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Investigation on crucian carp F_2 hybrids obtained from F_1 males and females (♀ *Cyprinus carpio* L. × ♂ *Carassius carassius* L.)

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Abstract — An analysis of different plastic and meristic features and of the variation of these features in carp and crucian carp F_2 hybrids bred in pond Księżok Mały III was conducted. The analysis included head length, dorsal and body width index, and the condition coefficient. Some anatomical features, such as the scheme of pharyngeal teeth, length and volume of chambers of the floating bladder, and length of the food canal, were also investigated.

Key words: Fish culture, crucian carp hybrids, crosses, life cycle, morphology.

1. Introduction

The investigation on crucian carp F_2 hybrids was carried out in ponds of the Fish Culture Experimental Station Gołysz of the Polish Academy of Sciences, like the previous study on the F_1 generation (Skóra 1962, 1965, Rudziński, Skóra 1963) and on back hybrids (Skóra 1968).

A number of authors (Siebold 1863, Knauthe 1901, Lieder 1957, Kiselov 1958, and others) who studied the carp × crucian carp cross, claimed complete sterility of carp × crucian carp F_1 hybrids. However, Nikoljukin (1952) succeded in obtaining a fertile male of the F_1 population (♀ *Carassius carassius* L. × ♂ *Cyprinus carpio* L.) and crossed it with a female crucian carp spawner. He obtained a scarce number of young fishes (back hybrids) which showed traits intermediate between hybrids and crucian carp.

The aim of the present study was to elucidate the question whether carp and crucian carp male hybrids can be used for breeding on commercial scale with females of the same populations of F_1 hybrids (♀ carp × × ♂ crucian carp).

A further object of research attempted to obtain a F_2 generation and to investigate the development of different morphological, meristic, and anatomical traits and their variation, in this generation.

The present report describes the preliminary results of experiments still in progress.

2. Material and method

In 1979, 15 females and 15 males were selected for breeding from a large base population of spawners of F_1 hybrids (♀ *Cyprinus carpio* L. × ♂ *Carassius carassius* L.). Figure 1 shows a male and a female of the carp and crucian carp F_1 population which were used with other spawners for spawning to obtain the F_2 generation. The mass spawning of 8 female and 11 male carp and crucian carp hybrids took place in

Table I. Dimensions and plastic features of carp and crucian carp F_1 spawners - parents of the investigated generations

Sex	Pondus	Longitudo totalis		Longitudo corporis		Longitudo capitis lateralis		Summa altitudo corporis		Summa latitudo corporis	
	g	cm	%	cm	%	cm	%	cm	%	cm	%
♀	3670.0	59.0	118.0	50.0	100.0	12.8	24.0	17.5	35.0	10.0	20.0
♀	4600.0	60.5	117.5	51.5	100.0	13.5	26.2	20.5	39.8	11.5	22.3
♀	3075.0	54.5	120.3	45.3	100.0	13.0	28.7	18.8	41.5	9.2	20.3
♀	3950.0	61.0	120.1	50.8	100.0	13.0	25.6	18.6	36.6	11.7	23.0
♀	4670.0	60.0	120.5	49.8	100.0	13.0	26.1	19.5	39.2	12.3	24.7
♀	4820.0	59.5	117.8	50.5	100.0	13.3	26.3	20.2	40.0	11.7	23.2
♀	5230.0	65.0	118.2	55.0	100.0	14.0	25.4	20.1	36.6	12.2	22.2
♀	5030.0	58.0	114.8	50.5	100.0	13.0	25.7	20.6	40.8	13.0	25.7
♂	5570.0	75.0	116.3	64.5	100.0	15.3	23.7	18.0	27.9	11.2	17.4
♂	5340.0	72.0	118.0	61.0	100.0	15.2	24.9	17.0	27.9	11.0	18.0
♂	4330.0	70.0	117.7	59.5	100.0	14.7	24.7	16.2	27.2	10.0	16.8
♂	3090.0	60.5	117.5	51.5	100.0	12.2	23.7	14.4	27.9	9.5	18.4
♂	7500.0	76.0	116.0	65.5	100.0	16.2	24.7	20.0	30.5	14.2	21.4
♂	5320.0	71.5	118.2	60.5	100.0	15.8	26.1	16.8	27.8	11.1	18.4
♂	5400.0	70.5	117.5	60.0	100.0	14.2	23.7	17.7	29.5	11.2	18.7
♂	4520.0	61.8	117.8	51.8	100.0	14.0	27.0	17.5	35.7	10.5	20.3
♂	4430.0	60.5	119.8	50.5	100.0	13.2	26.1	18.5	36.6	10.2	20.2
♂	3835.0	57.5	119.8	48.0	100.0	12.8	26.7	17.1	35.6	10.0	20.8
♂	4100.0	60.0	118.4	50.8	100.0	13.2	25.9	18.0	35.4	11.3	22.2

