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DWARF CRUCIAN CARP (*Carassius carassius* L.) POPULATION IN A FOREST POND

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A B S T R A C T. Studies were carried out on a dwarf crucian carp, *Carassius carassius* (L.) population in a small forest pond near Olsztyn. Sex, age, and body weight composition of the population were assessed, as well as mortality, biological production, and standing crop. The population consisted of 267 females, 81 males, and 205 juveniles. Fish age varied from 0+ to 8+, and their body length from 2.0 to 10.8 cm. Total number of harvestable fish in the pond, estimated by fish tagging, was 3513, and standing crop was 24 kg. Mortality coefficient (Z) in the third and fourth year of fish life was equal to 0.35 and 0.24, respectively, and was highest in the sixth year - Z=1.10. Production of age groups from III to IX was equal to 40% of the standing crop.

Key words: DWARF CRUCIAN CARP, SEX COMPOSITION, AGE, LENGTH, BODY WEIGHT, STANDING CROP, MORTALITY, PRODUCTION

INTRODUCTION

Crucian carp usually attains total body length about 20 cm, and mass 100 g. Sometimes, however, fish remain stunted, and such dwarf populations used to be identified as *Carassius carassius morpha humilis* (Mien'shikov, Revnivych 1937), or described as a separate species *Carassius humilis* (Heckel 1840). They seldom grow over 10 cm and 25 g. Such fish are more elongated comparing to "full-size" ones, and their body is usually 2.4-3.0 fold as long as high. Lateral line is incomplete or broken. These phenotypes usually occur under adverse environmental conditions. Population growth rate is high, less resistant, and predacious fish are eliminated. Excessive stock density results in an increase of feeding competition, and fish become stunted (Zawisza, Antosiak 1961, Czarnowski 1971). Growth inhibition as an effect of excessive population density was observed under rearing conditions too (Poston 1983). Stunting of *Carassius gibelio langsdorfii* population and its natural triploid forms were observed by Nakamishi and Onozato (1987), and explained as due to environmental impacts.

Crucian carp becomes sexually mature usually at 3-5 years, most often in the fourth year of life. Most males mature a year earlier than females. Maturation is accelerated in southern part of the natural range of the species distribution. In Romania mature 2 years old fish were observed, while in northern regions of Russia crucian carps reached maturation at 5 years (Banarescu 1964). Crucian carp matures earlier in ponds with better food conditions (Skóra 1961). Dwarf crucian carp usually matures earlier too (Mien'shikov, Revnivych 1937, Berg 1949).

Resistance of crucian carp to adverse environmental conditions is interesting for scientific and practical reasons. Scientific interests concern exceptional adaptive abilities of the species. Practical aspects include possibility of stocking dwarf forms of crucian carp into reservoirs in which its populations were considerably reduced.

Both aspects were taken into consideration in the present study on crucian carp population of a small forest pool situated near Olsztyn. The pool of 0.5 ha of area is a remain of a 10 ha lake (Skrzydło 1977), and is not supplied by any surface inflow. It is surrounded with pine forest, with the banks overgrown with birch and alder. Maximum length of the reservoir is equal to 120 m, and maximum width to about 66 m, depth is 1.9 m. Southern part is overgrown with broad-leaf cattail. Submerged vegetation occurs mainly around submerged objects such as tree branches or macrophyte stems, down to 0.4 m depth. The pool, according to Patalas criteria, is rich in phosphorus - 0.18 mg $PO_4 \cdot dm^{-3}$, and poor in nitrogen - 0.16 mg NO_2+$NO_3 \cdot dm^{-3}$ (Skrzydło 1977).

MATERIAL AND METHODS

The material was obtained by electric fishing. Harvests were repeated twice, using the same method, rowing around the bank 3 times, on September 7 and 21, 1992. The harvested fish (410 ind.) were tagged and released. For further studies 557 other individuals were collected. Age and sex composition, body length and weight were assessed. Total number of population and standing crop were estimated, assuming that the tagged fish were distributed within the reservoir in the same way as before harvesting. Tagging was done by cutting upper lobe of caudal fin. According to Radcliffe (1950), it was assumed that cutting of even two fins does not affect ability of fish to escape the harvesting tools. All collected fish were counted, measured, and weighed. Population number was estimated according to the formula (Ricker 1975):

$$N = \frac{m \cdot c}{r}$$

where:

N - population number

m - number of tagged fish

c - number of fish in the second harvest

r - number of tagged fish caught again in the second harvest.

