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VARIABILITY OF MERISTIC AND BIOMETRIC FEATURES OF CRUCIAN CARP *Carassius carassius* (Linnaeus 1758)

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A B S T R A C T. Comparative analysis of meristic and biometric features of dwarf ("M") and normally growing ("D") populations of crucian carp, *Carassius carassius* (L.), was carried out.
Fish of "M" group had average number of 25.4 gill rakers and 31.88 vertebrae. They also had one row of pharyngeal teeth in 4-4 arrangement. Numbers of fin rays were described by the formula: D III-IV, 17-19; A II-III, 5-8; P I, 12-14; V I-II, 6-8, and scale number: $32\,^{7\text{-}8}/_{7\text{-}8}\,35$. "D" population had 29.4 gill rakers on the first left branchial arch, 32.03 vertebrae, and one row of pharyngeal teeth in 4-4 arrangement. Fins were characterised by the formula: D III-IV, 17-20; A II-III, 5-8; P I, 11-15; V I-II, 5-8, and scales: $32\,^{7\text{-}8}/_{7\text{-}8}\,35$.
Fish of "D" group had strongly convect backs (x_7), higher minimum body height (x_8) and width (x_9), and larger fins D (x_{10}), A (x_{12}) comparing to the "M" fish having longer head (x_2) and longer fins P (x_{15}) and V (x_{14}).

Key words: DWARF CRUCIAN CARP, MERISTIC FEATURES, BIOMETRIC FEATURES.

INTRODUCTION

Crucian carp *Carassius carassius* (Linnaeus, 1758) belongs to the order *Cypriniformes*, superfamily *Cyprinoidea*, family *Cyprinidae*, subfamily *Cyprininae*, and genus *Carassius* (Jarocki 1822, Nelson 1984). At the present time the species is not divided into subspecies. Two subspecies were distinguished in the past: *Carassius vulgaris crasior* (Wałecki 1889) and *Carassius vulgaris lacustris* (Roule 1914).

Crucian carp reaches maximum body length of 50 cm, and the weight up to 5 kg (Berg 1949). Most common, however, are individuals up to 20 cm and 100 g. Very small, stunted fish also occur, known in the past as *Carassius carassius morpha humilis* (Mien'sikov, Revnivych 1937), described by Heckel (1840) as a species *Carassius humilis*. They seldom exceed 15 cm and 100 g. Their body is strongly elongated, with height to length ratio ranging from 1:2.4 to 1:3.0. Lateral line is often incomplete or broken. Such dwarf form often occurs under poor environmental conditions, in the absence of other fish. Lack of predation results in rapid population increase and crowding which causes strong food competition and stunting (Zawisza, Antosiak 1961, Czarnowski 1971). In some cases phenotypic modifications occur, and probably different genotypes develop later on.

The present study was undertaken to determine, based on meristic features, whether dwarf crucian carp developed any characteristics which could change its systematic status. The effect of environment on biometric features of dwarf crucian carp was also studied.

MATERIAL AND METHODS

Dwarf and normal crucian carps were harvested using electric fishing gear. Harvests always took place in September. Dwarf fish were obtained from a declining forest pond situated near Olsztyn. The pond of 0.5 ha area is a remain of an old lake of about 10 ha (Skrzydło 1977). It has no surface tributaries. Maximum length is equal to 120 m, width – about 66 m, and maximum depth – 1.9 m. Submerged vegetation grows mainly around underwater objects and emerged plants, down to 0.4 m depth. The pond, according to Patalas criteria, is rich in phosphorus – 0.18 mg PO_2 dm^{-3}, and poor in nitrogen – 0.16 mg NO_2 + NO_3 dm^{-3} (Skrzydło 1977).

Reference fish of average for the species growth rate were harvested from Sumówko Lake at Brodnickie Lake District. According to the fishery classification, it is a crucian carp lake (Marszelewski, Szczepaniak 1991). Its area is about 30 ha, and maximum depth 1.2 m. It is populated mainly by crucian carp, which comprised 50% of harvested fish. Other species die during winter oxygen depletions. Crucian carp reaches in this lake even 1 kg of body weight.

Dwarf crucian carps were described as "M" population, and normally growing ones – as "D".

Taxonomic studies were performed according to Pravdin's (1931) method for cyprinid fish. Eight meristic and 21 biometric features were analysed. 82 "M" fish of body length 4.9-13.8 cm (x = 8.5 cm), and 83 "D" fish (7.8-18.9, x = 12.1 cm) were studied.

Significance of the differences of body proportions between females and males was evaluated using t-Student test, assuming $\alpha = 0.01$ (Żuk 1989). The differences were not significant so both sexes in the two groups were analysed together. The same test was applied to evaluate the differences in body proportions between fish of different body length. Each group of fish was divided into two size classes. The "M" group included the following size classes: 4.9-9.3 cm (62 fish) and 9.4-13.8 cm (20 fish), and the "D" group: 7.8-15.4 cm (64 fish), and 15.9-18.9 cm (19 fish). Body proportions did not differ between the groups at $\alpha = 0.01$. Thus, both size classes were analysed as one group. Significance of correlation coefficients was checked using the tables (Platt 1977). All correlations were significant at $\alpha = 0.01$ and $r = 0.2830$.

