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Individual genetic variability within synthetic breeding lines of carp against the background of the electrophoretic fractionation of blood plasma transferrin

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Abstract — Using electrophoretic fractionation of transferrin, the individual genetic variability of carp of 9 inbreeding lines was investigated. Two polymorphic homozygous patterns were found besides four heterozygous ones occurring in 86.3% of the investigated fish, which were regarded as homozygous on the basis of selection carried out according to the type of scaliness.

Key words: carp, genetics, transferrin, electrophoretic separation.

1. Introduction

Since 1954 methodical inbreeding of carp lines has been carried out at the Gołysz Experimental Fish Culture Station of the Polish Academy of Sciences (Włodek 1958, 1959, 1966, 1968, 1969, Włodek, Matlakowa 1978) on the basis of results of the pleiotropic action of genes conditioning the scaliness of the carp (Rudziński 1928, Golovinskaja 1946, Probst 1953, Kirpichnikov 1969).

The aim of the present study was to characterize the individual genetic variability within the different breeding lines conducted as inbred lines for several generations. The electrophoretic separation of protein, the simplest method in investigating genetic variability, commonly applied in plants and animals, was used in the investigation (Thompson 1960, Tsujuki et al. 1965, Tsujuki, Roberts 1966, Nyman 1965, 1966, 1971, 1972, Nyman, Westin 1968, 1969, Truveller et al. 1973, Valenta 1978, Paaver 1979, Kirpichnikov 1981, Buth 1979, Buth et al. 1980).

2. Material and method

The investigated material consisted of randomly selected spawners of inbreeding lines bred in the Gołysz Experimental Station of the Polish

Academy of Sciences, marked with the following symbols: 2, 3A, 6, K, W, 7, 8, T, and J.

Breeding line "2", frame mirror carp, reared as an inbred line since 1954, originated from a female from the upper Vistula region and a male from the Mazurian Lake District. Currently, in the 6th generation, an inbreeding depression has become manifest in this line. Line „3A" also originated from a female from the upper Vistula region and a male from the Mazurian Lake District. It was selected in the aspect of growth rate and health. It does not show the typical scaliness of the mirror carp and no inbreeding depression has been manifested in the 7th generation. Line "6" with the typical scaliness of the mirror carp originated by crossing a local (Gołysz) female with a male from the Osiek strain, reared as an inbred line for 70 years. In the 6th generation of this line an inbreeding depression has become manifest. Line "K" was imported to the Gołysz Station from Knyszyn (northern Poland) in 1966. Line "W", also a frame mirror carp currently in the 3rd generation, was selected from carp of unknown origin imported from Hungary in 1966.

Apart from the line mentioned above, the following 3 lines of Hungarian carp imported to Poland in 1973 were investigated: line "7" from Szeged (the frame mirror carp), line "8" from Sumonyi (the mirror carp with atypical scaliness), and line "T" (the reduced mirror carp) from Bikal. The last line contains the blood of Palestinian carp. All 3 lines of Hungarian carp are now in the 7th generation. The last line included in the study was line "J" originating from Yugoslavian carp imported to Poland.

Blood for analysis was taken from the anal vein of representatives of the lines mentioned above and of progeny of the first generation of spawning pairs from lines "2", "3A", "6", "8", and "W". Transferrin of the blood plasma was electrophoretically fractionated on 10% polyacrylamid gel and stained using the method of Crambach et al. (1967). Genetic affinity of the investigated carp was calculated according to the formula given by Nei (1972).

3. Results

Blood plasma transferrin of spawners from 9 breeding lines, electrophoretically fractionated on polyacrylamid gel formed 6 polymorphic patterns (fig. 1): two homozygous B and D, and four heterozygous ABD, AD, BCD, and BD found in 86.3% of the investigated specimens. The frequency of occurrence of transferrin patterns in the different lines, shown on the figure, is presented in Table I. The most frequent polymorphic pattern of transferrin was the heterozygous BD one found in 52% of the investigated fish. Of the remaining patterns ABD reached 12%, AB and D 11%, BCD 7%, and B 6%. In all carp of line "T" there