Mortality coefficient (Z), and survival were calculated from age composition. Mortality was estimated taking into consideration age groups beginning from 3 years (most numerous group), according to the formula:

$$Z = -(ln\ N_{t+1} - ln\ N_t)$$

where:

Nt - number of fish at age "t".

Survival values were found in Ricker (1975) tables, according to the formula:

$$S = e^{-Z}$$

where:

S - survival

Z - mortality coefficient.

Mean population standing crop (P), production (Pg), and relationship between these values were calculated from growth and mortality coefficients, using methods described by Backiel (1964) and Nagięć (1964). In order to obtain the average yearly biomass of age groups III-IX, No = 192 (initial number of fish at age 3 years) was assumed. Growth rate (g) was calculated from the differences of natural logarithms of body weight between the age groups. Average standing crop (P) was estimated according to the formula:

$$P = \frac{W_0 N_0 (1 - e^{-(z-g)})}{z - g}$$

where:

No - sample size

Wo - average individual body weight in g

WoNo - initial biomass of fish

Z - mortality coefficient

g - growth coefficient

In cases of mortality coefficient lower than growth coefficient, another formula was used:

$$P = \frac{W_0 N_0 (e^{g-z} - 1)}{g - z}$$

Production (Pg) was calculated from standing crop value (P) and growth rate:

$$Pg = P \cdot g$$

Production to standing crop ratio was expressed in percent.

Sex of fish was determined using microscopic analysis of gonads at VI-II stage of maturity (Sakun, Bucka 1968), with visible resorbed eggs in females. Male gonads were white indicating non-ejaculated milt. Juvenile gonads were considerably smaller, pinkish-grey.

RESULTS

COMPOSITION OF SEX, AGE, LENGTH AND BODY WEIGHT

The sample of 557 fish consisted of the individuals aged from 0+ to 8+. Age group 2+ was most numerous (34.5%) (Tab. 2.). Fish 5.1-6.0 cm long predominated (27.5%). Longest fish of 10.1-11.0 cm were least numerous (0.4%) (Fig. 1.). Body weight of fish ranged from 0.2 to 39.3 g (6.9 g on the average), and most of the individuals weighed from 2.1 to 4.0 g (21.1%). Share of the heaviest fish weighing from 18.1 to 40.0 g was equal to 2.3% (Fig. 2.). Age group 2+ (three years old) of average body length 4.8 cm and weight 3.2 g was the most numerous (192 individuals).

TABLE 1

Study material.

Date	Sample size	Size length range - Lc (cm)	Weight range
7.09.1992 r.	410 (tagging)	-	-
21.09.1992 r.	557	2.0 - 10.8	0.2 - 39.3

TABLE 2

Age, length and body weight composition of dwarf crucian carp population

Age	N	%	Body weight (g)				Body length - Lc (cm)			
			range	$\bar{x}$	S.D.	V	range	$\bar{x}$	S.D.	V
0+	8	1.4	0.2 - 0.7	0.4	0.2	49.9	2.0 - 2.9	2.5	0.4	14.2
1+	32	5.7	0.7 - 1.8	1.3	0.3	20.3	3.0 - 4.0	3.5	0.3	7.2
2+	192	34.5	1.5 - 6.4	3.2	0.9	27.6	3.9 - 6.1	4.8	0.4	8.5
3+	134	24.1	3.9 - 10.5	5.9	1.2	21.2	5.2 - 7.0	5.9	0.4	6.0
4+	107	19.2	5.6 - 14.7	9.9	2.0	20.4	6.0 - 8.1	7.0	0.5	7.2
5+	54	9.7	9.5 - 18.8	13.6	2.2	16.1	7.1 - 8.7	7.9	0.4	5.2
6+	18	3.2	14.2 - 20.6	16.2	1.9	11.8	8.0 - 9.3	8.3	0.3	4.1
7+	7	1.3	15.2 - 29.9	20.7	4.8	23.3	8.2 - 10.0	8.9	0.7	7.7
8+	5	0.9	21.4 - 39.3	29.8	7.3	24.5	9.4 - 10.8	9.9	0.6	6.4
Total	557	100	0.2 - 39.3	6.9	5.1	74.4	2.0 - 10.8	5.9	1.5	24.8