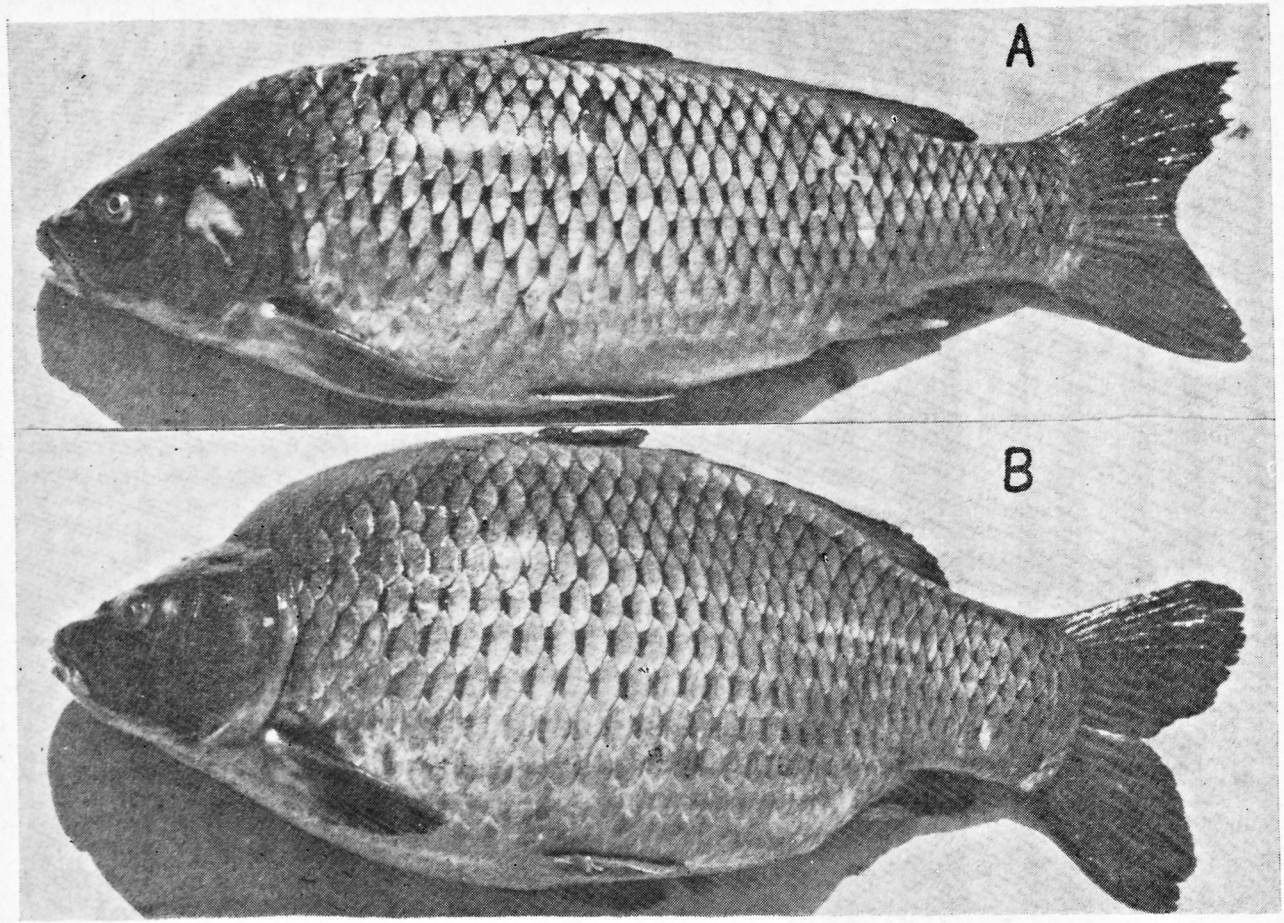

Fig. 1. Carp and crucian carp F_1 hybrids: A — female (4670 g), B — male (4430 g) which, with other spawners, were used in the mass spawning for obtaining the F_2 generation (May 15, 1979) (Photo: M. Janik)

Fig. 2. Four-day old hatch of F_2 hybrids (Photo: M. Janik)

a spawning pond of about 300 sq.m. of the Landek fish farm, on May 15, 1979. The biometric traits of the spawners are given in Table I. On the next day, May 16, under natural conditions, without hypophysation, the spawning of the hybrid spawners began at 7 a.m. and, with some intervals, lasted until 11^{40} a.m., at mean water temperature of 17.8°C. During the embryonal development in the spawning pond the temperature of water ranged from 17.5° to 26.0°.

On May 19, 1979 hatching of F_1 fry began, indicating an undisturbed embryonal development. The losses which were noted during the embryonal development and hatch did not exceed the average of about 25%. The first samplings and measurements were carried out on the third and fourth day after the hatch.

The hatch gave over 2,000,000 F_2 hybrids which were transferred on May 21—24, to the following ponds: Prząś Stara 140,000 fish, Rzeczny 38,000, Niewola 60,000, Polaczy 120,000, Gołysz Wielki 400,000, and Chyliński 90,000 for out breeding together with the carp hatch. Apart, from this pure breeding of 12,000 hybrids was conducted in pond Księżok Mały III of a 2.5 ha surface, lying in the Landek fish farm; 12,000 fishes were transported to a store pond, and the rest of the F_2 hatch was transported to state fish farms in the voivodship of Poznań. Figure 2 shows F_2 hybrids in the period of the transfer to first nursery ponds.

The paper contains data obtained from breeding in pond Księżok Mały III because in the other ponds the F_2 hybrids were kept together with the carp, and no catches were conducted for 2 successive years, for reasons of economy.

