ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. XXVII, Fasc. 2 Szczecin 1997

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Fish biology

REPRODUCTION AND FECUNDITY OF BLUE BREAM *ABRAMIS BALLERUS* L., 1758 IN MIĘDZYODRZE[1]

ROZRÓD I PŁODNOŚĆ ROZPIÓRA *ABRAMIS BALLERUS* L., 1758 Z WÓD MIĘDZYODRZA

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The age and length distribution of the blue bream spawning population of Międzyodrze—the wetland area in the lower part of the river Odra—was examined in the years 1992–1996. The length and age of sexual maturity was determined, the relative gonads size of mature fish in autumn and spring seasons as well as relationship between fecundity and weight or length of females was assessed.

INTRODUCTION

Blue bream is one of fishes inhabiting the lower parts of some great European rivers and some lakes situated in their drainage areas (see e.g. Kompowski 1971, 1991). In Poland, the fish appears in considerable abundance only in the lower and the middle part of the river Odra and its estuary, which comprises Szczecin Lagoon and Lake Dąbie (Kompowski 1995). The reproduction biology of blue bream has been quite thoroughly studied in the waters of Eastern Europe. The papers of many authors deal with this problem either entirely or partially (e.g. Sergeev et al. 1955; Zacharova 1955; Ginzburg 1958 a, b; Tkačeva, 1958; Balon, 1959; Rojenko and Špilevskaja 1962; Aleksandrova 1966; Smirnov 1966; Špilevskaja 1967; Chaem 1969; Konstantinova and Vavilova 1969; Volodin 1980; Kuzniecov 1990).

[1] Międzyodrze is the delta area of the river Odra situated above Szczecin. It consists of two main river branches, Regalica and Odra Zachodnia, as well as a sophisticated network of canals and river arms connecting the two branches (see e.g. Kompowski 1995). The area—with its unique values of nature and scenery—is a part of the Scenic Park Lower Odra Valley, created in 1993

The only paper concerning the reproduction of blue bream in the waters of Poland (Karabanowicz and Kompowski 1994) describes the fecundity, seasonal variation of relative gonads size and the egg diameter of the blue bream caught in Szczecin Lagoon and Lake Dąbie. The paper also presents some aspects of blue bream reproduction in the waters of Międzyodrze. Two spawning grounds were located: in Kurowski Canal and in Stara Regalica. The ratio of males and females among the fish spawning on the two grounds was also assessed.

The aim of this paper is to extend the knowledge about the reproduction of blue bream in the area of Międzyodrze through examination of the age and length structure of the spawning population, the length and age of sexual maturity, gonadal development, the spawning season in each year from 1992 through 1996, as well as fecundity and relative gonads size.

MATERIAL AND METHODS

The fish samples were taken at random from the commercial catches of the Fishery Cooperative "Regalica" in Gryfino during the autumn and spring seasons 1992–1996. Due to the selectivity of the fishing gear used (trap nets and gill nets), the samples were almost entirely composed of large, mature fish. Therefore a number of juvenile, immature specimens—particularly useful for the determination of the sexual maturity length—were sampled from several hauls of a summer seine.

The whole body weights (w_1) and the eviscerated body weights (w_2) of the examined fish were weighed to 0.1 g; the standard body lengths *(SL)* were measured to 1 mm; the age was read from the scales taken from the 1st or 2nd row under the lateral line, just under the first radius of the dorsal fin. The stages of gonadal development were assessed according to eight-stage Maier's gonadal development scale. The weight of the gonads before preservation was estimated to 0.1 g.

In order to study the fecundity, the females with gonads in stage IV and V of Maier's scale were chosen. The ovaries taken from the females were preserved in a solution of formalin. The fecundity was assessed by weight. Each pair of ovaries was thoroughly cleansed in running water and the eggs, separated from the ovary tissue, were dried on blotting paper. The dried eggs of each individual were weighed to 0.001 g. After that three samples of about 0.05–0.1 g were weighed with the same accuracy and the number of eggs in each sample was counted under a stereo microscope. The total number of eggs from three samples was then converted to the total number of eggs for each individual female, by proportion to its weight.

The indices of relative gonads size (RGS) were calculated according to the following formula:

$$RGS = \frac{g \cdot 100}{w_2};$$

where: RGS = relative gonads size index; g = gonads weight (before preservation); w_2 = eviscerated body weight. The list of analyses is presented in Table 1.

Table 1

The number of blue bream specimens studied

Type of analysis	Year					Total
	1992	1993	1994	1995	1996	
Measurements of standard length	9	136	69	155	55	424
Measurements of weight	9	133	69	155	55	421
Measurements of gonads weight	9	85	68	147	55	364
Estimation of sex and gonadal development	9	136	69	155	55	424
Estimation of fecundity	–	58	16	34	8	116
Estimation of age	9	136	69	154	55	423

RESULTS

Length and age of the studied population

The data demonstrating the length and age of the blue bream caught in the waters of Międzyodrze in the years 1992–1996 are presented in Table 2. The material has been divided into separate groups—for the autumn and spring seasons. Also the two samples from the autumn of 1993 and 12th April 1995 were taken separately, since they were entirely or almost entirely composed of juvenile, sexually immature fish.

Among the mature fish prevailed large and old ones belonging to age groups VII–XII, their mean length from approx. 29 cm to approx. 34 cm. The oldest two blue bream specimens belonged to the group XV. The bulk of the spawning population were the fish from the three age groups VII, VIII and IX. In 1993 they made up 76.7%, in 1994—69.8%, and in 1995—59.1% of the population.

The age group II predominated (84%) among the juvenile fish captured in the autumn of 1993, with standard length 12.1–20.4 cm ($\bar{x}$ = 17.1 cm), representing the year class born in 1991. This abundant year class could be observed also in the succeeding years. As the age group IV, it made up 85.9% of the sample captured on 12th April 1995, and—as the age group V—34.6% of the sample caught on 30th April 1996.

Length–weight relationship and condition

Fig. 1 demonstrates the relationship between the whole body weight and the standard length of the examined blue bream. The dependence can be expressed in the form of the power equation:

$$W_1 = 0.0113\, l^{3.0812}$$

where: W_1 = whole body weight in grams; l = standard length *(SL)* in centimetres.

