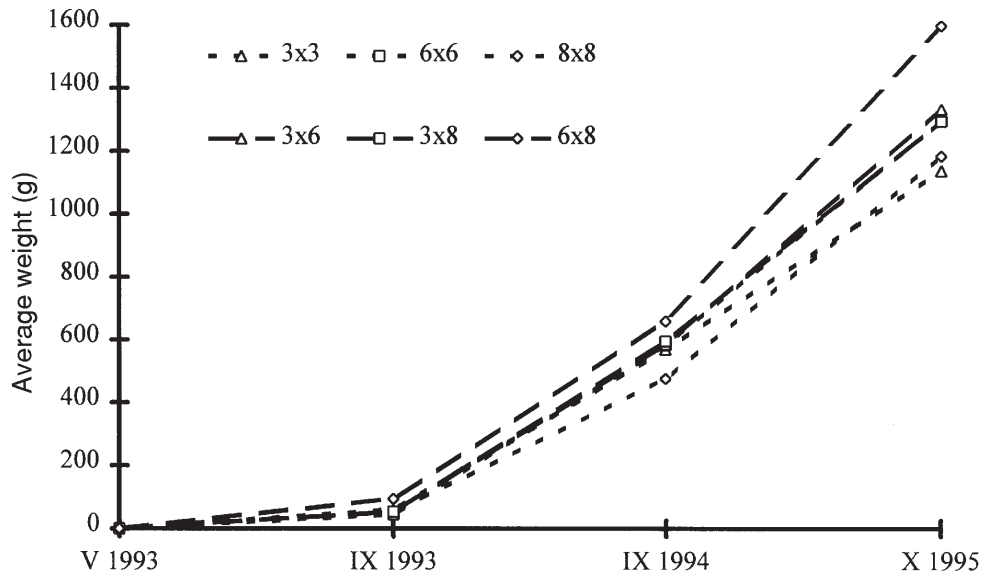


Fig. 2. Growth of crossbred carps of 3x6, 3x8, and 6x8 groups, and of their parental lines 3x3, 6x6, and 8x8, during 3 year rearing period.

TABLE 1

The results of final harvest of pure-line and crossbred fish.
F+M - females and males, F - females, M - males

Group	Survival (%)	Number (ind.)	Sex	Weight (g)	Share of flesh (%)
3x3	4.7	22	F+M	1136	62.0
			F	1117	62.3
			M	1159	61.6
6x6	14.8	115	F+M	1293	61.4
			F	1375	62.4
			M	1241	60.6
8x8	10.7	136	F+M	1182	60.8
			F	1181	61.5
			M	1182	59.8
3x6	19.6	188	F+M	1331	61.9
			F	1416	61.9
			M	1205	61.9
3x8	31.9	256	F+M	1292	63.3
			F	1362	63.6
			M	1181	62.6
6x8	25.0	233	F+M	1595	61.3
			F	1615	61.8
			M	1561	60.3

TABLE 2

The results of haematological analyses of pure-line and crossbred carps

Group	Ht (%)	Hb (g/l)	Erythrocytes (mln/mm ³)	d (g/ml)	OB 20 min (%)	OB 40 min (%)	Proteins (g%)	Lipids (mg%)
3x3	30.0	7.492	2.06	1.042	17.6	26.4	3.64	603.22
6x6	29.4	7.684	1.70	1.040	19.5	31.9	3.30	581.17
8x8	27.1	7.125	1.91	1.041	23.4	34.6	3.69	573.84
3x6	26.9	6.765	1.78	1.040	25.6	35.0	3.44	609.28
3x8	29.0	6.615	1.94	1.041	17.2	29.0	3.23	505.27
6x8	27.3	7.098	1.68	1.040	21.8	33.1	3.26	565.84

TABLE 3

The effect of heterosis in 3 year rearing period calculated for both parental lines (A), and for a better parental line (B).

Crossbreed		Heterosis effect (%)		
		survival	growth rate	Slaughter field
3x6	A	201.0	109.6	100.2
	B	132.4	102.9	99.8
3x8	A	414.3	111.5	102.7
	B	298.1	109.3	101.8
6x8	A	198.4	128.9	99.8
	B	170.9	123.4	99.3

group and 6x6, and 6x8 groups ($p < 0.01$), and between 3x8 and 8x8 ($p < 0.001$). All other groups did not differ significantly from each other.

Body weight of females was significantly higher ($p < 0.05$) compared to males (Tab. 1). The average difference was 90 g. Share of flesh was also higher in females, 1% on the average ($p < 0.01$).