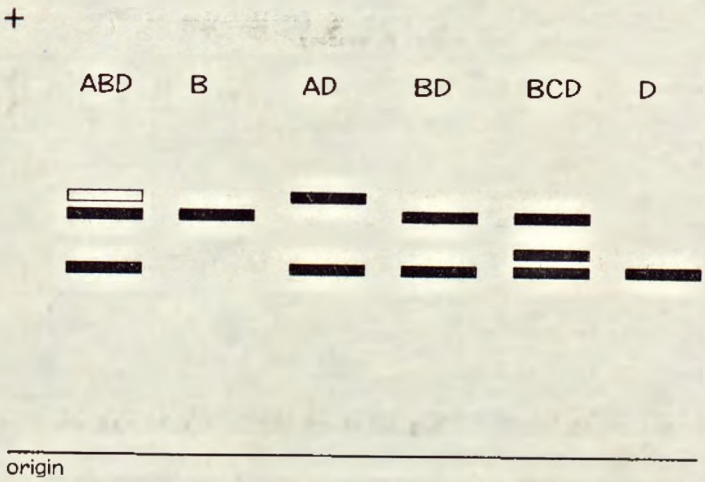

Fig. 1. Polymorphic patterns of blood plasma transferrin found in 9 breeding lines of carp

appeared the characteristic pattern ABD, which was not found in the representatives of any other line. Pattern AD was observed in 40% of fish of line "2", in 21% of line "8", and in 20% of line "W". Pattern BCD appeared in 49% spawners of line "3A" only. With the exception of fish from lines "J" and "T", the most frequent pattern, BD, was found in all representatives of the investigated lines: in 50% of fish from lines "2" and "6", in 40% of line "3A", 100% of lines "7" and "K", 53% of line "8", and 58% of line "W". The homozygous pattern B appeared in 11% of fish from line "3A", 24% of line "6", 8% of line "8", and 6% of line "W". Another homozygous pattern D occurred in 10% of carp

Table I. Elektrophoretic patterns of fractionation of blood plasma transferrin in spawners from 9 breeding lines in the Polish Academy of Sciences Fish Culture Experimental Station Gołysz

Breeding line	Number of individuals in particular patterns of transferrin						Total number of indiv.	Frequency of alleles				Ratio of heterozygotes to homozygotes
	ABD	AD	BCD	BD	B	D		A	B	C	D	
2	-	34	-	43	-	9	86	0,20	0.25	-	0,55	9 : 1
3A	-	-	49	40	11	-	100	-	0.47	0.16	0.36	8 : 1
6	-	-	-	31	15	16	62	-	0.49	-	0.51	3 : 1
7	-	-	-	80	-	-	80	-	0.50	-	0.50	1 : 0
8	-	25	-	64	10	21	120	0.10	0.35	-	0.55	2 : 1
J	-	-	-	-	-	12	12	-	-	-	1.00	0 : 1
K	-	-	-	40	-	-	40	-	0.50	-	0.50	1 : 0
T	80	-	-	-	-	-	80	0.33	0.33	-	0.33	1 : 0
W	-	15	-	44	5	12	76	0.10	0.35	-	0.55	5 : 1
Σ	80	74	49	344	41	70	656					

Table II. Electrophoretic patterns of fractionation of blood plasma transferrin in spawners and their F_1 progeny

Breeding line	Spawners ♀	Spawners ♂	Number of F_1 progeny with trasferrin patterns: ABD	BD	AD	B	D	Total number of indiv.	Frequency of alleles: A	B	D	Ratio of heterozygotes to homozygotes
6	D	D	-	-	-	-	30	30	-	-	1,00	0 : 1
3A	BD	BD	-	23	-	7	-	30	-	0.62	0.38	3 : 1
8	BD	BD	-	24	-	-	6	30	-	0.40	0.60	4 : 1
W	BD	BD	-	22	-	-	8	30	-	0.37	0.63	3 : 1
2	AD	BD	6	-	15	-	9	30	0.31	0.07	0.62	2 : 1
8	BD	AD	-	-	19	11	-	30	0.32	0.37	0.32	2 : 1
Σ			6	69	34	18	53	180				

from line "2", 26% of line "6", 18% of line "8", 100% of line "J", and 12% of line "W".

In the total number of 656 investigated spawners from 9 breeding lines 566 heterozygotes of 2- or 3-band patterns were found, only 90 fish being homozygotes. The ratio of hetero- to homozygotes in the different breeding lines is given in Table I.

An attempt at crossbreeding different transferrin patterns (Table II) showed that the 1-band pattern DxD of the spawners of line "6" was inherited 100% by the fry of the first generation. Pattern BDxBD was differently inherited in the progeny of 3 breeding lines investigated. 77% of the progeny of "3A" spawners had pattern BD and 23% pattern B. 80% of the progeny of spawners of line "8" had pattern BD and 20% pattern D. Spawners of line "W" of the same pattern (BDxBD) gave 73% of progeny with pattern BD and 27% with pattern D. In the investigated progeny the matching of patterns ADxBD (spawners of line "2") brought about splitting of polymorphic transferrin pattern into 3 different ones: 50% AD, 30% D, and 20% ABD. Patterns BDxAD (line "8") gave 63% of progeny with pattern AD and 37% with pattern B.