Table 2

Mean body length (*SL*—cm) and age of blue bream caught in Międzyodrze

Date of capture	Para-meter	Age group															Total
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	
09-12-92	n			2		1	2	2	2								9
	%			*22.2*		*11.2*	*22.2*	*22.2*	*22.2*								*100.0*
	mean *SL*			23.3		28.2	28.6	30.6	31.6								28.5
30-03-93,	n				2	3	8	17	31	8	1	1	2				73
26-04-93	%				*2.7*	*4.1*	*11.0*	*23.3*	*42.5*	*10.9*	*1.4*	*1.4*	*2.7*				*100.0*
	mean *SL*				26.4	27.7	29.2	30.0	31.0	32.3	32.8	32.6	33.7				30.6
27-09-93	n						3	1	5	2	1				1		13
	%						*23.1*	*7.7*	*38.5*	*15.4*	*7.7*				*7.7*		*100.0*
	mean *SL*						32.5	30.5	33.3	34.7	34.5				35.8		33.4
28-10-93,	n	4	42	4													50
04-11-93	%	*8.0*	*84.0*	*8.0*													*100.0*
	mean *SL*	14.3	17.1	19.6													17.1
10-03-94,	n						6	14	15	8	6	2		1		1	53
31-03-94,	%						*11.3*	*26.4*	*28.3*	*15.1*	*11.3*	*3.9*		*1.9*		*1.9*	*100.0*
07-04-94	mean *SL*						29.2	28.8	30.0	31.2	32.4	32.9		34.4		32.6	30.3
	n			5	1		5	3		1			1				16
25-10-94	%			*31.3*	*6.3*		*31.2*	*18.9*		*6.3*			*6.3*				*100.0*
	mean *SL*			24.4	28.6		29.3	30.9		35.3			33.9				28.7
06-03-95,	n					1	4	18	19	16	9	11	4	4	3	1	90
27-03-95,	%					*1.1*	*4.4*	*20.0*	*21.1*	*17.89*	*10.0*	*12.2*	*4.4*	*4.4*	*3.3*	*1.1*	*100.0*
26-04-95	mean *SL*					28	30.8	31.8	31.9	32.4	33.2	32.7	32.5	33.4	35.2	34.5	32.3
	n			3	55				1	3		2					64
12-04-95	%			*4.7*	*85.9*				*1.6*	*4.7*		*3.1*					*100.0*
	mean *SL*			21.3	23.8				32.0	29.1		31.6					24.3
	n		4	1	5	19	11	3		7	1	1	2	1			55
30-04-96	%		*7.3*	*1.8*	*9.1*	*34.6*	*20.0*	*5.5*		*12.7*	*1.8*	*1.8*	*3.6*	*1.8*			*100.0*
	mean *SL*		13.7	19.9	21.3	24.7	25.6	29.5		32.3	34.3	34.5	34.5	35.9			25.8

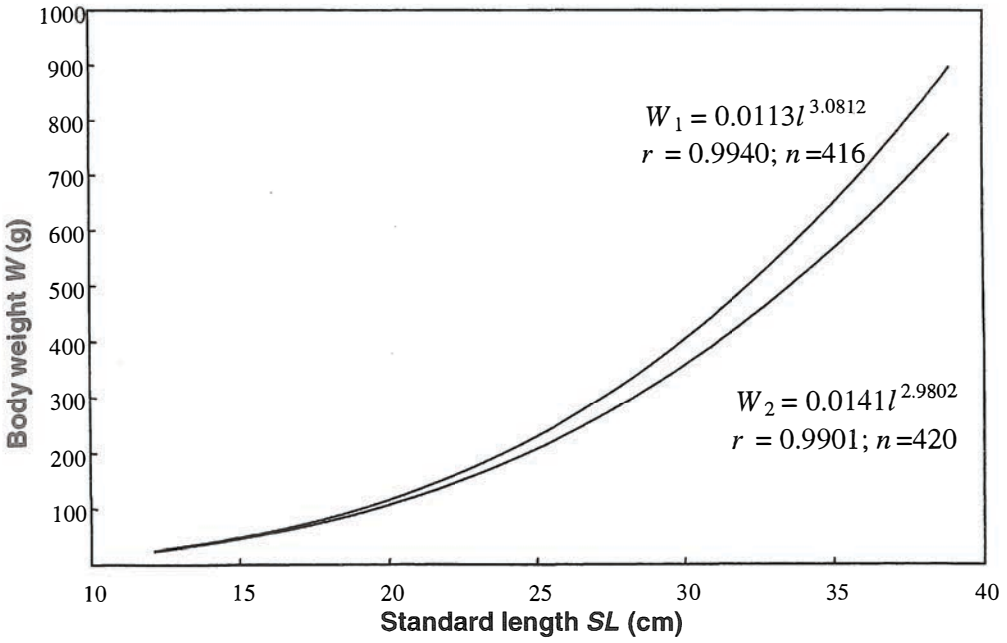

Fig. 1. Length–weight relationship (SL–w_1 and SL–w_2) of blue bream captured in Międzyodrze

The equation—based on the measurements of standard length and weight of 416 individuals with standard length range 12.1–36.9 cm and whole weight (w_1) range 23.4–902.3 g—fits the empirical data quite well, as it is demonstrated by the correlation coefficient r = 0.9940, assessed for the logarithmic (linear) form of the equation.

Fig. 1 also shows the relationship between eviscerated body weight and standard length. The power equation:

$$W_2 = 0.0141\ l^{2.9802}$$

was assessed on the basis of the measurements of 420 individuals, with length *(SL)* range 12.1–36.9 cm and eviscerated body weight (w_2) range 21.8–829.9 g. It again fits the empirical points quite well, as the correlation coefficient r—assessed for the logarithmic (linear) form of the equation—equals 0.9901.

In Table 3 the mean values of Fulton's condition coefficient, K_1, and Clark's, K_2 are demonstrated, where w_1 = whole body weight, w_2 = eviscerated body weight and l = SL in cm.

In both forms, the highest values of K were observed during the autumn seasons, whereas the lowest values occurred in the springs—after spawning. What is also clear, in the same seasons the males had generally higher condition coefficients than the females.

