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Karaś srebrzysty (*Carassius auratus gibelio* Bloch) z rzeki Iłownicy wsiedlony do stawu karpiowego

The German Carp (*Carassius auratus gibelio* Bloch) from the river Iłownica stocked in a carp pond

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Abstract — The present study was based on the results of measurements of specimens of 96 German carp collected at random from a population cultivated in the pond Młyński lying in the Landek farm controlled by the Laboratory of Water Biology of the Polish Academy of Sciences in Cracow. On the basis of body measurements and of other investigations it was found that the German carp is a form typical of this species. With regard to its outward appearance, colouring, shape of body, meristic and anatomical features it corresponds to the German carp (*Carassius auratus gibelio* Bloch) described by other authors.

The present work forms part of investigations on the crucian carp and its crosses with the carp carried out on the terrain of experimental farms (Gołysz Complex) of the Laboratory of Water Biology of the Polish Academy of Sciences.

The German carp, together with the common crucian carp, occurs in very large numbers in Poland, the area of its distribution continuously increasing.

The data reported in the home literature on the morphology of the German carp (*Carassius auratus gibelio* Bloch) are rather scarce, with the exception of those found in the works of Gąsowska (1934) and Stangenberg (1934). In the neighbouring countries the authors taking an interest in the German carp were, among others, Balon (1962), Berg (1949), Čerfas (1969), Golovinskaja (1965), Mišik, Holčik (1962), Romašov (1947), according to Čerfas (1969), Šapošnikova (1964), Serov (1959), and Žukov (1960, 1965).

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It therefore seemed expedient to fill the gap in the knowledge of this species by investigating larger numbers of German carp from the terrain of Cieszyn Silesia, where this fish has lately become widespread. According to Gąsowska (1934), the German carp in the thirties of the present century occurred exclusively on the terrains of Eastern Little Poland, while nowadays it is encountered not only in Southern Little Poland but also in Upper and Lower Silesia.

For the past few years the German carp has been observed in masses in the river Iłownica (Cieszyn Silesia), a right affluent of the Vistula (joining it below the Goczałkowice Reservoir) supplying water to the pond from which the investigated crucian carp were collected.

During the 1967 vegetation season German carp did not occur at all in the ponds of the Experimental Farm Landek (Gołysz Complex) of the Laboratory of Water Biology of the Polish Academy of Sciences in Cracow, while several ponds were stocked with the common crucian carp or with *Carpio Kollari*. In the autumn of 1968 during the fishing of the pond Młyński and of several other ponds of the mentioned farm, lying in the upper and lower part, two-year- and one-year-old German carp were caught in addition to carp stocked in the spring.

From the pond Młyński lying in the upper part of the complex Iłownica of the Landek farm, besides two-year-old commercial carp, about 1200 specimens of two-year-old German carp were caught, with a total weight of 150 kg. Hence it follows that this fish came to the pond from the river Iłownica during the flood which took place in this region towards the end of June 1968. The German carp stayed with the two-year-old commercial carp from the end of June to the 1st October 1968, i.e. to the autumn fishing of the pond. This pond was manured with mineral fertilizers (quick lime, ammonium sulphate, superphosphate, potash salt), the fish being additionally fed with grain fodder.

After the completion of fishing on 1st October 1968 the crucian carp were transported to a winter pond in the Mnich complex (Gołysz Complex), where they stayed till 11th May 1969. On that day 96 specimens of German carp were collected at random from the whole material to serve for the present investigations, while the remaining ones together with the commercial carp were transferred to the pond Kasprzyca in the Mnich complex.

To determine the age of the investigated material several scales were taken from each fish from the first and second row of scales above the lateral line at the height of the first ray of the dorsal fin. Sex and sexual maturity were examined by cutting open the belly of each fish, removing gonads, and weighing them on a technical balance.

The biometric investigations were carried out according to the schema accepted in the author's previous work (Skóra 1962).

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The size of the German carp

The size of the German carp from the pond Młyński in the Landek farm, the particular individuals of which had a body length of 13.7 to 17.4 cm (15.5 cm on the average) and body weight of 57—134 g (87.5 g on the average), can be considered as fair, since these figures are higher than those mentioned by Šapošnikova (1964) and Staff (1950) for the two-year-old German carp. Gierałtowski (1956) reported for the same age group of this species of crucian carp a body weight similar to that of the fish considered here. Serov (1959), investigating several populations of German carp from some water regions of Kazakhstan, noted various mean body lengths for the second age group, according to the environment from which the crucian carp came. He obtained various results, some of them being similar to those of the present investigations. Other populations of German carp grew not so well and still others better. According to Heuschmann (1938), the two-year-old German carp is of no lesser size than the common crucian carp. In the present investigations, however, after comparing the body length and weight of a two-year-old German carp with analogous measurements of a crucian carp of the same age cultivated under similar conditions on the same terrain but in different farms of the Gołysz complex, two different results were obtained (Skóra 1961, Rudziński, Skóra 1963). The two-year-old common crucian carp from the Gołysz farm (Skóra 1961) showed a much better size than the two-year-old German carp, whereas the common crucian carp of the same age from the Mnich complex (Rudziński, Skóra 1963) was of a similar and even slightly smaller size than the German carp discussed in the present study. Hence it follows that Heuschmann's (1938) opinion on the similar size of the two species of German carp is correct, the larger or smaller size of this or that species depending on the environment in which the given crucian carp is living.