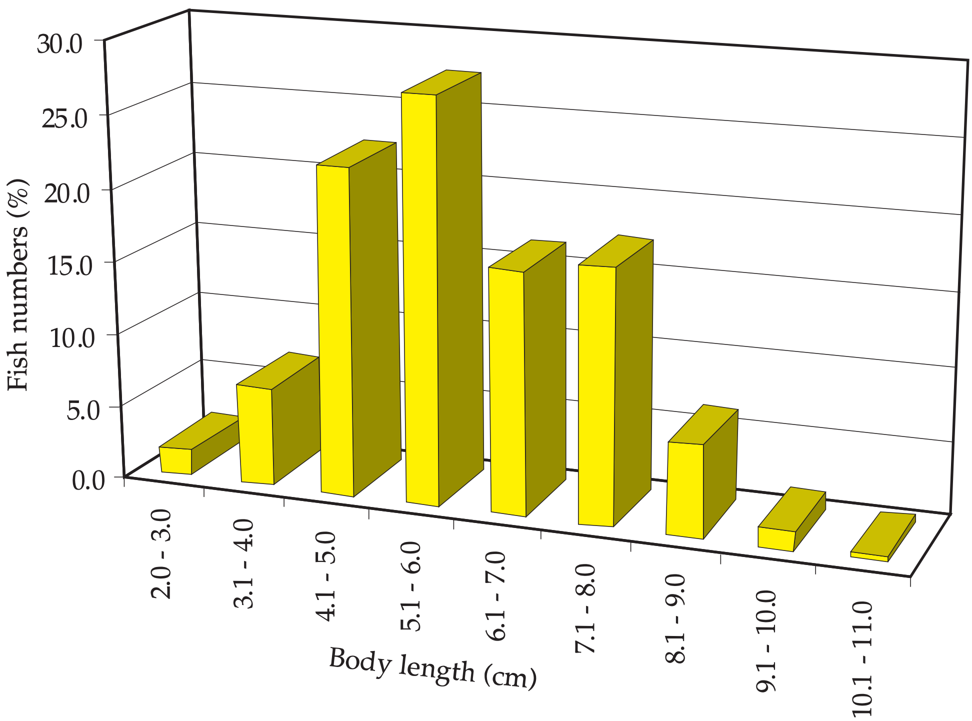

Fig. 1. Body length composition (lc) of dwarf crucian carp population.