The differences between biometric features of "M" and "D" fish were evaluated using t-Student test, at $\alpha = 0.01$.

RESULTS

MERISTIC FEATURES OF "M" AND "D" CRUCIAN CARP POPULATIONS

In the dorsal fin of both groups of fish there were III-IV hard rays (Du) (Tab. 1). In the "M" population, individuals having III rays predominated (68.3% of fish), and in the "D" population most of the fish (60.2%) had IV rays. In both populations 18 soft rays (Db) occurred most frequently (73.2 and 62.5% respectively).

Similar situation was observed in the case of anal fin. The range was identical in both populations, but in "M" group 73.7% of the fish had II hard rays, and in "D" group – 76.4% had III rays (Au). Number of soft rays (Ab) was equal in both groups –7.

Number of hard rays in the ventral fin (Vu) ranged in both groups from I to II. Within dwarf crucian carps, individuals with one hard ray predominated (98.8%), and in normally growing fish - 56.2% of individuals had II hard rays. Number of soft rays (Vb) was similar in both groups, and fish with 7 rays predominated.

No differences were observed in the number of hard (Pu) and soft (Pb) rays in

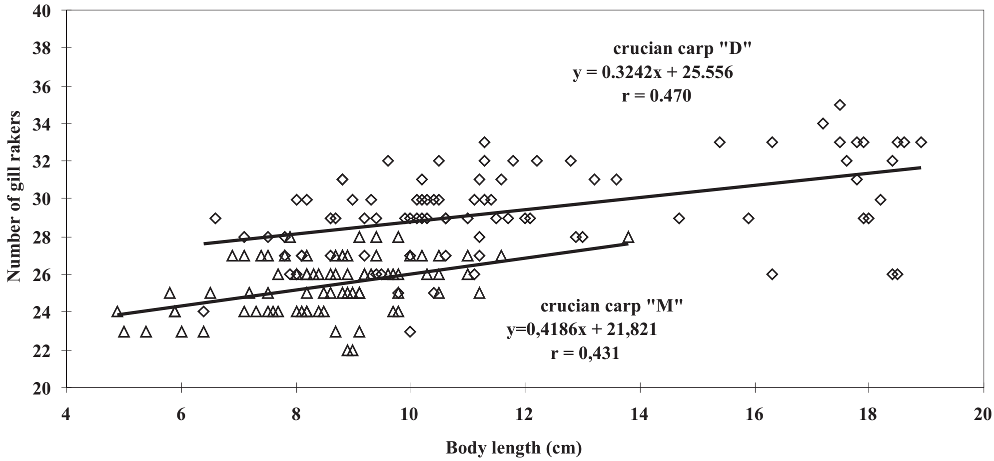

Fig. 1. Correlation between body length (lc) and number of gill rakers in crucian carp, *C. carassius* (L.).

TABLE 1

Meristic features of crucian carp

Feature	Crucian carp M							Crucian carp D						
	range	x	S.D.	V	n	predo-minating value	% of fish	range	x	S.D.	V	n	predo-minating value	% of fish
l.l.	32 - 35	33.70	0.58	1.73	82	33	60.9	32 - 35	33.69	0.61	1.82	89	34	66.3
l.l.s	7 - 8	7.17	0.38	5.28	82	7	82.9	7 - 8	7.31	0.47	6.68	89	7	68.5
l.l.i	7 - 8	7.89	0.31	3.99	82	8	89.0	7 - 8	7.92	0.27	3.42	89	8	92.1
Du	III - IV	3.32	0.47	14.11	82	III	68.3	III - IV	3.60	0.49	13.66	88	IV	60.2
Db	16 - 19	17.87	0.54	3.02	82	18	73.2	17 - 20	18.30	0.57	3.12	88	18	62.5
Au	II - III	2.26	0.44	19.57	80	II	73.7	II - III	2.76	0.43	15.45	89	III	76.4
Ab	5 - 8	6.59	0.65	9.87	80	7	52.5	5 - 8	6.85	0.74	10.74	88	7	42.7
Pu	I	1.00	0.00	0.00	82	I	100	I	1.00	0.00	0.00	89	I	100
Pb	12 - 14	13.01	0.46	3.52	82	13	79.3	11 - 15	13.22	0.84	6.32	89	13	56.2
Vu	I - II	1.01	0.11	10.91	82	I	98.8	I - II	1.56	0.50	31.95	89	II	56.2
Vb	6 - 8	6.98	0.50	7.11	82	7	75.6	6 - 8	7.34	0.56	7.67	89	7	57.3
sp.branch.	22 - 28	25.40	1.50	5.90	78	26	23.1	23 - 35	29.40	2.44	8.29	87	29	24.1
v.t.	30 - 33	31.88	0.64	2.01	74	32	66.2	30 - 33	32.03	0.60	1.86	88	32	68.2
os. ph.	4 - 4	-	0.00	0.00	82	4 - 4	100	4 - 4	-	0.00	0.00	89	4 - 4	100

pectoral fins. In both groups 100% of fish had one hard ray, and 13 soft rays occurred in 79.3 and 56.2% of fish, respectively.