Morphological features of the German carp

The body length of the examined two-year-old German carp ranged from 137 to 174 mm (155 mm on the average). The greatest percentage of individuals was found in the class of 146—150 and 151—155 mm.

The examined German carp possessed a spindle-shaped body with a slightly curved back. It had the appearance of a lively and well swimming fish.

The maximum height of the body was 2.8 to 3.2 times less than the body length (*longitudo corporis*), amounting to 31.0—35.5 per cent (33.1 per cent on the average). The minimum height of the body was 6.4 to 8.6 times less than the body length, this being 11.6 to 15.6 per cent (14.1 per cent on the average).

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The head of the examined German carp was more elongated and higher in the occiput than that of the common crucian carp (Skóra 1961, Rudziński, Skóra 1963). The length of the head was 3.4 to 3.8 times less than the body length, amounting to 26.3—29.3 per cent (27.4 per cent on the average) of the body length. The height of the head was 1.1 to 1.3 times less than the head length, this being from 78.3 to 93.5 per cent (85.1 per cent on the average). The length of the mouth was from 3.3 to 4.2 times less than the head length, amounting to 23.9—30.2 per cent (26.9 per cent on the average). The mouth aperture was small, slightly shifted downwards. The lips were more fleshy than in the common crucian carp, na barbels being found on them. The eye of the examined crucian carp was more like that of a carp than of the common crucian carp. It was large, with a wide pupil and narrow iris. The latter had a lively, metallic lustre, its internal circumference being limited by a light shining ring, owing to which the eye stood out more distinctly against the colour of the body than in the common crucian carp. The eyes were large, with a horizontal axis 4.4 to 5.5 times less than the head length, which amounted to 18.2—22.7 per cent (20.1 per cent on the average).

The post-orbital distance was 1.8 to 2.0 times less than the head length, this being 50.0 to 55.8 per cent (52.5 per cent on the average).

The dorsal fin was long with a concave external edge. The base of this fin was 2.6 to 3.0 times less than the body length, this amounting to 31.4—37.9 per cent (35.3 per cent on the average).

The anterior part of the body (from the first ray of the dorsal fin to the beginning of the mouth) and the post-dorsal part of the body (from the last ray of the dorsal fin to the base of the caudal fin). The anterior part of the body of the examined crucian carp was 2.0 to 2.2 times less than the body length, this amounting to 45.5—51.0 per cent (48.2 per cent on the average). The post-dorsal part of the body was 3.6 to 4.2 times less than the body length, this being 23.8—28.8 per cent (25.8 per cent on the average).

Of the 30 measured features of the German carp examined on the basis of absolute numbers (Table I) the largest body circumference (*summa longitudo in circuitu*) and the total length (*longitudo totalis*) showed the greatest deviation (σ) from the standard mean ($\bar{x}$), whereas the smallest deviation from this mean was observed in the diameter of the eye (*diameter oculi*) and in the length of the mouth (*longitudo spatii praeorbitalis*).

The greatest relative variability (v%) was noted in the length of the lower lobe of the caudal fin (*longitudo pinnae* C *inferior*) and in the thickness of the body (*latitudo corporis*). It was only in these two plastic features that the variability (v%) exceeded the value of 10 per cent, while in the remaining 28 features it was fairly low, ranging from 5.48 to 9.83 per cent.

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Tabela I. Zestawienie cech biometrycznych 96 egzemplarzy karasia srebrzystego (Carassius auratus gibelio Bloch) ze stawu Młyńskiego w gospodarstwie Landek

Table I. Biometric features of 96 specimens of Carassius auratus gibelio Bloch from the pond Młyński in the Landek farm