Biometric measurements included 629 hatch and fry hybrids. Investigation material was collected from the spawning pond, and later from pond Księżok Mały III which served as the first and second nursery pond for F_2 hybrids. The sampling was carried out with a lift net with 1—5 mm net mesh, depending on the fish size. In autumn random samples were collected from washers used for catches. Biometric measurements of sampled fish were carried out according to the scheme used in the investigation on carp and crucian carp F_1 hybrids and back hybrids (Skóra 1962, 1965, 1968, Rudziński, Skóra 1963).

3. Results and discussion

The breeding of hybrids in pond Księżok Mały III (Table II) was carried out in very difficult environmental conditions. In 1979 water supplies for filling ponds of the Landek fish farm were insufficient. The pond of 2.5 ha was overgrown with higher plants; only 30% of its dammed surface was filled with water and, as a result the water level was very low. Due to water deficit during the breeding season the results of fish pro-

Table II. Breeding of F_2 generation of carp and crucian carp hybrid population in pond Księżok Mały III at Landek fish farm

Dammed pond surface (ha)	2.50	
Breeding pond surface (ha)	0.85	
Fertilization of the pond:		
lime (q)	13.60	
ammonium salpeter (q)	1.50	
stable manure (q)	100.00	
Feeding: lupin (q)	16.85	
	Stocking	Catch
Dates	21.V.1979	2.XI.1979
Age	KKp	KK_1
Number	120000	54100
Total weight (kg)	-	681.0
Average weight of 1 fish (q)	-	12.6
Losses (%)	-	54.9

duction were lower than the expected ones. However, in spite of these difficulties on November 2, 1979 54100 specimens of the hybrid fry (i.e. 45.1% of the stock), 681 kg in weight, were caught. The size of the fry was fairly differentiated (fig. 3) and the weight of specimens ranged from 3—41 g (12.6 g on the average), the variation coefficient (v%) reaching 49.7%. The body weight of young fish varied from 4.2 to 10.9 cm (7.2 cm on the average) with the variation coefficient (v%) of 15.9%. The fry survival reached 45.1% of the stock and can be estimated as very good, considering the difficult breeding conditions. The high survival rate chiefly characterized the F_2 hybrids whose body was entirely covered with scales. They constituted 91.67% of all fish caught in autumn in pond Księżok Mały III, while hybrids with the frame scaliness reached 50% and those with the stripe scaliness 3.33% only. The biological resistance of carp and crucian carp hybrids with nontypical frame scaliness to diseases and difficult environmental conditions was very low. This is illustrated by the fact that in control catches carried out on August 9, 1979, fish with compact scaliness reached 75.54%, those with frame scaliness 16.12%, and with stripe scaliness 8.34% only.

Lieder (1957) in his experiments with carp and crucian carp hybrids also found that in a pond stocked with large numbers of such hybrids a marked oxygen deficit due to insufficient water inflow killed all carps and most hybrids with frame and stripe scaliness. Hybrids with compact scaliness tolerated these conditions perfectly. On the basis of his own other authors' results Lieder claims that the carp and crucian carp hybrids with non typical frame or stripe scaliness are less resistant to various diseases (e.g., carp dropsy) or pests *(Ichtyophtirus)*. The present observations support these earlier views.

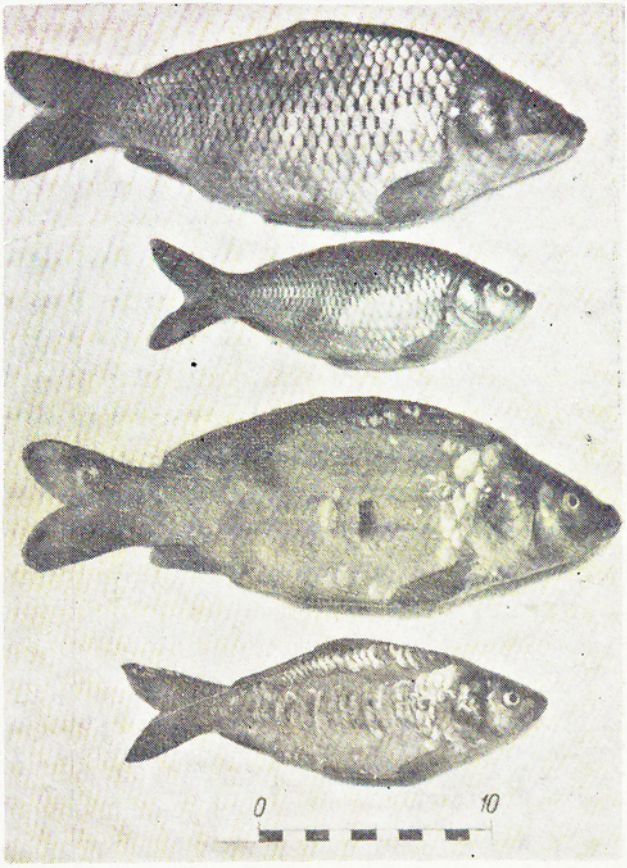

Fig. 3. The carp and crucian carp F_2 fry from pond Księżok Mały III in the Landek fish farm, Nov. 2, 1979 (Photo: M. Janik)

Table III. Mean dimentions (cm) of different body features ($\bar{x}$) of the hatch of carp and crucian carp F_2 hybrids, and their variation coefficients (v%) in 1979