Table 3

Mean values of Fulton's condition coefficient, K_1, and Clark's, K_2, of mature blue breams caught in Międzyodrze

Season	Statistics	$K_1 = \frac{w_1 \cdot 100}{l^3}$		$K_2 = \frac{w_2 \cdot 100}{l^3}$	
		Males	Females	Males	Females
Autumn	Range:	1.495–1.708	1.442–2.015	1.383–1.539	1.215–1.760
	Mean *SL*:	1.590	1.660	1.457	1.418
	Standard deviation:	0.060	0.155	0.049	0.142
	Number:	12	24	12	24
Spring – before spawning	Range:	1.214–1.950	1.252–1.854	1.137–1.780	0.968–1.504
	Mean *SL*:	1.508	1.533	1.412	1.260
	Standard deviation:	0.120	0.133	0.106	0.096
	Number:	106	98	109	97
Spring – after spawning	Range:	1.137–2.051	1.181–1.744	1.056–1.570	1.164–1.504
	Mean *SL*:	1.448	1.379	1.350	1.226
	Standard deviation:	0.146	0.121	0.115	0.110
	Number:	57	55	58	56
Total number:		175	177	179	177

Length and age of sexual maturation

Fig. 2 represents the percentage of sexually immature, male and female individuals within each length class. All the fish smaller than 20 cm were immature, i.e. it was impossible to determine their sex with unaided eye (stage I of maturity according to Maier's scale). The smallest female, with gonads in maturity stage II, was 19.9 cm long, whereas the smallest male—20.6 cm. All the blue bream above 27 cm of standard length were sexually mature.

On the assumption that the sexual maturity length is the length where 50% of fish are mature, it can be presumed, with some approximation, that the length of the maturity for blue bream in Międzyodrze equals 20.5 cm, according to Fig. 2. Substituting this length to von Bertalanffy's growth equation—the one expressing the growth of the blue bream caught in Międzyodrze in the years 1990–1993 (L_∞ = 40.01 cm, K = 0.1817, t_0 = –0.2092 years; Kompowski, 1995)—the mean age of the sexual maturity derived this way equals t_m = 3.74 years.

The smallest female ready for spawning (stage IV in Maier's scale), among the fish captured in the spring, was 24.1 cm long and in the age 3+ (4) years. It was captured on 12th April 1995.

It can also be seen from Fig. 2 that the sex ratio within the mature fish was like 1:1.

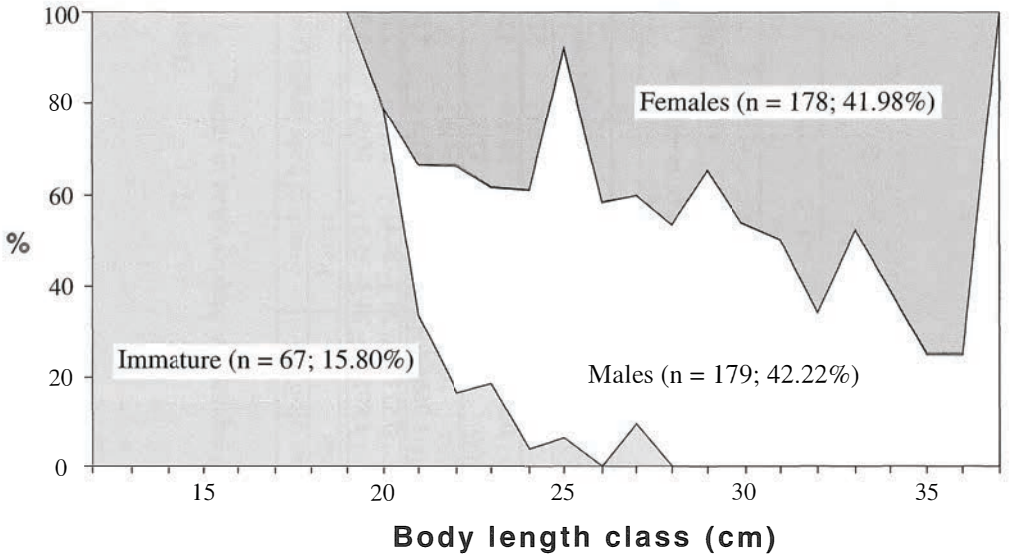

Fig. 2. Percentage of immature, male and female specimens within each standard length class

Gonadal development and time of spawning

In the autumn season (the end of September till the beginning of December) the gonads of sexually mature fish were already well developed. Most of females had their gonads in gonadal development stage IV or even V (Tab. 4). The relative gonads size *(RGS)* of the ovaries made up on the average 11–14% of eviscerated body weight (w_2). The testicles were much smaller (mainly stage II or III) and *RGS* measured on the average 0.8–1.7%. The above data demonstrate that the spawning concentrations of blue bream start as early as in autumn.

Table 5 contains the data concerning the gonadal development stages in the spring seasons of the years 1993–1996. In the sample caught on 30th March 1993, the gonadal development stage indicated the pre-spawning season. The testicles were in stages III, IV and V, whereas the ovaries in stage IV. The relative testicles size *(RGS)* ranged from 0.92% to 1.88%, on the average 1.54%; the relative ovaries size varied from 16.97% to 28.68%, with the mean value 21.67%. The gonadal stages of blue bream captured on 26 April 1993 (stages V, VII and VIII) indicated the final phase of the spawning. The relative size of testicles decreased slightly ($\bar{x} = 1.12\%$), whereas in the case of the females the index apparently dropped ($\bar{x} = 6.5\%$). The above observations show that in 1993 the spawning of blue bream occurred in the second half of April. Similarly, considering the observed gonadal development stages and the level of *RGS*, it can be concluded that in 1994 the spawning took place in the first decade of April, in 1995—in the second decade of April and, finally, in 1996—between the end of April and the beginning of May.