Nazwa cechy Designation of feature	Zakresy Range	$\bar{x}$	σ	v%	Zakresy Range	$\bar{x}$	σ	v%
	cm				%			
					in % longitudo corporis			
Longitudo totalis	16,6 - 20,4	18,55	1,035	5,58	114,9 - 121,9	119,6	5,135	4,29
Longitudo corporis	13,7 - 17,4	15,51	0,899	5,80	- -	100,0	-	-
Longitudo praeanalis	9,7 - 12,3	10,85	0,620	5,71	66,2 - 76,4	69,9	1,563	2,24
Longitudo praeventralis	6,4 - 8,0	7,12	0,417	5,86	41,9 - 47,7	45,9	1,144	2,49
Longitudo caudae	2,5 - 3,7	3,00	0,244	8,13	17,6 - 21,6	19,3	0,991	5,13
Longitudo trunci	10,5 - 13,2	11,78	0,676	5,74	70,8 - 79,1	75,9	1,648	2,17
Longitudo capitis lateralis	3,6 - 4,8	4,25	0,259	6,09	26,2 - 29,2	27,4	0,633	2,31
Longitudo P	2,6 - 3,5	3,07	0,227	7,39	17,6 - 21,0	19,7	0,832	4,21
Longitudo V	2,9 - 3,7	3,32	0,199	5,99	19,5 - 22,5	21,4	0,624	2,92
Summa altitudo A	1,9 - 2,7	2,32	0,184	7,94	12,0 - 16,5	15,0	0,824	5,50
Longitudo pinnae C superior	2,8 - 3,5	3,11	0,185	5,95	16,7 - 22,4	20,1	1,134	5,65
Longitudo pinnae C inferior	3,0 - 3,7	3,31	0,211	6,37	19,6 - 22,6	21,3	0,842	3,95
Longitudo pinnae C media	1,8 - 2,5	2,12	0,246	11,60	12,4 - 15,5	13,5	0,594	4,39
Summa altitudo D	2,3 - 2,9	2,59	0,142	5,48	14,9 - 18,4	16,7	0,698	4,18
Longitudo basis D	4,5 - 6,4	5,48	0,415	7,57	31,4 - 37,9	35,3	1,387	3,93
Distantia praedorsalis	6,8 - 8,5	7,48	0,436	5,83	45,5 - 51,0	48,2	1,349	2,80
Distantia postdorsalis	3,3 - 4,9	4,01	0,325	8,10	23,8 - 28,8	25,8	1,322	5,13
Spatium inter P et V	2,6 - 3,6	3,07	0,276	8,99	18,3 - 21,9	19,8	1,003	5,07
Spatium inter V et A	3,8 - 4,7	4,14	0,276	6,67	24,2 - 30,1	26,7	1,285	4,81
Longitudo basis A	1,4 - 2,1	1,79	0,176	9,83	9,2 - 13,3	11,5	0,750	6,52
Summa altitudo corporis	4,4 - 6,0	5,14	0,415	8,07	31,0 - 35,5	33,1	1,093	3,31
Altitudo analis	3,2 - 4,4	3,73	0,340	9,12	22,1 - 26,0	24,0	1,050	4,37
Minima altitudo corporis	1,7 - 2,5	2,18	0,193	8,85	11,6 - 15,6	14,0	0,702	5,00
Summa latitudo corporis	2,1 - 3,3	2,65	0,284	10,72	14,8 - 19,5	17,0	1,062	6,23
Summa longitudo in circuitu	10,5 - 14,5	12,44	1,050	8,44	73,9 - 87,1	80,1	3,085	3,85
					in % longitudo capitis lateralis			
Longitudo spatii postorbitalis	1,8 - 2,6	2,23	0,165	7,40	50,0 - 55,5	52,5	1,466	2,79
Diameter oculi	0,8 - 1,0	0,85	0,056	6,59	18,2 - 22,7	20,1	1,253	6,24
Longitudo spatii praeorbitalis	0,9 - 1,3	1,14	0,077	6,75	23,9 - 30,2	26,8	1,444	5,38
Summa altitudo capitis	3,1 - 4,3	3,62	0,276	7,62	77,5 - 90,5	85,1	3,421	4,02
Distantia inter oculos	1,7 - 2,2	1,92	0,132	6,87	41,9 - 50,0	45,5	1,854	4,08
Pondus in g	57,0 -134,0	87,47	19,116	21,85				

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On account of the appearing uniformity of the analysed material the examined population of German carp was characterized in percentage rate. The percentage was calculated in relation to the body length (*longitudo corporis*) and head length (*longitudo capitis lateralis*). Here also there appeared a uniformity of the material, since all proportions without exception showed a very low variability ranging from 2.17 to 6.52 per cent.

On the basis of this analysis it can be assumed that the examined material of the two-year-old German carp was very homogeneous.

The colour of the back of the German carp was dark steel-grey, almost navy blue, the sides being a little lighter with a green tint, passing into a bright silvery belly. The whole body had a slight brassy-golden colouring. The unpaired fins were grey and the paired ones light, very weakly pigmented and slightly pinkish.

The body of all the examined individuals was covered with large scales of rough surface, arranged in regular rows.

The curve illustrating the number of scales in the lateral line was one-modal. The number of scales with apertures of the lateral line on the left and right side of the body was usually the same, the observed asymmetry being limited to one or more rarely to two scales. The larger or smaller number of scales on the lateral line depended on the number of vertebrae occurring in the spinal column of the given fish. The limit of variations of the number of scales in the lateral line was not large, amounting to 29—31 scales (29—84 on the average). Most frequently occurring on the lateral line of the examined species were 30 scales with apertures (in 69.9 per cent of fish) at a fairly low coefficient of variability $V\% = 2.79$.

Above the lateral line, counting towards the base of the dorsal fin, 6 to 7 rows of scales (most frequently 6) were noted (Table II), at a standard mean $\bar{x} = 6.28$ and coefficient of variability $v\% = 7.17$.