Pond		Spawning pond Kaiżok Wały III							
Date of catch		21.V	22.V	26.V	30.V	1.VI	5.VI	13.VI	9.VIII
Age (days)		3	4	8	12	14	18	26	83
Number of investigated fish		102	100	74	50	70	38	40	35
Longitudo totalis	$\bar{x}$	0.815	0.991	1.393	1.710	1.833	2.425	3.865	7.957
	v%	5.203	5.100	10.936	22.000	12.385	16.426	10.763	11.401
Longitudo corporis	$\bar{x}$	0.765	0.931	1.180	1.477	1.518	1.964	3.170	6.488
	v%	4.317	5.237	10.641	19.290	12.244	23.224	10.556	12.289
Longitudo praeanalis	$\bar{x}$	-	0.674	0.880	-	1.141	1.507	2.372	4.937
	v%	-	5.509	10.698	-	13.264	16.648	19.972	12.468
Longitudo capitis	$\bar{x}$	0.193	0.240	0.418	0.483	0.554	0.722	1.101	2.181
	v%	14.998	7.805	14.702	21.493	14.155	16.627	11.122	12.686
Altitudo capitis	$\bar{x}$	0.150	0.164	0.286	0.359	0.407	0.559	0.816	1.824
	v%	13.861	9.014	17.409	22.764	16.343	17.060	21.226	12.181
Summa altitudo corporis	$\bar{x}$	0.145	0.157	0.321	0.377	0.462	0.684	1.063	2.490
	v%	11.279	12.828	14.286	32.942	17.362	21.200	13.012	12.842
Minima altitudo corporis	$\bar{x}$	0.046	0.050	0.144	0.134	0.203	0.288	0.417	0.839
	v%	18.878	11.663	19.761	35.143	14.469	17.358	12.635	12.298
Summa latitudo corporis	$\bar{x}$	0.145	-	0.235	-	0.332	0.442	0.635	1.336
	v%	11.289	-	15.577	-	12.621	17.133	20.004	11.394
Summa latitudo capitis	$\bar{x}$	0.110	-	0.205	-	0.279	0.403	0.538	1.301
	v%	21.367	-	6.780	-	18.266	20.585	13.748	11.418

Table IV. Moving index (I) and body proportions (P) of body dimentions of the carp and crucian carp F_2 hybrids breeded in the ponds at Tandek fish farm in 1979

Pond		Spawning pond Kaiżok Wały III							
Date of catch		21.V	22.V	26.V	30.V	1.VI	5.VI	13.VI	9.VIII
Age (days)		3	4	8	12	14	18	26	83
Number of investigated fish		102	100	74	50	70	38	40	35
Longitudo totalis	I	100.0	121.6	140.6	122.9	107.1	132.3	159.4	205.9
	P	106.5	106.4	118.1	115.9	120.7	123.5	121.9	122.6
Longitudo corporis	I	100.0	121.7	126.7	125.2	102.8	129.4	161.4	204.7
	P	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Longitudo praeanalis	I	-	100.0	130.6	-	129.7	132.1	157.4	208.1
	P	-	72.4	74.6	-	75.2	76.7	74.8	76.1
Longitudo capitis	I	100.0	124.3	174.2	115.6	114.7	130.3	152.5	198.1
	P	25.2	25.8	35.4	32.7	36.5	36.8	34.7	33.6
Altitudo capitis	I	100.0	109.3	174.4	125.5	113.4	137.3	146.0	223.5
	P	19.6	17.6	24.2	24.3	26.8	28.5	25.7	28.1
Summa altitudo corporis	I	100.0	108.3	204.5	117.4	122.5	168.1	155.4	234.2
	P	18.9	16.9	27.2	25.5	30.4	34.8	33.5	38.4
Minima altitudo corporis	I	100.0	108.7	288.0	93.1	151.5	141.9	144.8	201.2
	P	6.0	5.4	12.2	9.1	13.4	14.7	13.1	12.9
Summa latitudo capitis	I	100.0	-	162.1	-	141.3	133.1	143.7	210.4
	P	18.9	-	19.9	-	21.9	22.5	20.0	20.6
Summa latitudo capitis	I	100.0	-	186.4	-	136.1	144.4	133.5	241.8
	P	14.4	-	17.4	-	18.9	22.5	17.0	200.1

Tables III and IV contain data on increases in linear dimensions, their variation, the moving index, and proportions of the body calculated in relation to body length in the juvenile stage of the carp and crucian carp F_2 hybrids. The same values for hybrids after the first breeding period (KK_1) are given in Table VI.

No regularity of increasing or decreasing with age was found for the variation of nine investigated plastic features. Each investigated feature behaved differently, the same phenomenon having been observed with F_1 hybrids (S k ó r a 1962). The highest variation coefficient (v %) was noted in features of the largest and smallest body height of 12-day fry (Table III). Table IV shows that in the first period of life of F_2 hybrids the investigated features increased rapidly though sometimes not proportionally. After about 14 days certain stabilization in the growth of different linear features of the fry is noted, but insignificant deviations continue to appear. The body shape of carp and crucian carp F_2 hybrids is rather early formed, i.e., after 14 days of life (Tables IV, V), while in F_1 hybrids this occurred no sooner than after about 20 days after hatching (S k ó r a 1962). The head length index and the dorsal index decrease very rapidly during the first 8 days of life of the hybrids (Table V). From the 14th day on the head length index only insignicantly varied while the height index was still decreasing (in relative numbers) though not so rapidly as in the first period of life. A certain equilibrium of this index occurs after about 18 days of life, similarly as in the carp and crucian carp F_1 hybrids (S k ó r a 1962). The width index calculated in relation to the largest body height was distinctly lower in the first 14 days after the hatch than in the later period.