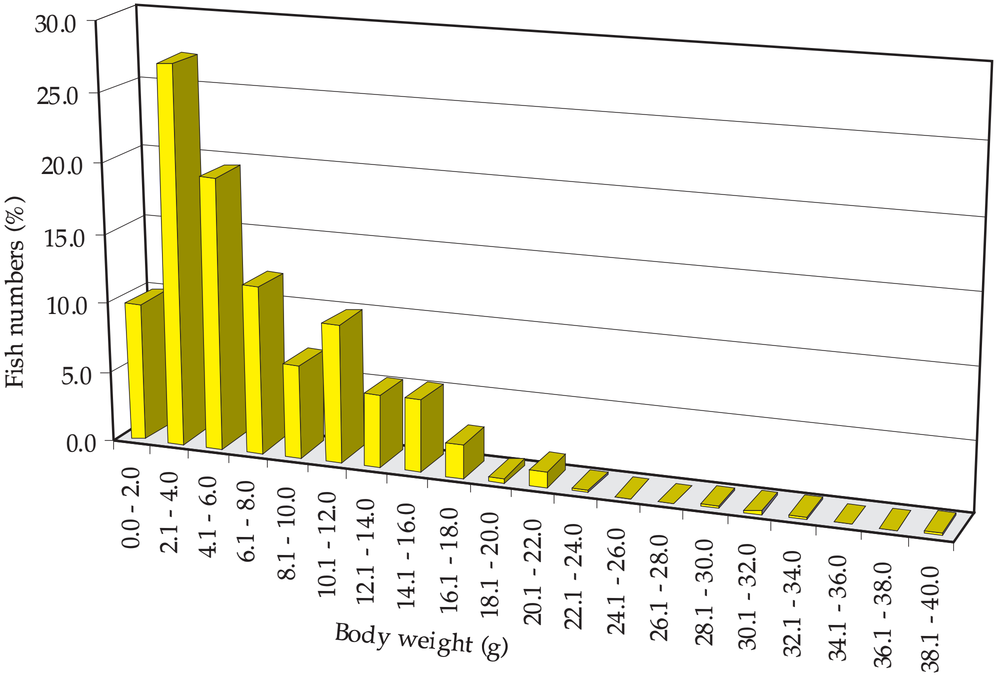

Fig. 2. Body weight composition of dwarf crucian carp population.

TABLE 3

Sex structure of dwarf crucian carp population

Age	Juveniles		Females		Males		Non-identifical		N
	n	%	n	%	n	%	n	%	
0+	8	3.9	-	-	-	-	-	-	8
1+	32	15.6	-	-	-	-	-	-	32
2+	165	80.5	13	4.9	14	17.3	-	-	192
3+	-	-	94	35.2	36	44.4	4	100	134
4+	-	-	86	32.2	21	25.9	-	-	107
5+	-	-	48	18.0	6	7.4	-	-	54
6+	-	-	18	6.7	-	-	-	-	18
7+	-	-	6	2.2	1	1.2	-	-	7
8+	-	-	2	0.7	3	3.7	-	-	5
	205	100	267	100	81	100	4	100	557

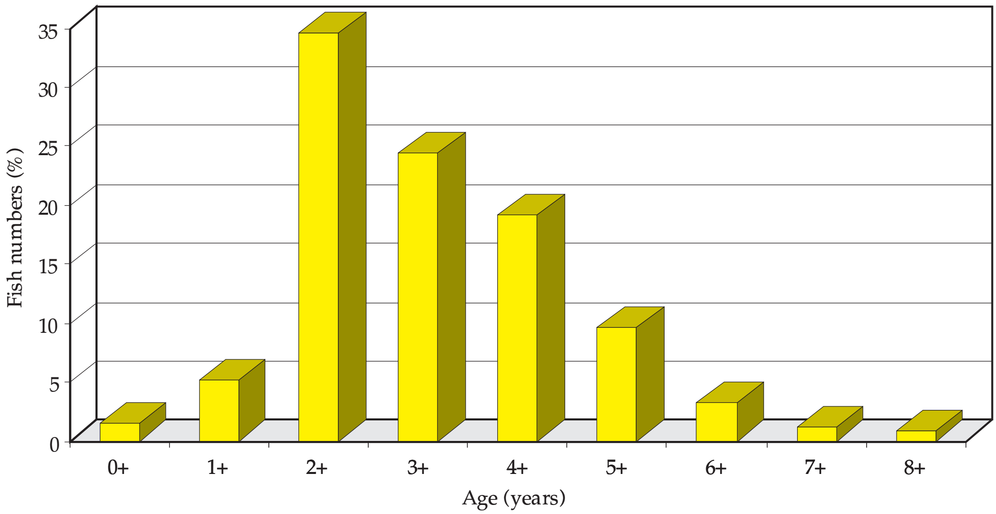

Fig. 3. Age composition of dwarf crucian carp population.