Below the lateral line towards the base of the ventral fins 5 to 7 rows of scales (most frequently 6) were counted. Seven rows of scales under the lateral line were noted only in three individuals of the 96 examined. The mean number of rows of scales below the lateral line amounted to $\bar{x} = 5.8$ at a fairly high coefficient of variability $v\% = 8.10$.

The gill rakers (counted on the external edge of the first branchial arches), an important diagnostic feature in distinguishing the German carp (*Carassius auratus gibelio* Bloch) from the common crucian carp (*Carassius carassius* L.), were long and very closely set, their number varying from 38 to 49 (43.36 on the average). Most often 44 gill rakers were observed (in 21.9 per cent of fish) and slightly less frequently 43 (12.5 per cent of fish) (Table II).

The number of vertebrae in the spinal column, on which depended the number of scales with apertures of the lateral line of the German

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Tabela II. Zestawienie cech merystycznych karasia srebrzystego (Carassius auratus gibelio Bloch) ze stawu Młyński w gospodarstwie Landek

Table II. Meristic features of Carassius auratus gibelio Bloch from the pond Młyński in the Landek farm

Cechy Features		$\bar{x}$	σ	v%
Liczba łusek na linii nabocznej ciała Number of scales on the lateral line of the body		29,84 (28-31)	0,833	2,79
Liczba rzędów łusek Number of rows of scales	nad linią boczną over the lateral line	6,28 (6- 7)	0,450	7,17
	pod linią boczną under the lateral line	5,80 (5- 7)	0,470	8,10
Liczba wyrostków filtracyjnych na łukach skrzelowych Number of gill rakers on the branchial arches		43,39 (38-49)	2,484	5,73
Liczba kręgów w kręgosłupie Number of vertebrae in the spinal column		29,59 (28-31)	0,744	2,51
Liczba promieni w płetwach: Number of rays in fins:	grzbietowych dorsal	III/16,41 (15-18)	0,605	3,69
	piersiowych pectoral	15,43 (14-17)	0,591	3,83
	brzusznych ventral	8,41 (8- 9)	0,491	5,84
	odbytowych anal	III/ 5,02 (5- 6)	0,143	2,85
	ogonowych caudal	18,92 (17-19)	0,312	1,65

carp, ranged from 28 to 31 vertebrae (29.59 on the average). Most often there occurred 30 vertebrae (in 46.9 per cent of fish) and the least frequently 28 vertebrae (in 6.25 per cent). The coefficient of variability (v%) of the number of vertebrae was very low, amounting to barely 2.51 per cent (Table II).

The formula of pharyngeal teeth of the German carp was very little variable, one row. Of the 96 examined specimens as many as 95 had the formula 4-4 and only in one of them was the formula 4-5 noted.

One of the most important diagnostic features is the black opalescent peritoneum and diaphragm of the examined German carp. This feature is an unmistakable indicator in the determination of the appurtenance to the species of the German carp (*Carassius auratus gibelio* B l o c h).

The air-bladder of the examined German carp was composed of two parts: an anterior one, shorter, of larger diameter and a posterior one, longer, of smaller diameter and shape very little departing from a regular cone. It is in the posterior section that the air-bladder of the German carp differs from that of the common crucian carp, in which this section is bent archwise on the dorsal side. The ratio of the anterior part of the air-bladder to its posterior part amounted on the average to 39.92 : 60.08 per cent, with variations of 35.08—42.86% : 57.14—64.92%.

The dorsal fin of the German carp was long with a concave upper edge, composed of three hard unbranched rays and 15 to 18 soft branched rays. Individuals with 16 soft rays in the dorsal fin markedly prevailed in the examined material (56.2 per cent of fish), followed by those with 17 rays

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(37.5 per cent of fish). Of the 96 fish examined only 3 specimens possessed 15 rays and 3 others 18 rays in the dorsal fin (Table II). In all the examined fishes this fin was well developed, showing no injuries or deformation.

The pectoral fin most often had 15 rays (in 53.1 per cent of fish) or 16 (in 41.7 per cent). Only in 5 cases (in 5.2 per cent of fish) were 17 rays noted and in one (1.0 per cent) 14 rays.

In the ventral fin there most often occurred (in 59.4 per cent of fish) 8 rays, the remaining 40.6 per cent of fish each having 9 rays in the ventral fin.

The anal fin was distinguished by very small variability in the number of branched soft rays. It was always composed of 3 hard unbranched rays and in 94 cases of the examined 96 fish (97.9 per cent) of 5 soft branched rays. Only 2 individuals of the 96 examined (2.1 per cent of fish) possessed 6 soft rays in the anal fin.

The caudal fin of the German carp was also distinguished by small variability. In as many as 93 cases (92.7 per cent of fish) of the 96 examined specimens there occurred here 19 rays, while only 2 fishes (2.1 per cent) possessed 18 rays and one (1.04 per cent) 17 rays.