Table 4

Maier's degree of gonadal development of mature males and females of blue bream captured in Międzyodrze in autumn

Date of capture	Sex	Stages of gonadal development (%)				Total		Relative gonad size (*RGS*)			Standard body length (cm)		
		II	III	IV	V	n	%	Range	Mean	SD	Range	Mean	SD
09-12-92	Males		100			6	100	1.217–1.976	1.704	0.275	28.2–32.6	30.3	1.6
	Females			100		2	100	6.071–14.566	10.319		26.3–27.8	27.1	
27-09-93	Males		100			1	100		0.771			34.8	
	Females			100		12	100	10.155–17.320	14.056	1.968	29.2–35.8	33.3	1.9
25-10-94	Males	80	20			5	100	1.067–2.216	1.671	0.523	24.3–29.4	27.4	2.3
	Females		10	10	80	10	100	2.421–17.224	11.200	4.892	24.3–35.3	30.0	3.8

Table 5

Maier's degree of gonadal development of mature males and females of blue bream captured in Międzyodrze in spring

Date of capture	Sex	Stages of gonadal development (%)							Total		Relative gonad size *(RGS)*			Standard body length (cm)		
		II	III	IV	V	VI	VII	VIII	n	%	Range	Mean	SD	Range	Mean	SD
30-03-93	Males		44	50	6				18	100	0.921–1.883	1.543	0.247	27.1–33.5	29.7	1.6
	Females			100					46	100	16.965–28.683	21.669	2.796	27.8–34.2	31.0	1.4
26-04-93	Males						33	67	3	100	0.617–1.787	1.116	0.604	29.5–32.8	31.6	1.9
	Females				20			80	5	100	0.489–25.645	6.504	10.727	26.2–31.2	29.7	2.0
31-03-94	Males		5	95					20	100	0.619–1.407	1.096	0.214	25.6–33.3	28.7	1.7
	Females			100					6	100	20.199–25.480	23.574	1.934	28.2–33.3	31.4	2.0
07-04-94	Males	13	88				19	81	16	100	0.797–2.693	1.502	0.640	29.8–33.2	31.3	1.0
	Females				25		25	50	8	100	2.400–27.479	10.783	11.906	29.3–34.4	31.4	1.5
06-03-95	Males		100						15	100	1.552–2.706	2.017	0.296	29.9–36.9	32.3	2.1
	Females			67	33				12	100	11.176–26.225	17.753	4.756	28.0–35.5	32.6	2.0
27-03-95	Males		92	8					24	100	1.208–2.499	1.636	0.340	30.3–34.3	32.5	1.3
	Females				100				5	100	22.215–30.824	26.332	3.524	31.1–34.4	33.0	1.2
26-04-95	Males	36						64	11	100	0.325–1.268	0.700	0.306	30.1–33.0	31.7	1.0
	Females	4		4	4			87	23	100	0.401–24.644	4.339	6.261	29.8–34.5	32.0	1.3
30-04-96	Males	32	18	7			29	14	28	100	0.055–2.747	1.393	0.759	20.6–34.5	27.0	4.4
	Females	30			40			30	20	100	0.114–23.778	7.045	7.450	19.9–35.9	27.1	4.6

Table 5 also shows that—during the period just before spawning—the weight of ovaries in mature females constituted approximately 20–30% of eviscerated body weight. The weight of the testicles, on the other hand, was always much lower, and it has never been observed to exceed 3% of the weight of the body. The maximum observed *RGS* index value for the males reached 2.75%. What is demonstrated in Tables 4 and 5, the mean length of mature males was comparable to the mean length of mature females within the same sample.

Fecundity

The absolute fecundity of blue bream in Międzyodrze ranged from 7743 eggs (*SL* = 25.0 cm) up to 112936 eggs (*SL*= 34.5 cm). The mean fecundity of the examined fish was 52912 ± 22330. Fig. 3 describes how the absolute fecundity increases with the length of fish. The relationship can be quite accurately expressed in the form of the power equation:

$$F = 0.000823\, l^{5.2265},$$

where: F = absolute fecundity,
l = *S*L in cm,
which has a considerably high correlation coefficient r = 0.9036 for its logarithmic form. For comparison, the model based on a linear equation does not match the empirical data equally well:

$$F = -143895.58 + 6447.97 \cdot l;\ \mathrm{r} = 0.8785.$$

The increase of the absolute fecundity with the weight of the females is shown in Fig. 4 (whole body weight) and Fig. 5 (eviscerated body weight). In both cases the theoretical curve goes with the empirical data in the best way when use a power equation. The following equations were derived respectively:

$$F = 1.9557\, w_1^{1.6558};\ r = 0.9311 \text{ and}$$

$$F = 2.0351\, w_2^{1.7076};\ r = 0.8875;$$

where: w_1 = whole body weight,
w_2 = eviscerated body weight.

The attempt to describe this relationship with a linear model resulted in the lines fitting the empirical data slightly worse:

$$F = -1712.86 + 152.23\, w_1;\ r = 0.9153 \text{ and}$$
$$F = -15208.04 + 183.39\, w_2;\ r = 0.8598;$$

which is shown by the little lower correlation coefficients. The absolute fecundity is better correlated with the whole body weight than with the eviscerated body weight.

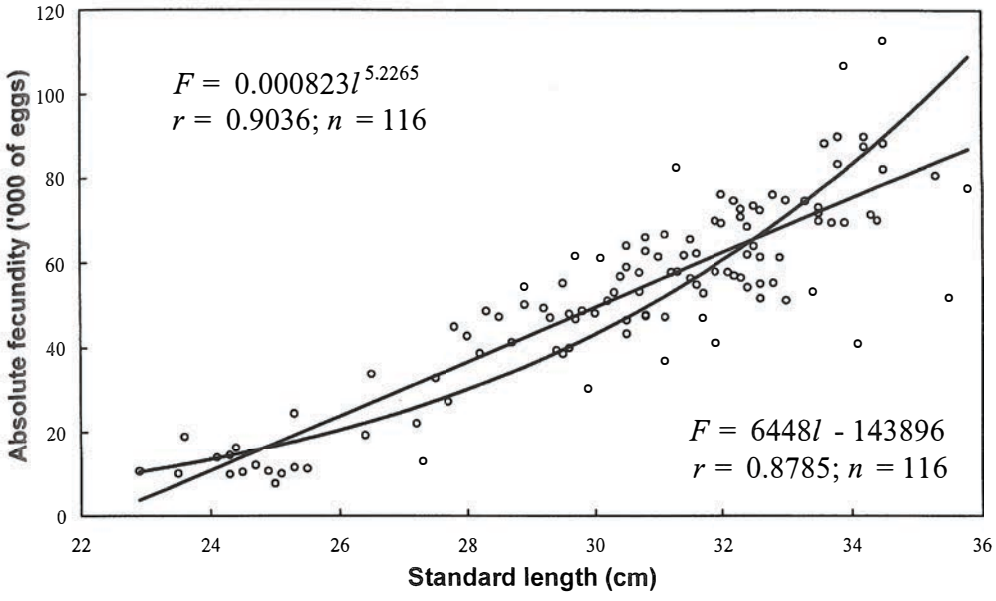

Fig. 3. Relationship between absolute fecundity (*F*) and standard length (*SL*) of blue bream from Międzyodrze