TABLE 4

Standing crop and production of dwarf crucian carp population

Age	N_0	Lc (cm)	W_0	$W_0 N_0$	Z	S	g	Z - g	P (g)	Pg (g)	Pg/P (%)
III	192	4.8	3.2	615.1	0.35	0.70	0.60	-0.25	700.1	422.4	60.3
IV	134	5.9	5.9	784.9	0.24	0.79	0.52	-0.28	907.4	474.9	52.3
V	107	7.0	9.9	1057.8	0.68	0.51	0.32	0.36	888.1	283.6	31.9
VI	54	7.9	13.6	734.9	1.10	0.33	0.17	0.93	479.0	83.1	17.4
VII	18	8.3	16.2	291.3	0.94	0.39	0.25	0.69	210.1	51.7	24.6
VIII	7	8.9	20.7	145.3	0.34	0.71	0.36	-0.02	147.1	53.6	36.4
IX	5	9.9	29.8	148.5							
					$\Sigma = 0.61$	$\Sigma = 0.60$			$\Sigma = 3331.7$	$\Sigma = 1369.4$	
										Pg/P =	40%

N_0 - sample size

W_0 - individual body weight (g)

W_0N_0 - initial fish weight

Z - mortality coefficient

S - survival coefficient

g - growth rate

P - average standing crop

Pg - annual production

The sample consisted of 267 females, 81 males, and 205 juveniles (Tab. 3.). Fish aged 3+ predominated among both sexes. Number of 3+ aged females was equal to 94 (35.2% of all the females), and number of 3+ old males was 36 (44.4%). Juvenile fish belonged to age groups from 0+ to 2+, with the highest share of 2+ individuals (80.5%). Males and females at age 2+ were sexually mature, in the post spawning period, indicating that female and male gonad maturation started in the second year of life (age 1+). Body length of mature females and males was 3.6 and 3.5 cm, respectively.

FISH NUMBER AND BIOMASS

In the first harvest total number of 410 fish were obtained. The fish were tagged and released. The next harvest took place two weeks later, and 557 fish were caught, of total weight 3.8 kg. Among them 65 tagged crucian carps were present, which was equal to 11.7% of all harvested fish. Thus, total population number was 3513 fish, of total biomass about 24 kg, which made 7026 individuals (48 kg) per hectare.

MORTALITY

Mortality coefficient of fish aged III-IX years was equal to 0.61 and survival to 0.60. This indicates that beginning from the third year of life, 60% of fish survived to the next year (Tab. 4.). In the third and fourth year of life mortality coefficient was 0.35 and 0.24, respectively. The highest value of mortality coefficient was observed among fish in the sixth year of life (Z=1.10).

PRODUCTION

Production of the fish of III-IX years was equal to 40% of the average biomass of these groups (Tab. 4.). The value was the highest for fish in III (60.3%), and IV (52.3%) years of life, and the lowest at IV years (17.4%). Average biomass of these age groups was 3331.7 g, and annual production - 1369.4 g.

DISCUSSION

Studies carried out 17 years ago by Skrzydło (1977) revealed that total dwarf crucian carp population number in the pool was 28850 individuals, and the biomass 147 kg, which was equal to 57700 individuals (294 kg) per hectare. At present population number is much lower - 7026 fish (48 kg) per hectare. The difference has resulted from environment degradation which usually causes decrease of fish density. Low number of fish aged 0+ and 1+ resulted from application of electric fishing tool which was appropriate for harvesting only large individuals. It is supposed that the youngest fish were more numerous than the 2+ years old ones and older, assuming that the environmental factors did not considerably deteriorate during the spawning and egg development. It is known that such populations usually have high reproductive potential, as had been observed by Piironen, Holopainen (1988) who experimentally introduced 280 mature crucian carps into a fishless pond. One year later population number increased to 16 thousand fish, and after two years to 25 thousand individuals. This resulted in a considerable drop of the fish growth rate. Population number of crucian carp in ponds was also studied by Holopainen and Hyvarinen (1985) who estimated fish number in a 2 ha pond at 44 thousand individuals (22 thousand per hectare), and biomass at 133 kg (66.5 kg per hectare). Nikol'skij and Subnikova (1974) harvested 342 fish of average body mass 3.9 g from a 14 m^2 pond.

According to Mann (1991) average crucian carp standing crop in European inland waters is equal to 0.13 kg per ha.