The greatest coefficient of variability (v%) for fins was that referring to the number of rays in the ventral fin (v% = 5.84), the smallest being noted for the number of these rays in the caudal (v% = 1.65) and anal (v% = 2.85) fins. The coefficient of variability (v%) of the dorsal fin amounted to 3.69 per cent and of the pectoral fin to 3.83 per cent.

After examining 96 individuals of German carp collected at random during the catch of this fish on 11th May 1969 from a winter pond, 95 females and 1 male were identified. The gonads of all females were fairly well developed, i.e. in stages II and IV of sexual maturity (after Maier), and their relative values (ratio of gonad weight to body weight) varied from 1.18 to 8.58 per cent (4.12 per cent on the average). This, as well as other observations, showed that the majority of these females after reaching the second year of age are already fit for the first spawning. The only male in this material was one of the largest specimens, its body length (16.0 cm) and weight (101 g) being larger than the average. However, the testicles of this male were poorly developed and its sex could be determined with certainty only after examining the gonads under the microscope.

Gynogenesis is the cause of the almost exclusive occurrence of females in the populations of German carp. The first to establish this phenomenon in the German carp was Romašov (in 1947) (according to Čerfas 1969). This author reflected on the fact that in populations of German carp one observes females almost exclusively. He came to the conclusion, supported by cytological investigations, that there exists in these fishes a particular way of reproduction, owing to which the fertilization by no matter which sperm, whether that of the German carp or of some other

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species of the family *Cyprinidae,* gives an exclusively female progeny. This is due to the fact that the spermatozoon, after penetrating into the female egg cell, only activates it to development, no conjugation of chromosomes taking place, independently of the species (of the family *Cyprinidae*) from which the activating sperm proceeds. Since the female reproductive cells are not haploid as might be expected, but, in consequence of the disturbance in the process of meiosis, diploid, as was hitherto considered, and on the other hand, the inheritance of sex in the German carp takes place according to the schema of male heterogamets (various schemata are encountered in fish), individuals born in this way must all be females.

The schema of male heterogamets is also observed in carp. It has lately been found (Čerfas 1969) that in natural conditions there occur two varieties of German carp: one deriving from natural gynogenesis and the other developing normally. The latter is very seldom encountered, this being the reason why males occur only sporadically in German carp populations.

A cytologic study recently carried out by Čerfas (1969) showed that the number of chromosomes in females from bisexual populations of German carp amounted to $2n = 94$, whereas in unisexual populations (gynogenetic) it is $2n = 141$. This leads to the conclusion that they are triploids and not diploid gynogenetic populations as was hitherto assumed. Females from bisexual and unisexual gynogenetic populations do not differ morphologically from one another. According to Čerfas (1969), the only difference between these two varieties of German carp is that females from bisexual populations are for the most part already mature towards the end of the second vegetative season, whereas those from gynogenetic populations are mostly still immature at that time.

In gynogenetic populations the first reduction division does not occur, in consequence of which the second division is the first and the set of chromosomes remains unaltered in the maternal form; the male nucleus, after penetrating into the egg cell, activates it to development without conjugation. Gynogenesis bears a certain resemblance to parthenogenesis, although the difference between them is essential, since in the first mentioned the male cell has to penetrate into the female cell for the latter to be able to develop.

Golovinskaja (1965) took up this problem with the view of making use of it in investigations on the carp. She assumed that if in natural conditions there occurs a gynogenetic population in the species *Carassius auratus gibelio* Bloch, it must be possible to induce it artificially in another species, e.g. in the carp. The results of experiments corroborated these theoretical assumptions. The principle of artificially producing gynogenesis consisted in deactivating the sperm of the milter carp by irradiation with X-rays. In this way a new line in the cultivation

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and selection of carp was set up, called gynogenetic. For this reason investigations on the German carp, especially those concerning its way of reproduction, have a bearing on the theory of selection and cultivation of the carp, which is the most important species bred in the ponds of this country.

Unfortunately, we are not able to distinguish gynogenetic females of the German carp from the normal ones, which are probably also as few as males. It would be of great interest to know what led this species by way of evolution to a state in which a disturbance in meiosis took place.

Results

The German carp from the pond Młyński in the Experimental farm of Landek was a form typical of this species. In outward appearance, colouring and shape of the body, as well as with regard to merisitc and anatomical features, it corresponded to the German carp (*Carassius auratus gibelio* Bloch) described by, among others, Balon (1962), Bauch (1966), Berg (1949), Gąsowska (1934, 1962), Heuschmann (1938). The whole investigated material was distinctly uniform as regards both the morphological and meristic features, often showing a smaller variability of these features than was reported in the literature.