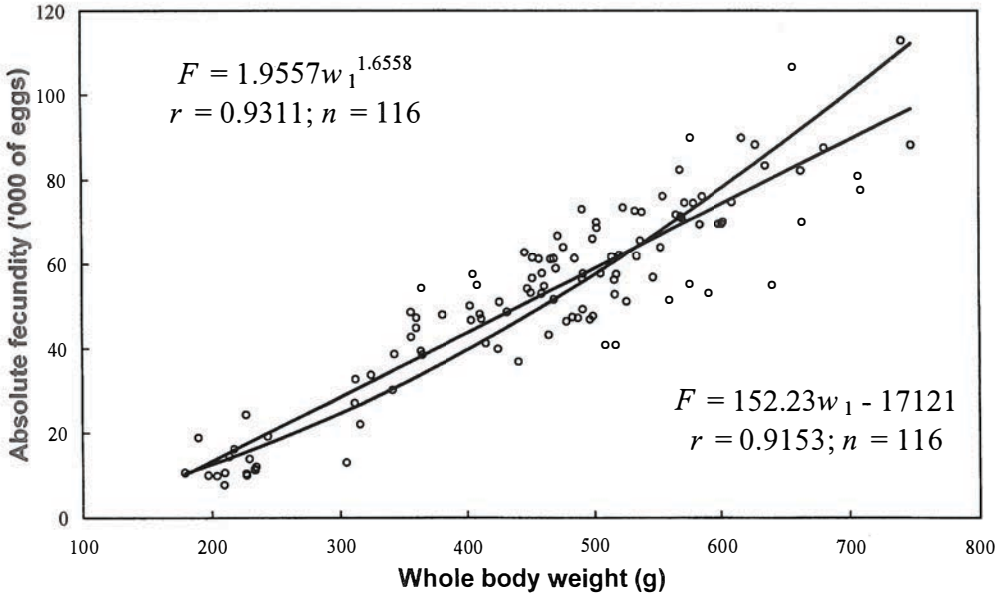

Fig. 4. Relationship between absolute fecundity *(F)* and body weight (w_1) of blue bream from Międzyodrze

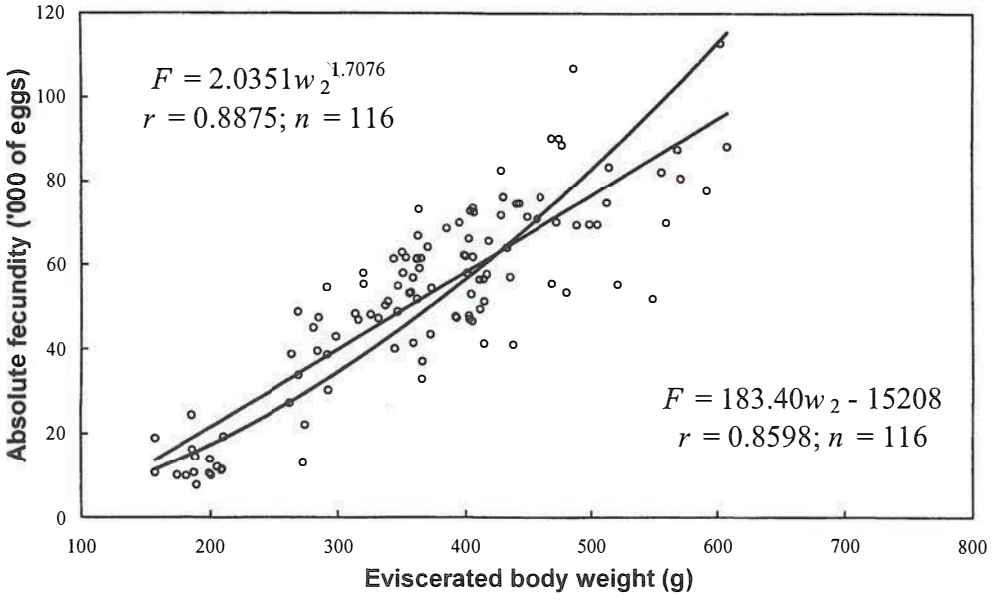

Fig. 5. Relationship between absolute fecundity (F) and eviscerated body weight (w_2) of blue bream from Międzyodrze

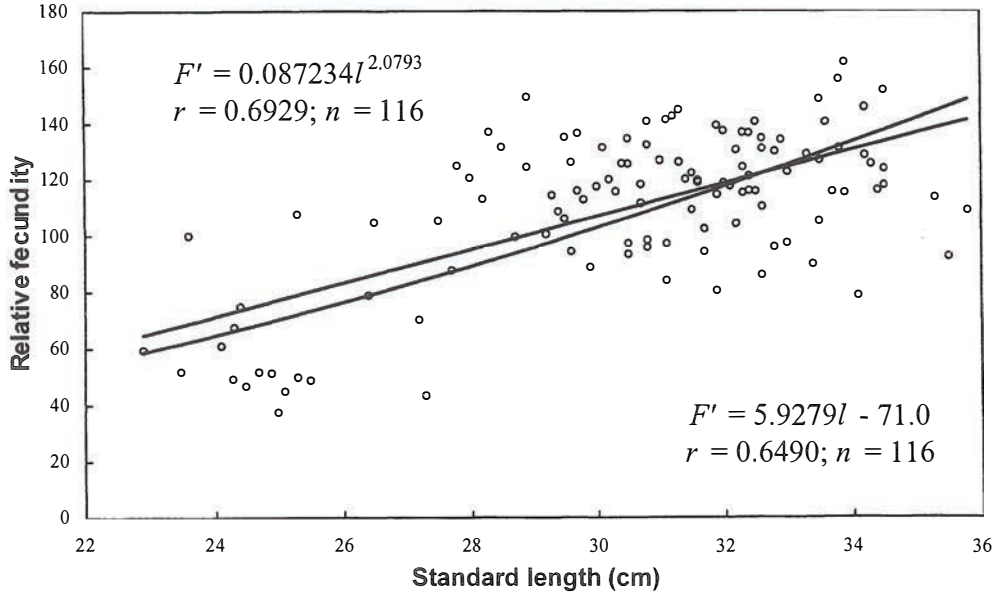

Fig. 6. Relationship between relative fecundity *(F')* and standard length *(SL)* of blue bream from Międzyodrze