Table V. Body shape indices of juvenile stages in the F_2 carp and crucian carp hybrids

Age of fish (days)	Number of investigated fish	Dorsal index	Index of head length	Index of body thickness
3	102	5.28	3.96	1.00
4	100	5.93	3.88	-
8	74	3.68	2.82	1.37
12	50	3.92	3.06	-
14	70	3.29	2.74	1.39
18	38	2.87	2.72	1.55
26	40	2.98	2.88	1.67
83	35	2.61	2.97	1.86

The analysis of 29 plastic features of F_2 hybrids bred in pond Księżok Mały III in the Landek fish farm is given in Table VI. As already noted in F_1 hybrids (S k ó r a 1962, 1965) and in back hybrids (S k ó r a 1968), the plastic features of the investigated hybrids were fairly variable, this being shown by the value of the standard deviation (σ) and of the variation coefficient (v %). The less variable features included: length of pe-

ctoral fin, eye diameter, length of trunk, total length, distance between dorsal and anal fin, and total body length. The most variable features were: length of caudal trunk, length of anal fin base, body circumference, and distance between ventral and anal fin.

Table VI. Biometrical features (cm) of 120 one-year old carp and crucian carp F_2 hybrids in pond Księżok Mały III at the Landek fish farm

Features	Ranges	$\bar{x}$	σ	v%	Ranges	$\bar{x}$	σ	v%
	cm				%			
Pondus in g	3.0 - 41.0	12.58	6.257	49.73	in % longitudo corporis			
Longitudo totalis	5.2 - 12.9	8.75	1.365	15.60	111.6 - 130.2	121.4	6.691	5.51
Longitudo corporis	4.2 - 10.9	7.18	1.141	15.89	- -	100.0	-	-
Longitudo caudae	0.7 - 2.1	1.23	0.264	21.36	11.8 - 21.7	17.1	2.114	12.33
Longitudo trunci	2.8 - 7.8	5.08	0.778	15.32	62.0 - 76.6	70.4	2.917	4.14
Longitudo capitis lateralis	1.3 - 3.4	2.31	0.368	15.93	28.9 - 36.0	32.1	1.577	4.91
Longitudo spatii praeorbitalis	0.3 - 1.2	0.76	0.149	19.62	8.5 - 12.8	10.5	1.000	9.49
Diameter oculi	0.4 - 0.7	0.55	0.077	14.08	5.5 - 9.8	7.7	0.893	11.60
Longitudo spatii postorbitalis	0.6 - 1.7	1.07	0.195	18.23	12.5 - 17.4	14.8	1.026	6.91
Longitudo P	0.9 - 2.0	1.40	0.186	13.32	16.1 - 22.2	19.4	1.347	6.93
Longitudo V	0.9 - 2.0	1.23	0.209	17.00	12.1 - 20.3	17.2	1.716	10.00
Summa altitudo A	0.7 - 1.7	1.20	0.209	17.35	11.9 - 20.0	16.7	1.817	10.89
Longitudo pinnae C superior	1.1 - 2.2	1.62	0.267	16.43	19.0 - 26.4	22.7	1.627	7.17
Longitudo pinnae C inferior	1.1 - 2.2	1.60	0.280	17.50	18.2 - 25.9	22.4	1.722	7.69
Longitudo pinnae C media	0.5 - 1.2	0.76	0.063	8.29	8.9 - 14.3	10.7	1.176	11.01
Summa altitudo D	0.6 - 1.8	1.22	0.202	16.56	13.3 - 21.4	16.9	1.803	10.62
Longitudo basis D	1.8 - 4.3	2.59	0.465	17.95	31.2 - 41.3	36.1	3.581	9.91
Distantia praedorsalis	1.9 - 6.0	3.71	0.630	16.98	40.3 - 59.4	51.7	2.944	5.70
Distantia postdorsalis	0.9 - 2.0	1.33	0.256	19.32	14.5 - 22.4	18.5	2.370	12.69
Spatium inter D et A	1.8 - 5.1	3.01	0.473	15.71	37.3 - 46.8	41.9	2.903	6.93
Spatium inter P et V	1.0 - 2.7	1.67	0.325	19.43	18.9 - 27.3	23.2	2.295	9.91
Spatium inter V et A	1.1 - 3.1	1.86	0.374	20.03	19.2 - 30.2	25.7	1.885	7.33
Longitudo basis A	0.4 - 1.0	0.59	0.126	21.33	5.2 - 10.7	8.2	1.203	14.62
Summa altitudo capitis	1.3 - 2.9	1.98	0.350	17.71	22.0 - 30.2	27.4	2.643	9.95
Summa altitudo corporis	1.5 - 4.3	2.60	0.476	18.30	31.9 - 40.0	36.1	1.499	4.16
Minima altitudo corporis	0.6 - 1.4	0.90	0.161	17.79	10.2 - 15.1	12.5	0.948	7.58
Distantia inter oculos	0.5 - 1.4	0.82	0.163	19.81	9.8 - 14.8	11.4	1.206	10.54
Summa latitudo corporis	0.7 - 2.1	1.33	0.263	19.79	13.9 - 22.3	18.4	1.344	7.32
Summa longitudo in circuitu	4.0 - 11.0	6.91	1.420	20.56	81.8 - 105.0	95.4	5.743	6.02