Crucian carps of the "M" group had an average number of 25.40 gill rakers (*sp. branch.*) on the first left branchial arch. The "D" fish had 29.40 gill rakers. Fish of the "M" population had always less gill rakers compared to the "D" population. Correlation between body length and number of gill rakers was significant at $\alpha = 0.01$ (Platt 1977) (Fig. 1).

Number of vertebrae (*v. t.*) did not differ between the populations (Tab. 1), and ranged from 30 to 33 (average 31.88 in "M" fish, and 32.03 in "D" fish).

Number of transverse rows of scales on the lateral line (*l.l.*) ranged from 32 to 35 in both populations. Number of longitudinal rows over the lateral line (*l.l.s*) was equal in both populations, and most of the fish had 7 rows. Similar situation was observed in case of longitudinal scale rows under the lateral line (*l.l.i*), fish with 8 rows predominated. Lateral line itself was broken in various parts of the body in 38 individuals (47.6%) of "M" group.

All the fish had one row of pharyngeal teeth (*os. ph.*), in a 4-4 arrangement. Average arch height in the "M"group (body length 8.8-13.8 cm) was 1.36 cm, and average width – 0.61. In the "D" fish of body length 15.4-18.9 cm they were 2.01 and 0.86, respectively. Arch width index was equal to 44.7% in the "M" group, and 42.8% in the "D" group. No differences in arch shape were observed between the groups at $\alpha = 0.01$.

BIOMETRIC FEATURES OF "M" AND "D" CRUCIAN CARP POPULATIONS

Correlations between particular body parts and body length, and head length were statistically significant ($\alpha = 0.01$). Correlation coefficients ranged from 0.762 to 0.975 in "M" fish (Tab. 2), and from 0.846 to 0.989 in "D" fish (Tab. 3). In the "M" group, fin and head shape were the most variable, and in the "D" group – body width, and fin and head shape.

All biometric values, including body and head length, with the exception of the preanal length (x_6) and A height (x_{13}), were significantly different between the groups (Tab. 4). The highest differences occured in lateral head length (x_2), which in "M" fish was equal to 30.1% of body length, and in "D" fish only to 24.0%. Maximum body height (x_8) was, on the other hand, equal to 35.5% and 49.0% of body length respectively. Also in head width (x_{21}) significant differences were observed: in "D" group it was equal to 69.0% of head length, and in "M" group to only 58.1%.

DISCUSSION

The effect of environment on the variability of meristic features during early stages of the embryogenesis was observed by Vladykov (1934) and Tåning (1946). Once developed, the features usually do not change any more. Number of gill rakers is an exception, and it may increase with body length (Astachin, Podgornyj 1963, Èihaø 1958), and age (Kanep 1971, Vladykov 1934). Gill raker number differed between the populations under study. Crucian carps of the "D" group had on the average 3 rakers more compared to the "M" fish, this allowing more efficient food filtration. A different situation was observed in dwarf crucian carps from Jashan Lake (Haberman 1981) which had the highest number of gill rakers ever observed in this species. Number of gill rakers in "D" fish was similar as in other populations (Tab. 5), and in "M" fish – similar to Èihaø's (1958) data for fish of similar size.

Number of vertebrae fitted the range established by other Polish authors: 31-35 (Tab. 5). Wider range of vertebrae number was observed in crucian carps from Belorussia (Žukov 1965) and Yakutia (Silin 1983), and lower variability and number

TABLE 2

Biometric features of "M" crucian carp population and relations between variable features and body length (x_1) or head length (x_2)

Feature	Correlation coefficient r**	Regression equation y=a+bx	Significance level H_0: a=0	Body proportions in %*
Correlation between abdomen shape and body length, longitudo corporis - lc (x_1)				
(x_2) longitudo capitis lateralis	0.940	$y=-0.1312+0.317x_1$	P>0.01	29.0-30.7
(x_3) distantia praedorsale	0.968	$y=+0.0723+0.518x_1$	P>0.01	53.3-52.3
(x_4) distantia postdorsale	0.922	$y=+0.0318+0.241x_1$	P>0.01	24.8-24.4
(x_5) longitudo pedunculi caud.	0.872	$y=-0.0172+0.178x_1$	P>0.01	17.4-17.7
(x_6) longitudo praeanalis	0.961	$y=+0.2487+0.734x_1$	P>0.01	78.5-75.2
(x_7) altitudo corporis maxima	0.898	$y=-0.2123+0.381x_1$	P>0.01	33.7-36.5
(x_8) altitudo corporis minima	0.975	$y=-0.0987+0.151x_1$	P<0.01	13.1-14.4
(x_9) latitudo corporis	0.923	$y=-0.1234+0.173x_1$	P>0.01	14.8-16.4
Correlation between fin shape or position and body length, longitudo corporis - lc (x_1)				
(x_{10}) longitudo D	0.946	$y=+0.0378+0.115x_1$	P<0.01	30.6-30.1
(x_{11}) altitudo D	0.841	$y=+0.0099+0.185x_1$	P>0.01	18.7-18.6
(x_{12}) longitudo A	0.788	$y=+0.0878+0.080x_1$	P>0.01	9.8-8.6
(x_{13}) altitudo A	0.762	$y=+0.3289+0.115x_1$	P<0.01	18.2-13.9
(x_{14}) longitudo V	0.957	$y=-0.2397+0.237x_1$	P<0.01	18.7-22.0
(x_{15}) longitudo P	0.923	$y=-0.1235+0.173x_1$	P>0.01	16.6-21.0
(x_{16}) distantia P-V	0.904	$y=+0.0973+0.214x_1$	P>0.01	23.4-22.1
(x_{17}) distantia V-A	0.919	$y=+0.0225+0.245x_1$	P>0.01	25.0-24.6
Correlation between head shape and head length, longitudo capitis lateralis (x_2)				
(x_{18}) spatium praeorbitale	0.894	$y=-0.0778+0.288x_2$	P>0.01	23.6-27.0
(x_{19}) diameter oculi	0.864	$y=+0.1856+0.135x_2$	P<0.01	25.0-17.7
(x_{20}) spatium postorbitale	0.921	$y=+0.0505+0.488x_2$	P>0.01	52.1-50.0
(x_{21}) latitudo capitis	0.898	$y=+0.3196+0.452x_2$	P<0.01	66.4-52.4