As can be seen from the comparison of the relative dimensions of the examined crucian carp with those of the German carp from the Ural basin (Šapošnikova 1964) and from the Revučee lake (Žukov 1965), the majority of corresponding plastic features of these three populations are alike, and in some cases even identical (base of the dorsal fin). A characteristic trait is the much greater body height of the German carp from the Ural basin (Šapošnikova 1964) (by 12.6 per cent on the average) and from the Revučee lake (Žukov 1965) (by 7.8 per cent on the average) than that of the investigated crucian carp. Similarly the body height of the crucian carp from the Danube was greater (Balon 1962) than that of the investigated one. On the other hand, the body height of a specimen of German carp examined by Mišik and Holčik (1962) was slightly less than that of the crucian carp from the pond Młyński. Also slightly different proportions of the predorsal distance and head length, but similar proportions of the height and base of the anal fin, of the least body height, and of the height of the pectoral and ventral fins were noted in the investigated crucian carp as compared with that described by Šapošnikova (1964). The German carp from the Revučee lake (Žukov 1965) possessed a slightly longer anterior part of the body (from the mouth to the first ray of the dorsal fin) and a slightly shorter post-dorsal part of the body (from the last ray of the dorsal fin to the base of the caudal fin) than the corresponding dimensions of the

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investigated crucian carp. This difference, however, was smaller than that of the body height, amounting to 3 per cent. The German carp from the Kazakhstan waters (Serov 1959) also possessed a greater body height and a similar head length as the investigated crucian carp.

The range of variability of plastic features of 4 crucian carp from the Danube (Balon 1962) lay within the range of variations of the corresponding features of the investigated crucian carp. However, some features of this species examined by Balon (1962), such as the preventral distance, the height of the anal fin, the length of the lower and upper lobes of the caudal fin, the height of the dorsal fin, the body height, and mouth length, had ranges of variations shifted above the range of variability of these features in the investigated material.

The problem of sex in the German carp is very interesting, since this species is represented almost exclusively by females. Among the 96 specimens examined only one male was found with very poorly developed gonads, so that it is scarcely possible to say if he could have ever been capable of spawning. A similar proportion of females to males in this species was observed by Serov (1959) in the waters of Kazakhstan, and by Žukov (1965) in White Russia. The only known population of German carp where as many as 30 per cent of males were noted is found (Čerfas 1969) in White Russia in the fish farm „Volma".

According to Gąsowska (1962), only females are encountered in Poland, spawning with the participation of the carp, though the process of fertilization does not take place. Gierałtowski (1956) assumes that German carp are produced by the spawning of German carp females with carp males. These observations corroborate the phenomenon of gynogenesis in this species of crucian carp, as well as the fact that besides gynogenetic German carp there occur populations of normal German carp in which also males are encountered, but under normal conditions it is impossible to distinguish one from another.

The meristic features of the German carp from the pond Młyński did not in principle depart from the data quoted in the literature. The number of scales on the lateral line was reported only by Gąsowska (1934) on the basis of a more closely determined material from Poland. The scale pattern accepted for the investigated material did not always tally with the data of the authors mentioned above. The mean numbers of scales for the species described counted by Šapošnikova (1964), Serov (1959), and Žukov (1965) were never lower than those counted for the investigated German carp, being, on the contrary, higher by one, two, and even 3 scales. Only Bauch (1966), Gąsowska (1934), Heuschmann (1938), Schindler (1953), and Stangenberg (1934) reported similar ranges of variability of the number of scales on the lateral line, giving as upper limit of this range 31 scales, i.e. as many as occur in the examined material. On the other hand, Berg (1949), Gąsow-

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ska (1962), Šapošnikova (1964), Serov (1959), and Žukov (1960, 1965) report as upper limit of the range of the number of scales in the German carp 32 or 33, and even 34 scales. Staff (1950), and after him Gierałtowski (1956), mention 37 scales as the upper limit of the number of scales with apertures of the lateral line, though these numbers are not based on a more fully determined material. Balon (1962) observed in the lateral line of the material of German carp he examined only 30 and 31 scales, while Mišik and Holčik (1962) noted 28 scales in their material.

The number of gill rakers on the external edge of the first branchial arch of the German carp from a more fully determined material collected on Polish terrain was reported by Gąsowska (1934). The range of variability of this feature for the mentioned species but for a material not fully determined was reported by the following Polish authors: Gąsowska (1962), Gierałtowski (1956), Rudnicki (1965), Staff (1950), and Stangenberg (1934).

The number of gill rakers occurring on the external edge of branchial arches in the crucian carp inhabiting White Russia was reported by Žukov (1960, 1965), for the German carp inhabiting the Ural basin by Šapošnikova (1964), for that living in the waters of Kazakhstan by Serov (1959), from the Orava terrains by Mišik and Holčik (1962), and from the Danube by Balon (1962). This is a very important diagnostic feature in distinguishing the German carp from the common crucian carp. The range of variability of this feature in the examined species reported by various authors varied greatly and was for the most part very wide. According to Berg (1949), Dyk (1956), Gierałtowski (1956), and Stangenberg (1934), the number of gill rakers in the German carp varies from 39 to 50, while Bauch (1966) reports from 35 to 40, Heuschmann (1938) from 35 to 43, and Schindler (1953) from 35 to 48 gill rakers. The mean calculated for this feature of the crucian carp examined in the present investigations amounts to $\bar{x}=43.39$, $n=96$, while that calculated by Žukov (1965) for the German carp from the Revučee lake was $\bar{x} = 43.3$, $n = 75$. These data can be regarded as identical.