The results of haematological analyses are shown in Table 2. No significant differences were observed between crossbred populations and parental lines. No correlation was found between the parameters of blood serum (protein, lipids), but significant correlation occurred between parameters determined in the whole blood.

The effect of heterosis calculated from mean values for the two parental lines ranged from 109.6 to 128.9% for growth rate, for survival 198.4-414.3%, and for share of flesh in body weight 99.8-102.7% (tab. 3). The effect of heterosis calculated from the

values for the better parental line was lower: 102.9-123.4%, 132.4-298.1%, and 99.3-101.8% respectively.

DISCUSSION

All tested crossbred populations showed positive effect of heterosis in growth rate compared to the two parental lines and to a better one. In cross breeding of various carp lines such effect sometimes does not occur. Wohlfarth (1993) obtained better weight gains comparing to the better parental lines only in 47 crossbred groups out of 73. Studies carried out in the Institute of Ichthyobiology and Aquaculture in Gołysz revealed the effect of heterosis in survival and growth rate in about 50% of crossbred fish groups (Białowaś 1996).

The results obtained by other authors and in the Institute indicate that heterosis effect is mostly expressed during the early development (Andrijasheva 1966, Włodek, Matlak 1978, Białowaś 1991, Wohlfarth 1993). Higher survival of crossbred fish results from their higher resistance to adverse environmental conditions and pathogenic factors. Later on, the effect of heterosis decreases but crossbred fish remain better (Białowaś 1996). The effect of heterosis in carp growth rate is not as high as in the case of survival, but still higher than in other domestic animals.

Heterosis becomes a commonly used way to improve productivity in carp farms. Stocking the ponds with carps obtained from cross breeding of selected lines results in higher survival and weight gains, and consequently, in higher production (Mejza 1990, Białowaś 1990). It should be stressed that the effect of heterosis, contrary to the improvement achieved by selection, is transient. Thus, crossbred fish showing heterosis effect should be used only for rearing, and not for breeding (Włodek 1976, 1980, Nowak et al. 1980).

There are many data showing considerable differences in blood parameters between crossbred and pure-line warm blooded animals (Kołątaj et al. 1973). The present study did not reveal such differences, however, the results might have been affected by low temperature during blood sampling.

Studies on the effect of heterosis in carp will be continued. They should result in an assessment of the effects of cross breeding of all carp lines, and of specific combination ability between particular lines.

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STRESZCZENIE

EFEKT HETEROZJI PRZY KRZYŻOWANIU MIĘDZYLINIOWYM KARPI

Przetestowano trzy krzyżówki karpia: 3x6, 3x8 i 6x8 oraz ich linie rodzicielskie: 3x3, 6x6 i 8x8. Zastosowano trzyletni cykl produkcyjny. W pierwszym sezonie poszczególne grupy chowane były w oddzielnych stawkach o maksymalnie ujednoliconym środowisku. Począwszy od narybku jesiennego, po oznakowaniu, wszystkie grupy chowane były w jednym stawie.

Przeżywalność linii rodzicielskich za cały okres chowu wynosiła 4,7–14,8%, a krzyżówek 19,6–31,9% (tab. 1, rys. 1). Średni ciężar końcowy karpi linii rodzicielskich wynosił od 1136 do 1293 g, a krzyżówek 1292–1595 g (tab. 1, rys. 2), przy czym statystycznie istotne różnice ($P < 0,001$) wystąpiły tylko między krzyżówką 6x8, która osiągnęła największy ciężar końcowy, a pozostałymi grupami. Wydajność rzeźna linii rodzicielskich wynosiła 60,9–62,0%, a krzyżówek 61,1–63,1%. Statystycznie istotne różnice wystąpiły między krzyżówką 3x8 a grupami 6x6 i 6x8 ($P < 0,01$) oraz 8x8 ($P < 0,001$).

Ciężar samic był istotnie wyższy ($P < 0,05$) niż samców (tab. 1). Różnica ta wynosiła średnio 90 g. Również wydajność rzeźna samic była istotnie wyższa ($P < 0,01$) niż samców, średnio o 1%.

Nie stwierdzono statystycznie istotnych różnic między poszczególnymi krzyżówkami i liniami hodowlanymi pod względem badanych parametrów pełnej krwi i surowicy (tab. 2).

Efekt heterozji, mierzony w stosunku do średniej wartości linii rodzicielskich, w przypadku tempa wzrostu wyniósł od 109,6 do 128,9%, przeżywalności 198,4–414,3%, a dla wydajności rzeźnej 99,8–102,7% (tab. 3).

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