**Body proportions were calculated for the extreme measures of body length 4.9 and 13.8 cm, and head length 1.5-4.4 cm, according to the formula y100 = a/x + b.*
***r from the table = 0.2830 for n-1 degrees of freedom at significance level =0.01 (Platt 1977)*

(28-30) occurred in fish from Kazakhstan (Mitrofanov 1988). Jordan attempted in 1893 to establish the relation between geographic position of the reservoir and number of vertebrae, taking into consideration thermal conditions (Vladykov 1934). This relation was confirmed by Gąsowska (1968) who observed lower number of vertebrae in bream at higher temperature. Orska (1956), who studied the effect of thermal stress on trout embryos, observed an increase of vertebrae number after rapid temperature drop. Fahy (1978) noted reduced number of vertebrae at increased stock density. The present data reflect an overall situation, particularly worldwide distribution of crucian carp, and indicate that the number of vertebrae may vary among populations.

TABLE 3

Biometric features of "D" crucian carp population and relations between variable features and body length (x_1) or head length (x_2)

Feature	Correlation coefficient r**	Regression equation y=a+bx	Significance level H_0: a=0	Body proportions in %*
Correlation between abdomen shape and body length, longitudo corporis - lc (x_1)				
(x_2) longitudo capitis lateralis	0.969	$y=+0.6192+0.189x_1$	P<0.01	26.9-22.2
(x_3) distantia praedorsale	0.989	$y=+0.4774+0.498x_1$	P<0.01	55.8-52.3
(x_4) distantia postdorsale	0.935	$y=+0.1149+0.195x_1$	P>0.01	20.9-20.1
(x_5) longitudo pedunculi caud.	0.959	$y=-0.1309+0.169x_1$	P>0.01	15.2-16.2
(x_6) longitudo praeanalis	0.949	$y=+0.1915+0.741x_1$	P>0.01	76.5-75.1
(x_7) altitudo corporis maxima	0.987	$y=+0.3714+0.457x_1$	P<0.01	50.5-47.7
(x_8) altitudo corporis minima	0.984	$y=-0.0677+0.164x_1$	P>0.01	15.5-16.0
(x_9) latitudo corporis	0.846	$y=-0.0073+0.191x_1$	P>0.01	19.0-19.1
Correlation between fin shape or position and body length, longitudo corporis - lc (x_1)				
(x_{10}) longitudo D	0.986	$y=+0.0037+0.373x_1$	P>0.01	37.4-37.3
(x_{11}) altitudo D	0.930	$y=+0.5219+0.151x_1$	P<0.01	21.8-17.8
(x_{12}) longitudo A	0.948	$y=-0.2107+0.138x_1$	P<0.01	11.1-12.6
(x_{13}) altitudo A	0.926	$y=+0.4323+0.124x_1$	P<0.01	17.9-14.7
(x_{14}) longitudo V	0.966	$y=+0.3188+0.174x_1$	P<0.01	21.4-19.0
(x_{15}) longitudo P	0.952	$y=+0.3312+0.143x_1$	P<0.01	18.6-16.1
(x_{16}) distantia P-V	0.980	$y=-0.2400+0.281x_1$	P<0.01	25.1-26.9
(x_{17}) distantia V-A	0.981	$y=+0.0211+0.293x_1$	P>0.01	29.6-29.4
Correlation between head shape and head length, longitudo capitis lateralis (x_2)				
(x_{18}) spatium praeorbitale	0.878	$y=+0.0009+0.273x_2$	P>0.01	27.3-27.2
(x_{19}) diameter oculi	0.910	$y=+0.1679+0.161x_2$	P<0.01	24.5-20.0
(x_{20}) spatium postorbitale	0.961	$y=-0.3543+0.673x_2$	P<0.01	49.7-59.3
(x_{21}) latitudo capitis	0.953	$y=-0.3767+0.825x_2$	P<0.01	63.8-74.0