The data concerning the number of vertebrae in the German carp were reported by Bauch (1966), Berg (1949), Serov (1959), Žukov (1965), and others. The range of variability of the number of vertebrae in the examined crucian carp is inconsiderable, ranging from 28 to 31 ($\bar{x} = 29.84$) vertebrae, i.e. the same as that obtained by Žukov (1965) in his investigations of the German carp from the lake Revučee, at a sligthly lower mean ($\bar{x} = 29.3$). Bauch (1966) reported for this feature a sligthly smaller range of variability: 28 to 30 vertebrae, and so did Berg (1949): 29 to 31 vertebrae. Serov (1959) obtained similarly low ranges of variations of the number of vertebrae in the German carp

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occurring in the waters of Kazakhstan, though, in a sense, they depended on the aqueous environment from which the given investigated group proceeded. The crucian carp from this terrain were distinguished by a slightly higher upper limit of variations, 1 to 2 vertebrae more than was noted in the examined German carp.

The German carp discussed in the present work showed an identical range of variations of soft rays in the dorsal fin as the same species from the Ural basin described by Šapošnikova (1964) and as that from the Irgiz in Kazakhstan (Serov 1959). The majority of authors are in accordance as to the upper limit of the range of variations of the number of soft rays in the dorsal fin of this species, amounting to 19 rays, but as regards the lower limit of variations their opinions differ. Most often mentioned is the number of 15 and then of 17 soft rays. Balon (1962), investigating the German carp from the Danube, found in the dorsal fin of each of three individuals 3 hard and 16 soft rays and in one specimen 3 hard and 17 soft rays. Mišik and Holčik (1962) noted in the German carp 16 soft rays in the dorsal fin. In the examined material 3 hard rays were regularly observed in the dorsal fin, whereas a number of the authors mentioned above reported that sometimes 4 hard rays occur in this fin.

The number of soft rays in the anal fin of the investigated population of German carp was the same as that reported by the majority of authors mentioned in this study. In the examined crucian carp there regularly occurred 3 hard rays, similarly as in the same species from the Danube (Balon 1962). Berg (1949), Gąsowska (1962), Rudnicki (1965), Staff (1950), and Žukov (1960, 1965) mentioned 2 to 3 hard rays and 5 to 6 soft rays. Gąsowska (1934) reported that in the German carp 3 hard and 6 soft rays regularly occur, similarly as in this species living in the Ural basin (Šapošnikova 1964). Serov (1959), examining this feature in 9 populations of German carp from various environments of Kazakhstan, found in all these fishes 3 hard rays and 5 to 6 or 5 to 7 soft rays. Heuschmann (1938) reported that in the anal fin of this species 2 hard rays and 5 to 7 soft rays occur.

The question of the number of rays in the pectoral, ventral, and caudal fins was dealt with by Balon (1962), Bauch (1966), Heuschmann (1938), and Rudnicki (1965). According to these authors, there occur in the pectoral fins 15 to 16 rays, in the ventral fins 7 to 9 rays, and in the caudal fin 19 rays (except Balon 1962). The mentioned ranges are therefore identical with the ranges of variability of these features in the examined material, but these differences are not so significant as to indicate essential differences.

The formula of pharyngeal teeth in the German carp was of one row 4-4, typical of this species in 95 fishes, a departure from norm (4-5) being observed in one case. The formula of teeth in this species (4-4) with no

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deviations was reported by, among others, Gąsowska (1962), Gierałtowski (1956), Heuschmann (1938), Mišik and Holčik (1962), and Serov (1959).

On the whole, it can be said that some differences between the features of the investigated German carp discussed above and the corresponding features of the same species described by other authors are the result of individual variability, conditioned in a high degree by the age of the fishes and the trophic conditions of the particular aqueous environments.

STRESZCZENIE

Praca została wykonana w ramach prowadzonych badań nad karasiem i jego krzyżówkami z karpiem na terenie gospodarstw doświadczalnych Zakładu Biologii Wód PAN Zespół Gołysz.

Karaś srebrzysty w towarzystwie karasia pospolitego występuje w Polsce bardzo licznie, a jego zasięg występowania stale się powiększa.

Ze stawu Młyńskiego położonego w górnej partii kompleksu Iłownica gospodarstwa Landek odłowiono, oprócz dwuletnich karpi handlowych, około 1200 okazów dwuletniego karasia srebrzystego o łącznym ciężarze 150 kg. Po odłowie jesiennym karaś został przewieziony do zimochowu w kompleksie Mnich (Zespół Gołysz), gdzie zimował do dnia 11. V. 1969 r. W dniu tym z całości materiału pobrano losowo 96 okazów karasia srebrzystego do niniejszych badań.