Nikol'skij and Subnikova (1974) reported that crucian carp mortality during the first five years of life (excluding several initial months) was usually low. It increased in the sixth year, which might have been caused by higher exploitation intensity. At that time fish biomass considerably decreased too, but not so heavily as the numbers. This was related to faster growth of the fish. Survival of fish in crucian carp lakes was studied by Ciepielewski (1967) who estimated survival for VI, VII and VIII years of life at 37.9, 26.2, and 9.1%, respectively (average 24.4%). This indicates that among 100 crucian carps at age of 6 years, only 1 survived until 10 years. In the forest pool described in the present paper, survival rates of fish at that age were equal to 33, 39, and 71%, respectively (on the average 47.7%), so they were higher than in crucian carp lakes. However, it should be stressed that only natural mortality took place in the pool since it has not been exploited by fishermen or anglers. Total mortality of dwarf bream in Jashan Lake was 0.56 (Haberman 1981). High natural mortality - 0.348 (comparing to 0.61 in crucian carp) was caused by high temperatures, small size of fish, and their poor condition. Natural mortality coefficient of bream in Szczeciński Lagoon was equal to 0.24 (Kompowski 1988), and in Balaton Lake to 0.329 (Biro 1978 a, b).

Generally it may be assumed that production to standing crop ratio (Pg/P) of lake fish ranges from 30 to 70% (Szczerbowski et al. 1993). Annual production of fish of

III-IX age groups equal to 40% (1369.4 g) may be considered as very low. It indicates that 40% of total standing crop may be harvested annually. For bream from Jashan Lake this value was even lower - 36%, and for Tjeukemeer Lake bream - 39% (Goldspink 1978), comparing to twice higher value for Balaton Lake bream - 72.6%. Low production might have resulted from poor food conditions, or poor food utilisation by the fish. In the case of bream populations mentioned above, also feeding competition might have played an important role. For cyprinid fishes production is usually about 100%, and even much higher under pond conditions.

CONCLUSIONS

1. Crucian carp population consisted of 0+ - 8+ aged individuals. Fish aged 2+, of average body length 4.8 cm and weight 3.2 g predominated. Share of fish from 5.1 to 6.0 cm was 27.5%, and of body weight from 2.1 to 4.0 g - 21.1%.
2. In the sample 267 females, 81 males and 205 juveniles were identified. Among the females and males, fish aged 3+ predominated (35.2% of females, and 44.4% of males).
3. Juvenile fish belonged to the age classes 0+ - 2+, among which fish 2+ predominated (80.5%).
4. Production of III-IX age groups was 40% of the average biomass, and survival about 60%.

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STRESZCZENIE

CHARAKTERYSTYKA POPULACJI KARŁOWATEJ FORMY KARASIA (Carassius carassius L.) W ŚRÓDLEŚNYM STAWIE

Badano populację karłowatej formy karasia pospolitego *Carassius carassius* (L.), bytującą w małym, śródleśnym stawie w okolicach Olsztyna. W badaniach uwzględniono strukturę płci, wieku, długości i masy ciała, śmiertelność, produkcję biologiczną oraz biomasę populacji.

Populacja składała się z 267 samic, 81 samców i 205 ryb młodocianych w wieku 0+ - 8+ o długości ciała od 2,0 do 10,8 cm. Dominowały ryby w wieku 2+, o średniej długości ciała - 4,8 cm i masie 3,2 g. Zarówno wśród samic jak i samców dominowały ryby w wieku 3+ (35,2% - , 44,4% -). Początek dojrzewania płciowego samców i samic przypadał na drugi rok życia. Populacja łowna, określona na podstawie znakowania, liczyła 3513 ryb o łącznej masie około 24 kg. W trzecim i czwartym roku życia współczynnik śmiertelności wyniósł Z=0,35 i Z=0,24, a największą wartość osiągnął w szóstym roku życia (Z=1,10). Produkcja biologiczna ryb z grup wiekowych od III do IX wyniosła 40% średniej biomasy, a przeżywalność wahała się na poziomie około 60%.

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