**Body proportions were calculated for the extreme measures of body length 4.9 and 13.8 cm, and head length 1.5-4.4 cm, according to the formula y100 = a/x + b.*

***r from the table = 0.2830 for n-1 degrees of freedom at significance level =0.01 (Platt 1977)*

TABLE 4

Relative values (%) of biometric features of crucian carp in relation to body and head length

Feature	Crucian carp M				Crucian carp D				H_0: $x_1=x_2$
	range	x	S.D.	V	range	x	S.D.	V	
(x_1) l. corporis	7.8-18.9	12.1	3.4	28.0	4.9-13.8	8.5	1.5	18.0	-
Relative values of biometric features expressed as percent of body length, l. corporis (x_1)									
(x_2) l. capitis lat.	20.9-29.0	24.4	2.0	8.5	23.8-35.6	30.1	2.0	6.0	-
(x_3) dist. praedors.	48.1-60.0	53.9	2.4	4.4	43.9-63.7	52.7	2.5	4.7	-
(x_4) dist. postdors.	14.7-26.2	20.4	2.1	10.2	20.6-31.4	24.5	1.9	7.6	-
(x_5) l. pedun. caud.	12.6-19.6	15.8	1.5	9.3	13.5-24.0	17.6	1.8	10.2	-
(x_6) l. praean.	64.4-85.3	75.8	7.5	9.9	63.4-85.6	76.4	4.0	5.2	
(x_7) alt. corp. max.	43.7-54.4	49.0	2.2	4.4	27.2-39.3	35.5	3.4	9.6	-
(x_8) alt. corp. min.	13.9-17.8	15.8	0.8	5.3	12.2-15.3	13.9	0.7	4.8	-
(x_9) lat. corp.	16.0-21.5	19.0	4.1	21.5	12.0-19.0	15.8	1.4	8.6	-
(x_{10}) longitudo D	32.9-41.0	37.4	1.6	4.8	25.8-35.5	30.3	1.9	6.2	-
(x_{11}) altitudo D	15.9-25.6	19.7	2.0	10.2	13.9-23.4	17.7	4.5	25.4	-
(x_{12}) longitudo A	8.9-16.3	11.9	1.4	11.4	6.4-12.1	9.1	1.1	12.1	-
(x_{13}) altitudo A	11.9-20.1	15.6	3.4	21.8	11.5-27.7	15.1	3.2	21.1	
(x_{14}) longitudo V	16.5-23.3	20.2	1.4	6.8	16.7-24.4	20.8	1.5	7.2	-
(x_{15}) longitudo P	15.0-26.7	17.2	1.5	8.7	13.7-23.7	19.3	1.7	9.1	-
(x_{16}) distantia P-V	20.2-29.7	26.0	1.8	7.0	18.8-26.6	22.6	1.8	8.0	-
(x_{17}) distantia V-A	25.6-33.3	29.5	1.7	5.8	19.5-30.4	24.8	1.9	7.8	-
(x_2) l. capitis lat.	2.0-4.4	2.9	0.7	22.7	1.5-4.4	2.6	5.1	20.1	-
Relative values of biometric features expressed as percent of head length, l. capit. lat.(x_2)									
(x_{18}) spat. praeor.	20.5-38.4	27.3	3.3	12.2	19.9-33.4	25.6	2.8	11.0	-
(x_{19}) diam. oculi	17.4-29.0	22.2	2.3	10.4	16.7-26.8	21.0	2.1	9.8	-
(x_{20}) spat. postor.	41.3-67.6	54.6	5.0	9.2	41.7-62.5	50.8	3.9	7.8	-
(x_{21}) lat. capitis	55.7-82.2	69.0	6.4	9.3	47.7-66.1	58.1	4.6	8.0	-

* *+ difference not significant, - significant difference*

Similar differences were observed in the number of scales within transverse and longitudinal rows. It is usually assumed (Vladykov 1934) that the number of scales decreases in north-south direction. In this study, no differences of scale numbers were noted since all the fish lived in the same region and all could be described with one formula. Wider range of scale numbers in Polish crucian carp was reported by Staff (1950). No differences were observed between the dwarf population "M" and dwarf crucian carp from Elta River (Čihař 1958).