The body shape of F_2 hybrids from pond Księżok Mały III was fairly variable. The dorsal index, the head length index, and the condition factor varied in the population. The dorsal index ranged from 2.54 to 3.22 (2.76 on the average), the head length index ranged from 2.75 to 3.48 (3.18 on the average) while the head length to head height ratio was 1.07—1.46 (1.17). The condition factor calculated according to the Fulton formula, was rather low, reaching 1.88 for the whole population of hybrid fry (1.22—2.28). In pond Księżok Mały III the poor condition of the investigated F_2 fry was caused by very difficult breeding conditions in the 1979 breeding season. The insufficient level of atmospheric precipitations did not secure necessary amounts of water for filling the whole pond while the stock had been calculated in relation to the total pond area, this resulting in great density of fish in the pond.

Apparently, the F_2 hybrids with compact, stripe, or frame scaliness (fig. 3) resembled the carp by their head structure and the dorsal fin. Most hybrids (89%) had four moustaches: two shorter ones on the upper labium, and two longer ones on the lower one. Specimens with two moustaches (on the lower labium only — 8% of fish) and even with three (3% of fish) were also encountered. There were no specimens without moustaches, while such specimens were sporadically noted in the F_1 population obtained from carp females and crucian carp males (Skóra 1965).

In F_2 hybrids from pond Księżok Mały III the dorsal line rose up almost uniformly from the forehead (fig. 3). No distinct border between the head and the body could be observed. The red-golden eye with dark blue pupils, smaller than those in the carp, was rather similar to the eye of the crucian carp.

The heredity of forms of the scaliness in F_2 hybrids worth of noting: about $^3/_4$ of specimens of the investigated population had the compact scaliness while about $^1/_4$ of fish showed the nontypical scaliness, specimens with typical and nontypical stripe scaliness and specimens with typical and nontypical frame scaliness being encountered in the samples (the data are based on control catches carried out on August 9, 1979). The F_2 hybrids with bodies only partly covered with scales resembled the forms of scaliness which were noted in the carps used in crosses with the crucian carp for obtaining the F_1 population. In these specimens scales only appeared along the lateral line (sometimes with breaks) and on body circumference, chiefly near fins and head. There were also hybrids with scales on body circumference only while the sides were scaleless or covered with single scales or small groups of scales. In carp and crucian carp hybrids whose bodies were all covered with scales, the size and shape of individual scales were intermediate between the scales of the carp and those of the crucian carp. There appeared hybrids with two types of scales on their bodies: smaller and larger ones which differed by their structure. Some of them were similar to the scales of the carp; others to those of the crucian carp. In hybrids with the stripe or frame scaliness the scales were similar to those of the carp.

The colouring of F_2 hybrids with the compact scaliness was metallic brazen, with the dorsal part darker than the sides and with the light-golden ventral side. In the examined population about 70% of specimens were distinctly lighter, rather more silvery than the remaining 30% of dark-golden fish. The skin colouring of hybrids with stripe or frame scaliness was similar to the carp, being slightly lighter only. No caudal speck which is observed in young crucian carps (Skóra 1961) was noted in F_2 hybrids, neither was it found in the F_1 population (Lieder 1955, Skóra 1962) nor in back hybrids (Skóra 1968).

The range of variation of the number of scales and the number of

rows of scales over and particularly under the lateral line was greater than in carp and crucian carp F_1 hybrids (Nikoljukin 1952, Lieder 1955, Kiselov 1958, Skóra 1962, 1965, Rudziński, Skóra 1963) and in back hybrids (Skóra 1968). The formula of scales found in the F_2 population was $35\frac{5—7}{5—8}—40$. However, the variation coefficient for the number of scales in the lateral line was not high, reaching 3.21%. In the investigated hybrids the number of scales in the lateral line corresponded to the number of vertebrae in the spine. Most frequently 37, 38, or 39 scales appeared in the lateral line, and similar numbers of vertebrae were found in the spine of the hybrids. The difference between the mean number of scales on the lateral line (38.02) and the mean number of vertebrae in the spine (37.38) was also insignificant. The coefficient of variation calculated for the number of vertebrae also reached similar values (3.39%, Table VII).

Table VII. Meristic features of carp and crucian carp F_2 hybrids in pond Księżok Mały III at the Łódek fish farm

Features	n	$\bar{x}$	σ	v%
Number of scales: on the lateral line	110	38.02 (35-40)	1.221	3.21
above the lateral line	110	6.25 (5- 7)	0.519	8.31
Number of scale ranges below the lateral line	110	6.45 (5- 8)	0.682	10.57
Number of vertebrae in the spine	120	37.78 (35-40)	1.279	3.39
Number of gill rakers on gill arches	120	25.92 (22-32)	0.993	3.83
Number of rays in: dorsal fins	120	III-IV/19.68 (18-22)	0.991	5.04
pectoral fins	120	15.72 (14-18)	0.858	5.46
ventral fins	120	9.25 (9-11)	0.470	5.08
anal fins	120	III/ 5.07 (4- 6)	0.335	5.43
caudal fins	120	19.17 (18-22)	0.568	2.96

In F_2 hybrids, as in back hybrids (Skóra 1962), the number of gill rakers on the outer margin of the first gill arch was variable (22—32 processes). The variation was much more pronounced than in the population of F_1 hybrids (Skóra 1962). In the investigated F_2 population the variation coefficient for this trait was also fairly high, reaching 8.88%.