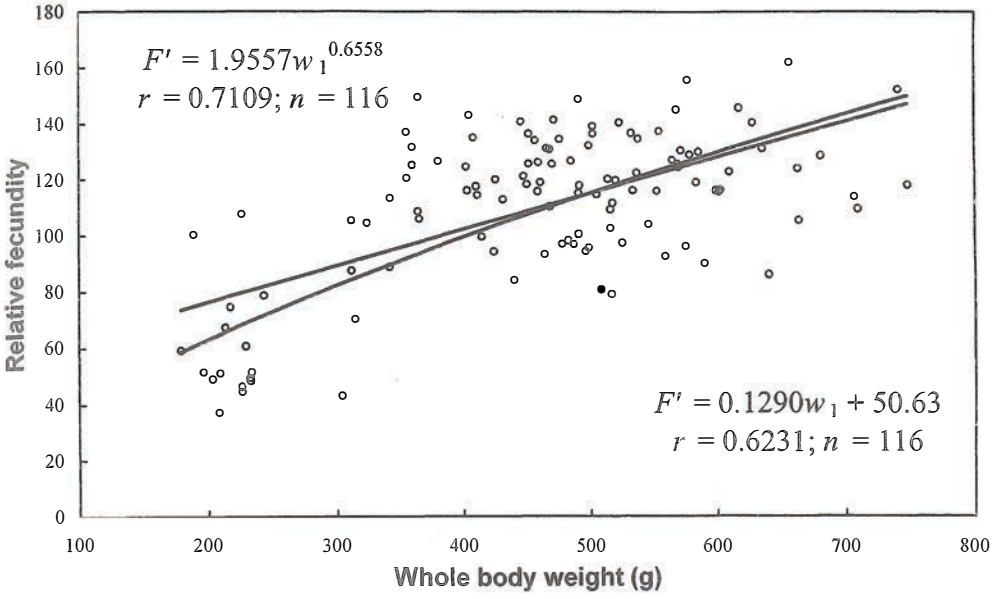

Fig. 7. Relationship between relative fecundity (F') and body weight (w_1) of blue bream from Międzyodrze

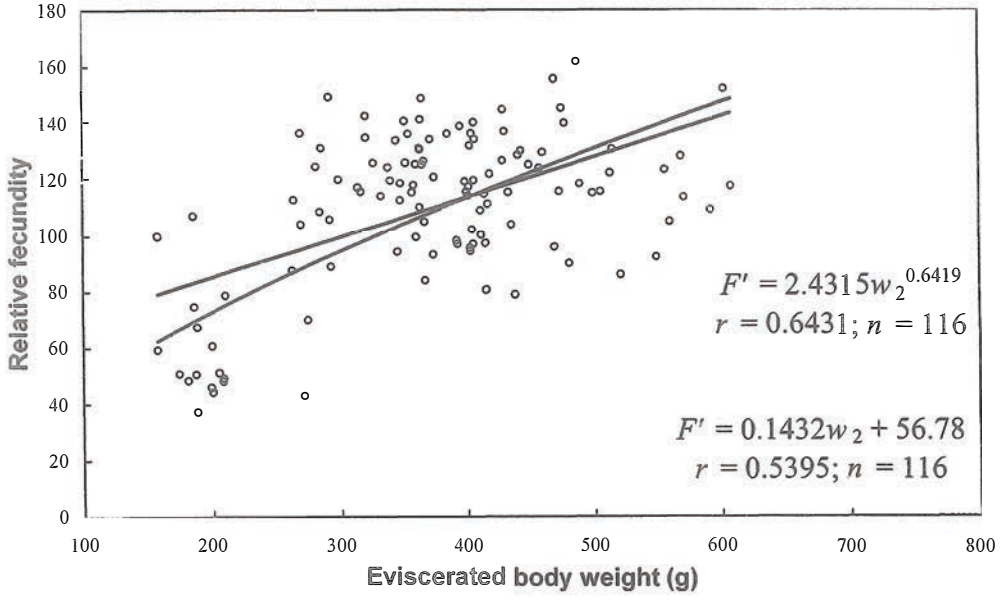

Fig. 8. Relationship between relative fecundity (F') and eviscerated body weight (w_2) of blue bream from Międzyodrze

The relative fecundity was from 36.9 eggs per 1 g of the whole body weight of a female 25.0 cm long *(SL)* up to 162.2 eggs (*SL* = 33.9 cm), with the mean relative fecundity of the examined sample 110.0 ± 27.8. The relative fecundity increased apparently with the length of the blue bream females. As it is shown in Fig. 6, the relationship can be well expressed with the power equation:

$$F' = 0.0872\ l^{2.0793};\ r = 0.6929;$$

where: F' = relative fecundity.
The linear equation slightly worse describes the relationship:

$$F' = -70.937 + 5.928\ l;$$

what is shown by the lower correlation coefficient $r = 0.6490$.

The relative fecundity is positively correlated with body weight (Figs. 7 and 8). This relationship is slightly curvilinear and can be quite exactly expressed in the form of a power equation. Matching this formula to the empirical data, the following equation—with use of whole body weight (w_1)—was derived:

$$F' = 1.9557\ w_1^{0.6558};\ r = 0.6929.$$

In the case of eviscerated body weight (w_2), the equation has the following form:

$$F' = 2.4315\ w_2^{0.6419};\ r = 0.6431.$$

The following linear equations describe these relationships slightly worse:

$$F' = 50.6284 + 0.1290\ w_1;\ r = 0.6231 \text{ and}$$

$$F' = 56.7760 + 0.1432\ w_2;\ r = 0.5395.$$

The testing of correlation significance confirmed all the equations in this chapter to be statistically significant at the confidence level ≥0.001.