The range of the number of hard fin rays of both fish groups did not differ from

TABLE 5

Meristic features of various populations of crucian carp

Water body Author	l. *soveri* l.	Number of hard and soft fin rays				sp. branch.	v.t.	os. ph.
		D	A	P	V			
Jakutzia Silin 1983	25-36	25-36	III-IV 14-21	II-III 5-8	-	-	23-35	28-37
Poland Staff 1950	28 6 - 8over5 - 6 37	III-IV 14-21	II-III 6-8	-	-	23-33	-	-
Elta River Čihař 1958	32-35	15-21	5-7	-	-	9-30	-	-
Poland Skóra 1961	33 6 - 8*over*5 – 6 36	III 16-18	III 7	-	-	26-34	31-34	-
Belorussia Žukov 1965	32-35	15-19	6-8	12-17	7-9	23-29	28-37	4 - 4
Belorussia Penjaz' 1973	-	III-IV 15-18	II-III 6-7	-	-	-	-	-
Lake Skopy Białokoz 1979	32 6 - 8*over*6 - 7 34	III-IV 15-19	II-III 6-8	14-16	8-10	24-35	31-34	-
Lake Warniak Białokoz 1979	32 7 - 8*over*6 – 7 35	III 14-18	III 6-7	13-16	9-19	27-33	32-35	-
Caspian Sea Kazančeev 1981	32-36	III-IV 14-21	II-III 6-8	-	-	23-36	-	-
Biebrza River Witkowski 1984	30 7 - 8*over*6 – 8 34	II-IV 16-19	II-III 5-7	I 13-15	II 7-8	-	-	-
Belorussia Žukov 1988	32-35	III-IV 15-19	II-III 6-8	-	-	23-34	-	4 - 4
Kazakhstan Su-Žargan, Mitrofanov 1988	32 6 - 8*over*6 – 7 36	III-IV 15-19	III 5-7	-	-	28-33	28-30	-
Kazakhstan M.Džalangas, Mitrofanov 1988	31 7 - 8*over*6 – 7 35	III-IV 16-18	III 5-6	-	-	30-34	28-30	-

the values obtained by other authors for other crucian carp populations (Tab. 5). Slight differences observed in the numbers of soft rays in the dorsal and anal fins might have resulted from thermal conditions in the reservoirs. Increase of the number of rays in the dorsal fin with temperature was observed by Fahy (1980) in *Fundulus majalis*, and by Tåning (1944) in brown trout. A decrease was noted by Orska (1963) in rainbow trout, and by Tatarko (1968) in common carp. Temperature related decrease of the number of soft and hard rays in the anal fin was observed by Fahy (1979) in *Fundulus majalis*. Similar situation was noted by Lindsey (1962) in three-spined stickleback, and by Tatarko (1968) in common carp. Contrarily to this, number of anal fin ra-

TABLE 6

Biometric features of "M" and "D" crucian carp in different populations; mean values and range

Feature	Dnieper (n = 36) Žukov 1965	Dwina (n = 16) Žukov 1965	Biebrza (n = 28) Witkowski 1984	Su-Žargan (n = 15) Mitrofanov 1988	M. Džalangas (n = 50) Mitrofanov 1988	Own data M fish	Own data D fish
As per cent of body length							
(x_2) l. capit. lat.	22.6-33.0 27.6	26.5-29.5 27.2	25.2-29.7 27.3	23.6-26.2 24.5	22.8-28.5 25.4	23.8-35.6 30.1	20.9-29.0 24.4
(x_3) dist. praedors.	48.8-58.0 53.1	53.5-59.5 55.9	49.7-57.8 54.7	47.9-53.5 50.4	48.1-58.5 52.8	43.9-63.7 52.7	48.1-60.0 53.9
(x_4) dist. postdors.	17.7-25.5 21.1	18.5-21.5 19.3	17.7-23.5 20.3	18.0-25.8 22.3	18.6-29.5 23.0	20.6-31.4 24.5	14.7-26.2 20.4
(x_5) l. pedun. caud.	13.5-22.8 16.9	14.5-19.5 15.5	12.5-20.9 16.9	15.2-20.0 17.7	13.3-21.7 17.7	13.5-24.0 17.6	12.6-19.6 15.8
(x_6) l. praean.	70.0-81.0 76.0	71.5-81.5 77.7	75.0-80.0 77.3			63.4-85.6 76.4	64.4-85.3 75.8
(x_7) alt. corp. max.	34.3-58.8 46.6	53.5-61.5 56.8	43.1-55.5 52.0	42.5-50.0 45.6	45.0-56.5 50.5	27.2-39.3 35.5	43.7-54.4 49.0
(x_8) alt. corp. min.	13.2-18.1 15.7	16.5-19.5 18.0	15.0-19.0 17.1	13.7-16.6 15.3	14.3-21.1 17.1	12.2-15.3 13.9	13.9-17.8 15.8
(x_9) lat. corp.	14.4-22.2 18.7	17.5-22.5 20.2				12.0-19.0 15.8	16.0-21.5 19.0
(x_{10}) long. D	28.8-41.5 36.0	39.5-48.5 41.9	30.5-41.3 37.5	31.6-39.0 35.2	33.0-41.5 37.0	25.8-35.5 30.3	32.9-41.0 37.4
(x_{11}) alt. D	13.4-25.8 18.6	18.5-26.5 22.0	17.2-24.5 21.5	14.0-21.4 18.1	13.9-24.6 19.9	13.9-23.4 17.7	15.9-25.6 19.7
(x_{12}) long. A	9.2-15.2 11.7	12.5-15.5 13.5	8.4-13.2 11.6	9.0-13.5 11.8	10.0-14.1 11.8	6.4-12.1 9.1	8.9-16.3 11.9
(x_{13}) alt. A	11.6-21.3 15.5	15.5-20.5 17.5	14.1-20.3 17.3	11.1-16.6 13.8	12.5-18.5 15.5	11.5-27.7 15.1	11.9-20.1 15.6
(x_{14}) long. V	15.4-24.2 20.2	20.5-26.5 23.0	18.0-24.4 21.8	19.2-23.8 21.4	16.0-28.4 22.0	16.7-24.4 20.8	16.5-23.3 20.2
(x_{15}) long. P	14..7-21.4 17.7	17.5-21.5 19.2	15.1-21.2 18.2	16.9-22.2 19.3	15.7-23.0 19.0	13.7-23.7 19.3	15.0-26.7 17.2
(x_{16}) dist. P-V	19.6-27.7 24.0	21.5-28.5 25.2	23.0-27.6 25.5	12.2-27.9 25.8	22.0-31.2 25.7	18.8-26.6 22.6	20.2-29.7 26.0
(x_{17}) dist. V-A	19.8-32.2 27.5	25.5-33.5 29.6	26.5-31.4 29.1			19.5-30.4 24.8	25.6-33.3 29.5
As per cent of head length							
(x_{18}) spat. praeor.	27.0-36.8 31.9	30.5-38.5 33.6	30.5-38.6 34.4	29.6-35.9 32.8	26.2-37.5 31.0	19.9-33.4 25.6	20.5-38.4 27.3
(x_{19}) diam. oculi	15.7-30.0 20.5	17.5-22.5 19.1	17.4-23.9 20.1	14.5-23.2 19.1	14.6-24.1 18.9	16.7-26.8 21.0	17.4-29.0 22.2
(x_{20}) spat. postor.	40.0-56.0 49.63	45.5-52.5 48.8	41.7-54.2 51.0	41.7-51.7 47.8	43.2-55.0 50.3	41.7-62.5 50.8	41.3-67.7 54.6
(x_{21}) lat. capitis	34.7-52.0 42.0	43.5-48.5 44.7		39.5-44.2 39.8	39.2-50.0 48.2	47.7-66.1 58.1	55.7-82.2 69.0