4. Discussion

The investigation of invididual genetic variability within the different inbred lines, using the method of electrophoretic fractioning of transferrin, which is currently also applied in the research of carp genotypes (Balakhnin, Solomatina 1970, Balakhnin, Romanov 1971, Balakhnin, Galagan 1972a, b, Moskovski et al. 1973, Valenta et al. 1976, 1977, Valenta 1978), showed that the investigated lines were mostly composed of heterozygous individuals (Table I). The only exception was line "J" where all the fish were homozygous. However, owing to the small number of specimens in this line it is impossible to evaluate the degree of its inbreeding. Of the

remaining lines the smallest ratio of heterozygotes to homozygotes was found in carp of lines "8" and "6". Line "6" originated from a local female and a male from the Osiek strain inbred for 70 years. Lines "2" and "3A" were characterized by the largest ratio of heterozygotes to homozygotes. Line "2" showed a distinct inbreeding depression. In this carp population the large number of heterozygotes was probably due to the poor survival of homozygotes and in line "3A" to the selection carried out so far in the aspect of survival and growth rate, the type of scaliness having been disregarded.

Of the four heterogenous patterns presented in Table I two 3-band patterns may be distinguished. According to Valenta et al. (1976), they result from changes in the structure of the transferrin molecule. The first of these patterns (ABD) appears in all fish of line "T". The other one (BCD) was found in 49% of carp of line "3A". Unfortunately, no progeny of ABD and BCD spawners was obtained and investigation of the inheritance of these patterns was not possible.

The pronounced genetic similarity of the investigated representatives of the breeding lines, calculated on the basis of frequency of alleles, showed (Table III) that the method of electrophoretic transferrin fractio-

Table III. Genetic similarity of breeding lines of carp spawners

Breeding line	2	3A	6	7	8	J	K	T	W
2	X								
3A	0.81	X							
6	0.89	0.95	X						
7	0.88	0.95	0.99	X					
8	0.98	0.89	0.96	0.96	X				
J	0.86	0.58	0.72	0.70	0.83	X			
K	0.88	0.95	0.99	1.00	0.96	0.70	X		
T	0.90	0.78	0.81	0.81	0.87	0.57	0.81	X	
W	0.97	0.89	0.96	0.96	1.00	0.83	0.96	0.87	X

nation applied instead of the type of scaling in evaluating the individual variability of carp genotypes, enabled a more precise determination of genetic differences between the individuals to be made. This is particularly important with regard to differences which, without visible morphological changes, condition the physiological adaptability to local climatic conditions and to intensive and industrial fish culture carried out in greatly changed environmental conditions. Thus the determination of individual genetic variability of spawners on the basis of polymorphic transferrin patterns makes it possible to crossbreed fishes of similar or different electrophoretic patterns and then to select combinations which may give progeny characterized by traits most favourable for fish production.

5. Polish summary

Osobnicza zmienność genetyczna w obrębie syntetycznych linii hodowlanych karpia na tle badań elektroforetycznego rozdziału transferyny plazmy krwi

Na podstawie wyników plejotropowego działania genów warunkujących ułuszczenie karpia, od roku 1954 w Zakładzie Doświadczalnym PAN w Gołyszu prowadzona jest systematycznie hodowla wsobnych linii karpia. Niniejsze badania podjęto, aby bliżej określić genetyczną zmienność osobniczą w obrębie poszczególnych linii hodowlanych. Zastosowano do tego celu metodę elektroforetycznego rozdziału transferyny plazmy krwi.

Stwierdzono, że transferyna 9 linii hodowlanych rozdzielona elektroforetycznie na żelu poliakryloamidowym tworzy 6 polimorficznych wzorów: 2 homozygotyczne B i D oraz 4 heterozygotyczne ABD, AD, BCD i BD występujące u 86,3% zbadanych ryb. Częstotliwość występowania wzorów transferyny przedstawionych na ryc. 1 podano w tabeli I. Dziedziczenie kojarzonych między sobą niektórych wzorów transferyny przedstawiono w tabeli II.

Duże podobieństwo genetyczne badanych karpi (tabela III) reprezentujących 9 linii hodowlanych, obliczone na podstawie frekwencji alleli, wskazuje, że zastosowana metoda, w miejsce dotychczas stosowanej po typach ułuszczenia, pozwala na dokładniejsze uchwycenie różnic genetycznych poszczególnych osobników. Szczególnie jest to ważne w odniesieniu do różnic, które bez widocznych zmian morfologicznych warunkują przystosowania fizjologiczne do zmienionych warunków środowiska w chowie intensywnym i przemysłowym.

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