DISCUSSION

The age structure comparison of the examined Międzyodrze population with the populations from Szczecin Lagoon and Lake Dąbie (Karabanowicz and Kompowski 1994) shows that larger and older fish predominated in the waters of Międzyodrze. Namely, in April 1991, directly before the spawning, in Lake Dąbie prevailed the fish belonging to age groups V–VIII, with mean Standard length *SL* = 27.9 cm. At the same time in Szczecin Lagoon mature females belonged to age groups IV–VIII, with mean standard length 27.9 cm, whereas mature males belonged to age groups III–VII, with mean standard length 26.0 cm. The bulk of the spawning populations in both Lake Dąbie and Szczecin Lagoon were the fish from

age groups V–VII, with standard length range 26–30 cm, whereas in the waters of Międzyodrze prevailed older fish belonging to age groups VII–XII, and the groups VII–IX, with mean lengths 30–34 cm, made up the bulk of the population.

The strong year class born in 1991, observed among the juvenile blue bream from Międzyodrze, confirms the occurrence of the year-class abundance fluctuations (see e.g. Jurovickij 1958; Poddubnyj and Gordejev, 1968; Strelnikov et al. 1983—Rybinsk reservoir on the Volga; Lapickij 1958—Cymlansk reservoir on the river Don; Smirnov 1966; Kuzniecov 1990—Kujbyšev reservoir on the Volga; Kompowski 1991, 1995—Szczecin Lagoon, Lake Dąbie, Międzyodrze).

The seasonal variations of the mature blue bream condition coefficients correspond with the previous observations of many authors. The highest values occur in autumn, after feeding season, the lowest after spawning (compare Chašem 1970—Rybinsk reservoir on the Volga and Kompowski 1971—Lake Dąbie). The phenomenon of condition coefficients being—on the average—higher for males than for females can be explained with the higher consumption of the energy needed for the growth of female reproductive organs. In the pre-spawning season the ovaries make up 5–6 times larger part of the mature fish body than the testicles.

The data given by many authors indicate that the age and length of the sexual maturity differ depending on the environmental conditions in the water body, especially feeding conditions. The improvement of the feeding conditions and the increase of growth rate have the effect in both the decrease of the maturity age and the increase of the maturity length (e.g. Tkačeva 1958; Špilevskaja 1967; Rojenko and Špilevskaja 1962; Smirnov 1966; Chašem 1969; Konstantinova and Vavilova 1969). According to these authors, this length vary from approx. 16 cm to 24–25 cm, and the males mature at the lengths slightly (approx. 1–2 cm) lower than the females. The age of the sexual maturity vary between 2 and 6 years. The length and age of the sexual maturity in Lake Dąbie—adjacent to Międzyodrze—measure 22 cm and 4.2 years respectively, whereas in Szczecin Lagoon—20.3 cm and 3.2 years (Kompowski 1991). These values are comparable to the length (20.5 cm) and age (3.7 years) for the first maturing blue bream from Międzyodrze.

Blue bream spawning season is the earliest from among the cyprinids. The wide geographical range of blue bream causes the variation in spawning time; the spawning season falls to March – April in the drainage basin of the Danube (Balon 1959; Antipa after Bânârescu 1964), whereas in Vedlozero in Karelia it occurs at the end of May (Aleksandrova 1966). Kožin (1949) reports that in the area of the former Soviet Union the blue bream spawns in the season between the end of April and the beginning of June. It has been confirmed by many authors' observations (e.g. Zacharova 1955; Sergeev et al. 1955; Ginzburg 1958 b; Smirnov 1966; Aleksandrova 1966; Konstantinova and Vavilova 1969). The spawning is single

and spreads for a few days (Sergeev et al. 1955; Zacharova 1955; Karabanowicz and Kompowski 1994). Our observations show that in the waters of Międzyodrze blue bream spawning—depending on the year—occurs in the period from the first decade of April till the end of April – beginning of May. The previous research, carried out in 1991 (Karabanowicz and Kompowski 1994), demonstrated that the spawning season of the blue bream can exceptionally move even to the second half of May, especially when the spring is cold and comes late.

Table 6

Comparative list on blue bream fecundity in different water bodies; range in numerator, mean value in denominator

Water body	Absolute fecundity F ('000)	Relative fecundity F' (no. of eggs per 1 g of w_1)	Length range	N	Reference
Reservoir Rybinsk on river Volga	13.6 – 133.0 / –	– / –	27.0 – 35.0	100	Zacharova, 1955
Reservoir Rybinsk on river Volga	17.7 – 89.5 / –	51 – 151 / –	26.5 – 39.5	23	Sergiejev et al., 1955
Reservoir Rybinsk on river Volga	7.1 – 51.2 / –	39.7 – 116.3 / –	23.0 – 32.0	142	Chašem, 1969
Reservoir Kujbyšev on river Volga	4.7 – 66.9 / –	– / –	18.0 – 34.0	82	Smirnov, 1966
Reservoir Kujbyšev on river Volga in 1984	– / 15.4	– / 69.7	$\bar{x}$ = 24.9	14	Kuzniecov, 1990
Reservoir Kujbyšev on river Volga in 1985	– / 26.2	– / 121.8	21.0 – 29.0	43	Kuzniecov, 1990
Reservoir Kujbyšev on river Volga in 1986	– / 25.4	– / 110.2	$\bar{x}$ = 25.8	32	Kuzniecov, 1990
Lake Dąbie	10.5 – 106.9 / 36.3	47.5 – 232.5 / 124.0	24.5 – 34.3	65	Karabanowicz and Kompowski, 1994
Szczecin Lagoon	12.6 – 70.8 / 30.4	58.2 – 196.7 / 106.4	25.0 – 33.3	31	Karabanowicz and Kompowski, 1994
Międzyodrze	7.7 – 112.9 / 52.9	36.9 – 162.2 / 110.0	22.9 – 35.8	116	Kompowski and Błaszczyk this paper

Table 6 demonstrates the data concerning the absolute and relative fecundity of the blue bream from different water bodies. However, any comparisons—either between the extreme values or the means for the populations—are difficult, because the data depend upon the length distribution of the spawners, and this can vary from year to year because of the variations in the recruitment of the blue bream, not to mention the impact of the selectivity of various fishing gear used on the obtained results.