ys increased with temperature in rainbow trout (Orska 1963), and in tsawytscha (Seymour 1959). No clear tendency, however, can be established.

Pharyngeal teeth of crucian carp are arranged in one row. 4 teeth are present at both sides (Nikoljukin 1952, Horoszewicz 1960). Both populations under study had identical tooth formula and did not differ from other populations (Tab. 5). Index of arch width (44.7% in "M" group and 42.8% in "D" group) was slightly higher compared to the value obtained for crucian carp from the Vistula River – 46.6% (Horoszewicz 1960).

Morphometric and limnological conditions considerably affect biometric features of fish (Mayr 1974). Food supply and availability, water temperature (Brylińska et al. 1991) and parental genetic diversity (Sluckij 1978) play a most important role.

Crucian carp body is narrow and high. Body thickness usually comprises 31.5-44.5% of body height. Under average food conditions, body height to length ratio is equal to 1:1.8 – 1:2.2. According to Bãnãrescu (1964) body height comprises usually 43-56% of body length. However, individuals of lower body are sometimes seen. In fish belonging to *humilis* form, length to height ratio ranges from 2.4 to 3.0. In Germany the lowest body height observed in crucian carp was equal to 24.5% of body length, and the highest to 55.9% (Libosvarsky 1964). Average values in various populations ranged from 36.2 to 51.4%. Bãnãrescu (1964) reported that the length – height ratio for *humilis* form was equal to 30.3-36.0%, which was also true for the "M" population. In the "D" group, this value was higher compared to the "M" group and fitted the values calculated for other populations (Tab. 6). Similar relation was observed for the minimum body height (x_8) which was lower in "M" fish compared to "D" and other populations (Tab. 6). Head of crucian carp is small and comprises 24.5-27.6% of body height. "M" fish, however, had longer heads (x_2) compared to "D" fish and to other populations. Other head parameters also showed differences. "M" fish had smaller preocular space (x_{18}), but bigger eye diameter (x_{19}), postocular space (x_{20}), and head width (x_{21}). Considerable differences in head morphology between "D" group and other populations seem interesting. Fish of "D" group had lesser preocular space (x_{18}), larger postocular space (x_{20}), and wider head (x_{21}) (Tab. 6). Predorsal space (x_3) usually comprised 48.0-58.0% of body length, and postdorsal space (x_4) 15.5-21.8%. In "M" population, predorsal space was shorter than in other populations, and postdorsal space comprised the biggest part of body length. The length of dorsal fin (x_{10}) was equal to 36-42% of crucian carp body length, and its height (x_{11}) was from 18 to 22%. Values of these parameters were lower in the "M" group compared to the "D" group and other populations. The same was observed for anal fin parameters (x_{12}, x_{13}). Average ventral fin length (x_{14}) ranges in various populations from 20.2 to 23.0% of body length. Values for both populations fitted this range. Pectoral fin length (x_{15}) of "M" fish was higher comparing to "D" fish and other populations. Contrarily to this, the distance between pectoral and ventral fin (x_{16}), and between ventral and anal fin (x_{17}) was lower in the "M" group (Tab. 6).