The determination of the number of hard and soft rays in the fins of F_2 hybrids revealed no fin deformations. Such deformations had been frequently noted in carp and crucian carp F_1 hybrids (♀ crucian carp × × ♂ carp) and in back hybrids, chiefly in specimens obtained from a hybrid female and crucian carp males (Skóra 1965, 1968). In 120 specimens of the investigated F_2 population the absence of the right pectoral fin was noted in one fish only. The number of long branched rays in anal, ventral, and caudal fins was much less variable than in the dorsal or pectoral ones (Table VII). In the anal fin 5 soft branched rays were most frequently noted, besides 3 hard unbranched ones (in 92.5% of the popula-

tion). In the caudal fin 19 rays (82.5% of fish); and in ventral fins 9 rays (76.7% of fish) were found. It should be mentioned that the last ray in the dorsal and anal fin was frequently divided down to the base, and was always counted as one. The variation coefficients calculated for the number of soft rays were similar to each other in the dorsal, pectoral and ventral fins (5.04—5.46%) while the coefficient calculated for the caudal fin markedly differed from them (2.96%). The following numbers of hard and soft rays were determined in the fins of the investigated hybrids from pond Księżok Mały III: the dorsal fin D III—IV/18—22, the anal fin A III/4—6, the pectoral fin P 14—18, the ventral fin V 9—11, the caudal fin C 18—22. In the anal fin the constant number of 3 hard rays was noted in all investigated specimens of the population. In the dorsal fin 3 hard rays were also found in most hybrids, but specimens with 4 hard rays in this fin were also encountered.

In the F_2 population and in the carp and crucian carp back hybrids (Skóra 1968) the scheme of pharyngeal teeth was very variable, changing from one-row to three-row arrangements in different combinations. In the investigated population most fishes (56.4%) had the scheme of pharyngeal teeth which corresponded to that found in the carp: 1.1.3—3.1.1. or similarly 1.1.2—2.1.1., 1.1.2—3.1.1, 1.1.3—2.1.1, 1.1.4—2.1.1, or 1.1.3—4.1, 1.4—3.1.1, 1.1.3—3.1, 1.3—3.1.1, 1.1.3—3.2, 2.3—3.1.1, 1.1.2—2.1, 1.2—2.1.1, 1.1.3—4, 2.4—3.1.1, 1.1.2—3.1, 1.3—2.1.1, 1.1.3—2, 1.2—3.1.1. Some specimens (7.5%) of the investigated population was characterized by a scheme typical of the crucian carp: 4—4 or 3—4, 3—3, 2—3, 3—2. A fairly large group (27.3% of the F_2 population) was composed of fishes with a two-row arrangement of teeth, according to the formula most often encountered in F_1 hybrids: 1.4—4.1 (Nikoljukin 1952, Kiselov 1958, Skóra 1962) or 1.3—3.1, 1.3—4.1, 1.4—3.1, 2.4—4.2, 2.3—3.2, 2.3—4.2, 2.4—3.2, 2.4—4.1, 1.4—4.2, 1.2—2.1, 1.3—2.1, 1.2—4.1. In some specimens (8.8% of the population) the following arrangements of teeth were noted: 3—3.1, 1.3—3, 1.4—4, 4—4.1, 1.4—3, 3—4.1, 2—3.1, 1.3—2, 1.4—2, 2—4.1.

Table VIII. Length of alimentary ducts carp and crucian carp hybrids of the F_2 generation

Classes and body length (cm)	Number of fish	Length of alimentary ducts			
		in cm		% of body length	
		Limits of variation	Mean	Limits of variation	Mean
4.1- 5.0	2	7.5-10.2	8.8	178.6-204.0	191.3
5.1- 6.0	17	9.3-15.0	12.1	171.7-256.7	211.3
6.1- 7.0	40	11.0-19.5	14.4	172.3-263.6	217.3
7.1- 8.0	41	13.3-21.5	17.7	184.0-286.7	232.5
8.1- 9.0	10	17.0-23.0	19.5	192.8-265.5	229.3
9.1-10.0	7	16.3-24.5	21.6	171.6-253.2	229.2
10.1-11.0	3	20.5-26.5	23.8	201.0-262.4	229.4

The length of the alimentary duct of F_2 hybrids increased as the body length grew (Table VIII*j*. Relative numbers show that, like in the carp (K l u s t 1940), in the crucian carp (S k ó r a 1961), and in F_1 hybrids (S k ó r a 1962), the alimentary canal grew faster than the body length in the first period of growth of the investigated hybrids. Not before the hybrid fry reached about 8 cm in length, the growth of the alimentary duct became more uniform and parallel to body length increase (Table VIII). The length of alimentary ducts of hybrids from pond Księżok Mały III was fairly variable. This was indicated by the variation coefficient which reached 22.19%.