Pomiary wykonano według schematu przyjętego w porzednich pracach autora. Na podstawie tych pomiarów i badań scharakteryzowano karasia srebrzystego występującego obecnie bardzo licznie na terenie gospodarstwa doświadczalnego Landek.

Wzrost dwuletniego karasia srebrzystego ze stawu Młyńskiego w gospodarstwie Landek, przy długości ciała poszczególnych osobników od 13,7 do 17,4 cm (średnio 15,5 cm) i ciężarze ciała od 57 do 134 g (średnio 87,5 g), trzeba uznać za dobry, ponieważ liczby te są wyższe od liczb, jakie podaje dla dwuletniego karasia srebrzystego wielu autorów.

Ciało badanego karasia srebrzystego było wrzecionowate o nieznacznie wygrzbieconym tułowiu, miał on wygląd ryby ruchliwej i dobrze pływającej. Głowa jego była bardziej wydłużona i wyższa w potylicy niż karasia pospolitego. Otwór ustny mały, nieco przesunięty ku dołowi, końcowy, a wargi bardziej mięsiste niż u karasia pospolitego. Na wargach nie stwierdzono wąsików. Oko karasia srebrzystego było bardziej zbliżone do oka karpia niż karasia pospolitego, duże, źrenica szeroka, tęczówka wąska. Tęczówka miała żywy metaliczny połysk, a jej obwód wewnętrzny ograniczał jasny błyszczący pierścień, wskutek tego oko wyraźniej odcinało się od barwy ciała niż u karasia pospolitego.

Płetwa grzbietowa długa o krawędzi zewnętrznej wklęsłej. Przednia część ciała (od pierwszego promienia płetwy grzbietowej do początku pyska) karasia srebrzystego była dłuższa od części tylnej ciała (od ostatniego promienia płetwy grzbietowej do nasady płetwy ogonowej).

Z 30 badanych cech mierzonych karasia srebrzystego, rozpatrywanych na podstawie liczb bezwzględnych (tab. I) największe odchylenie (σ) od średniej ($\bar{x}$) wykazywał największy obwód ciała i długość całkowita, natomiast najmniejsze odchylenie od średniej obserwowano w wymiarach średnicy oka i długości pyska.

Największą zmiennością (v) charakteryzowały się: długość dolnego płatu płetwy ogonowej i grubość ciała. Właśnie tylko u tych dwóch cech plastycznych zmienność (v) przekroczyła wartość 10%, u pozostałych 28 cech zmienność była niska i wahała się od 5,48 do 9,83%.

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Scharakteryzowano zbadaną populację karasia srebrzystego w odniesieniu procentowym. Uwidoczniła się tu jednolitość materiału, gdyż wszystkie — bez wyjątku — proporcje ciała wykazywały bardzo niską zmienność (v%). Na podstawie tej analizy można stwierdzić, że badany materiał dwuletniego karasia srebrzystego był bardzo wyrównany i jednorodny.

Liczba łusek przebitych otworkami linii nabocznej po lewej i prawej stronie ciała była najczęściej taka sama, a obserwowana asymetria zamykała się w granicach jednej, rzadko dwóch łusek. Granica wahań liczby łusek w linii nabocznej była niewielka i wynosiła od 29 do 31 łusek (średnio 29,84). Nad linią naboczną licząc w kierunku nasady płetwy grzbietowej, stwierdzono od 6 do 7 rzędów łusek. Pod linią naboczną w kierunku nasady płetw brzusznych naliczono 5 do 7 rzędów łusek (tab. II).

Wyrostki filtracyjne, które są ważną cechą diagnostyczną przy rozróżnianiu karasia srebrzystego od karasia pospolitego, były długie i bardzo ciasno osadzone, a ich liczba wahała się od 38 do 49 (tab. II).

Liczba kręgów w kręgosłupie wahała się od 28 do 31 (Tab. II).

Układ zębów gardłowych karasia srebrzystego był bardzo mało zmienny, jednoszeregowy. Na 96 badanych okazów aż 95 ryb miało formułę 4-4, a tylko w jednym przypadku stwierdzono układ 4-5.

Jedną z najważniejszych cech diagnostycznych była czarna opalizująca otrzewna badanego karasia srebrzystego.

Pęcherz pławny badanego karasia srebrzystego składał się z dwóch części: przedniej krótszej o większej średnicy i tylnej dłuższej o mniejszej średnicy i o kształcie niewiele odbiegającym od prawidłowego stożka.

W płetwach występowała następująca liczba promieni twardych i miękkich: w grzbietowej III/15-18, w piersiowych 14-17, w brzusznych 8-9, w odbytowej III/5-6 i ogonowej 17-19 (tab. II).

U badanych karasi srebrzystych występowało ginogenetyczne rozmnażanie i dlatego na 96 badanych osobników stwierdzono 95 samic i tylko jednego samca o słabo rozwiniętych gonadach. Gonady samic badanych były stosunkowo dobrze rozwinięte, tj. od II do IV stadium dojrzałości płciowej.

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