CONCLUSIONS

The present study of dwarf and normally growing crucian carp (*Carassius carassius* Linnaeus) populations allowed formulating the following conclusions:

1. Crucian carps of "M" population had average number of 25.4 gill rakers and 31.88 vertebrae. Single row of pharyngeal teeth showed 4-4 arrangement. The fins were described by the formula: D III-IV, 17-19; A II-III, 5-8; P I, 12-14; V I-II, 6-8, and the scales: $32\ ^{7\text{-}8}/_{7\text{-}8}\ 35$.
2. Crucian carps of "D" population had average number of 29.4 gill rakers on the first left branchial arch, and 32.03 vertebrae. Single row of pharyngeal teeth showed 4-4 arrangement. The fins were described by the formula: D III-IV, 17-20; A II-III, 5-8; P I, 11-15; V I-II, 6-8, and the scales: $32\ ^{7\text{-}8}/_{7\text{-}8}\ 35$.
3. Fish of "D" population had higher body, bigger minimum body height and width, and larger D and A fins compared to "M" fish, which had longer heads and longer P and V fins.

The results do not allow to consider the dwarf crucian carp *Carassius carassius* (L.) to be a separate species or subspecies, but only an ecophenotype. Dwarf fish tend to maintain juvenile body shape, with big head, lower body and lower D and A fins.

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STRESZCZENIE

ZRÓŻNICOWANIE CECH MERYSTYCZNYCH I BIOMETRYCZNYCH KARASIA POSPOLITEGO *Carassius carassius* (Linnaeus, 1758)

Przeprowadzono analizę porównawczą cech merystycznych i biometrycznych populacji karłowatej ("M") oraz populacji charakteryzującej się przeciętnym dla karasia pospolitego *Carassius carassius* (L.) tempem wzrostu ("D"). Badania taksonomiczne zebranego materiału przeprowadzono według ogólnie przyjętej dla ryb karpiowatych metody Pravdina (1931) i dotyczyły 8 cech merystycznych i 21 cech biometrycznych. Do pomiarów użyto 82. karasi "M" o długości ciała od 4,9 do 13,8 cm ($\bar{x}$= 8,5 cm) i 83. karasi "D" (7,8 - 18,9 cm; $\bar{x}$= 12,1 cm). Różnice badanych cech biometrycznych karasi "M" i "D" określono testem t-Studenta oraz za pomocą testu równoległości obliczonych prostych regresji. Umożliwiło to ustalenie, czy wartości poszczególnych cech plastycznych zmieniają się wraz z długością głowy i ciała podobnie w obu badanych populacjach.

Na podstawie przeprowadzonych badań karłowatych i szybko rosnących form karasia pospolitego *Carassius carassius* (L.) stwierdzono, że:

Karasie "M" miały średnio 25,4 wyrostków filtracyjnych i 31,88 kręgów. Zęby gardłowe były jednoszeregowe, występowały w układzie 4 - 4. Płetwy charakteryzuje wzór: D III-IV, 17-19; A II-III, 5-8; P I, 12-14; V I-II, 6-8, a liczbę łusek wzór: 32 $^{7-8}/_{7-8}$ 35. Karasie "D" miały średnio 29,4 wyrostków filtracyjnych na pierwszym lewym łuku skrzelowym , 32,03 kręgów. Karasie "M" miały zawsze mniej wyrostków filtracyjnych niż osobniki o tej samej wielkości z populacji szybko rosnącej. Zęby gardłowe jednoszeregowe, występowały w układzie 4 - 4. Płetwy opisuje wzór: D III-IV, 17-20; A II-III, 5-8; P I, 11-15; V I-II, 6-8, a liczbę łusek wzór: 32 $^{7-8}/_{7-8}$ 35. U karasia "D" centrum wzrostu łuski było przesunięte ku krawędzi kaudalnej

(44% długości łuski), natomiast u karasia "M" leżało w pobliżu środka geometrycznego, z przesunięciem w kierunku części kranialnej (55% długości łuski). Na poziomie istotności = 0,01 nie stwierdzono statystycznie istotnych różnic w badanych cechach merystycznych.

Karasie "D" charakteryzowały się większym wygrzbieceniem, większą najmniejszą wysokością i szerokością ciała, a także większymi płetwami D, A w stosunku do długości niż karasie "M", które miały większą boczną długość głowy i dłuższe płetwy P i V.

Porównanie cech biometrycznych karasi "M" i "D" za pomocą testu równoległości wykazało, że za pomocą jednego równania można przedstawić ich długość przedanalną. Wspólny współczynnik kierunkowy prostej regresji posiadały natomiast następujące cechy: długość przedgrzbietowa, długość trzonu ogonowego, najmniejsza wysokość ciała, szerokość ciała, wysokość D i A, przestrzeń przedoczna i średnica oka.

Wyniki przeprowadzonych badań karłowatej populacji karasia pospolitego nie dają podstaw do traktowania tej formy jako odrębnego taksonu na poziomie gatunkowym i podgatunkowym, a jedynie jako ekofenotypu tego gatunku ryb. Ogólną jej cechą jest zachowanie młodocianej sylwetki ciała, charakteryzującej się mniejszym wygrzbieceniem oraz mniejszą wysokością płetw D i A.

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