Among the investigated features of internal organs there was the position of the floating bladder. In the F_2 population it slightly differed from that in the F_1 generation. In the first generation of hybrids the anterior chamber was shorter than the posterior one (R u d z i ń s k i, S k ó r a 1963), their relative ratio reaching 45 : 55%. In the F_2 population a reverse situation was observed. The anterior chamber was longer, the ratio of the two chambers being 55 : 45%. The volume of chambers of the floating chamber determined in cubic centimetres, was also investigated. In F_2 hybrids the volume ratio of the anterior to the posterior chamber was 65.9 : 34.1% (72.2 : 27.8%—54.6 : 45.4%). This ratio ranged from 53.3 : 46.7 to 57.1 : 42.9 in F_1 hybrids (R u d z i ń s k i, S k ó r a 1963). The obtained results show that in hybrids from pond Księżok Mały III the anterior chamber of the floating bladder was larger than the posterior one with respect to length and volume. In the investigated carp and crucian carp F_2 hybrids the shape of the posterior chamber differed from that of F_1 hybrids. It was shorter and smaller than in the first generation of hybrids, and more sharply pointed than in the carp (R u d z i ń s k i, S k ó r a 1963).

4. Conclusions

The investigation shows that there are great possibilities of large-scale production of the F_2 generation because among the hybrid females and males of the F_1 population there occurs a large percentage of fertile specimens which can be used for breeding. In my experiments there was about 70% of fertile female hybrids and 45% of fertile males. Also, it seems that the F_2 hybrids (particularly those with the compact scaling), similarly like the carp and crucian carp F_1 hybrids, are more tolerant of diseases (chiefly the carp dropsy) and difficult environmental conditions (e.g., poor oxygenation or pollution with wastes) than the carp. They can, therefore, be used in stocking of small country ponds, exploited areas, depressions, lakes, and dam impoundments, but also ponds in

fish farms where difficult breeding conditions make it impossible to obtain good production results in carp breeding.

5. Polish summary

Badania nad mieszańcami karpiokarasia pokolenia F_2 pozyskanymi od samic i samców mieszańca pokolenia F_1 (♀ *Cyprinus carpio* L. × ♂ *Carassius carassius* L.)

Badania zostały przeprowadzone w stawach Zakładu Doświadczalnego Gołysz Zakład Biologii Wód PAN. Miały na celu stwierdzenie, czy samce mieszańców karpiokarasia zdolne są do rozrodu z samicami tych samych populacji mieszańców pokolenia F_1 (♀ *Cyprinus carpio* L. × ♂ *Carassius carassius* L.) i dania potomstwa pokolenia F_2 na skalę gospodarczą.

Następnym celem badań miało być poznanie kierunku rozwoju poszczególnych cech morfologicznych, merystycznych i niektórych anatomicznych oraz zmienności tych cech u mieszańców karpiokarasia pokolenia F_2.

Wysadzone wiosną 1979 r. do jednego tarliska w gospodarstwie Landek samce i samice karpiokarasia pokolenia F_1 (ryc. 1 i tabela I) wytarły się i dały potomstwo pokolenia F_2 (ryc. 2) w liczbie około 2 000 000 sztuk.

Część pozyskanego wylęgu pokolenia F_2 w liczbie 120 000 sztuk w dniu 21.V.1979 r. została przeniesiona z tarliska do stawu Księżok Mały III, w którym przebywały przez cały sezon wegetacyjny (tabela II). Przeżywalność mieszańców pokolenia F_2 w wieku KK_1 hodowanych w stawie Księżok Mały III była dobra i wynosiła 45,1% obsady.

W pracy wykorzystano dane z pomiarów 627 sztuk wylęgu (509 sztuk) i narybku (120 sztuk) mieszańców. Spośród cech morfologicznych u wylęgu rozpatrywano 9 (tabele III—V), a u narybku jednorocznego 29 cech liniowych (tabela VI). Dane liczbowe poddano podstawowej analizie statystycznej, obliczając średnie arytmetyczne ($\bar{x}$), odchylenia średnie (σ), współczynniki zmienności ($v\%$) i proporcje ciała (P) w odniesieniu do długości ciała oraz indeksy ruchome (I) u wylęgu. Na podstawie tych pomiarów i obliczeń scharakteryzowano karpiokarasia pokolenia F_2 hodowanego w stawach.

W skład badanej populacji mieszańców pokolenia F_2 wchodziły osobniki o ułuszczeniu całkowicie zwartym oraz o ułuszczeniu ramowym i lampasowym (ryc. 3). Wzór łusek u mieszańców o ułuszczeniu zwartym przedstawiał się następująco: $35 \frac{40\ 5—7}{5—8}$ (tabela VII). Liczbie łusek na linii nabocznej bardzo często odpowiadała ilość kręgów w kręgosłupie mieszańców (F_2).

Liczba wyrostków filtracyjnych na zewnętrznej krawędzi pierwszych łuków skrzelowych wahała się od 22 do 32. W płetwach mieszańców stwierdzono następujące liczby promieni twardych i miękkich: D III–IV/18—22, A III/4—6, P 14—18, V 9—11, C 18—22 (tabela VII).

Układ zębów gardłowych wykazywał bardzo dużą zmienność, od jedno- do trójrzędowego i to w różnych kombinacjach.

Długość przewodu pokarmowego karpiokarasi pokolenia F_2 początkowo wzrastała szybciej niż długość ciała (wyrażona w liczbach względnych). Dopiero po osiągnięciu przez narybek długości 8 cm, wzrost przewodu pokarmowego wyrównuje się i przebiega równolegle ze wzrostem długości ciała (tabela VIII).

Przednia komora pęcherza pławnego u mieszańców pokolenia F_2 była dłuższa i objętościowo większa od komory tylnej (odwrotnie niż u karpiokarasi pokolenia F_1).

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