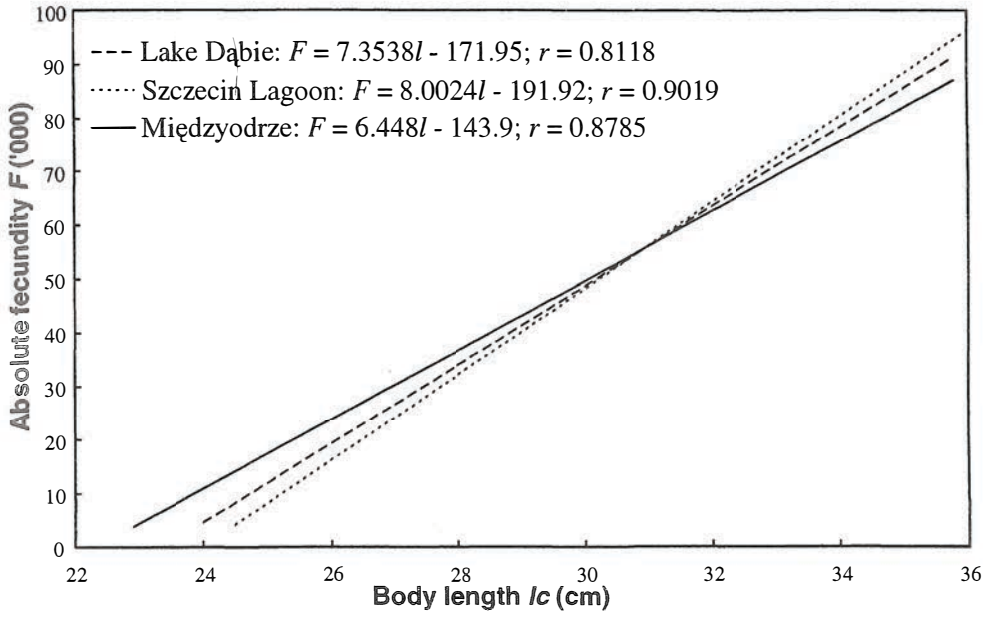

Fig. 9. Comparison of absolute fecundity – standard length relationships *(F–SL)* between blue bream captured in three water bodies: Lake Dąbie, Szczecin Lagoon (after Karabanowicz and Kompowski 1994) and Międzyodrze (own data)

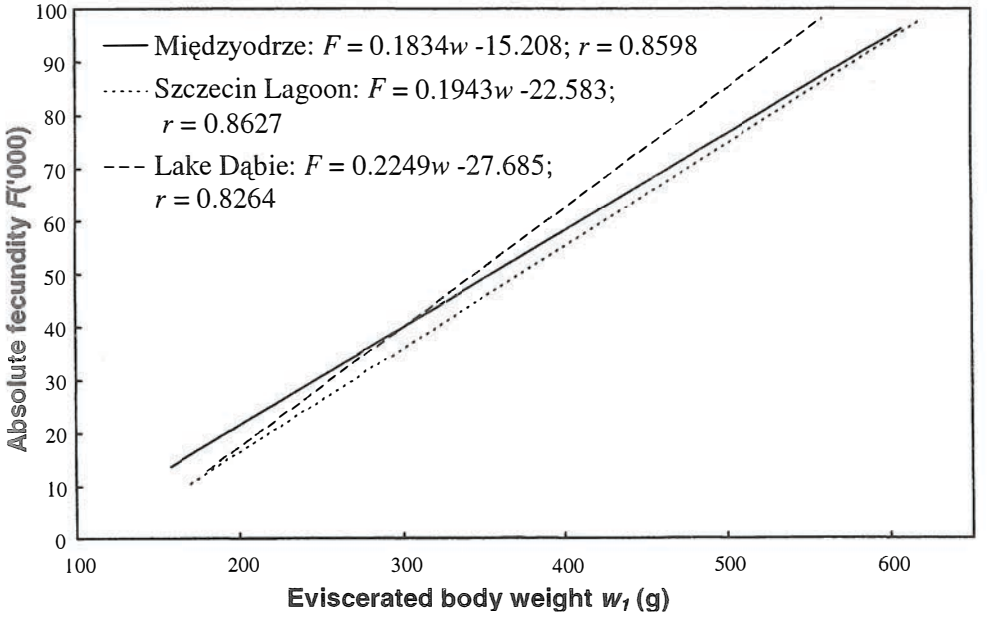

Fig. 10. Comparison of absolute fecundity – eviscerated body weight relationships *(F–w_2)* between blue bream captured in three water bodies: Lake Dąbie, Szczecin Lagoon (after Karabanowicz and Kompowski 1994) and Międzyodrze (own data)

The length of the sexual maturity—different for various stocks and changing from year to year—can also be a very important factor in this respect. Therefore, it is the most favourable to compare the tracks of the curves which represent the relationship between the fecundity and the length or weight of fish (see e.g. Brylińska 1971). Such a comparison is demonstrated in Figs 9 and 10; the lines represent the changes of fecundity with length or weight for the blue bream within the three areas of the Odra estuary: Szczecin Lagoon, Lake Dąbie and Międzyodrze. The tracks of the lines lie very close to each other, so it can be concluded that the relationships between the absolute fecundity and length or weight are similar for the blue bream in the three compared water bodies.

CONCLUSIONS

1. In the blue bream population from Międzyodrze prevailed fish 29–34 cm of *SL* belonging to age groups VII–XII; among the juvenile fish the strong year class 1991 dominated.
2. The highest values of the condition coefficients were observed in the autumns, the lowest in the springs, after spawning. The males had generally higher condition coefficients than the females.
3. On the average, the blue bream from Międzyodrze reach their sexual maturity at the length of 20.5 cm, which reflects the age of 3–4 years.
4. In the period directly preceding the spawning, the weight of the mature females ovaries made up 17.0–30.8% of the eviscerated body weight, whereas the weight of the testicles was much lower, comprising maximum 2.75% of the eviscerated body weight.
5. The spawning time of blue bream in Międzyodrze waters varies considerably from year to year (from the beginning of April till the second half of May) depending on temperature conditions.
6. The absolute fecundity of the examined blue bream varied from 7743 for the female of *SL* = 25.0 cm to 112936 eggs for the female 34.5 cm long; the mean value was 52912 ± 22331.
7. The absolute fecundity rises with the increase of length or weight. This relationship between the fecundity and the two variables is significant when expressed either as a linear equation or in the form of a power equation.
8. The relative fecundity of the blue bream changed within 36.9–162.2 eggs per 1 g of the whole female body weight.
9. The relative fecundity is positively correlated with the length or weight of the female blue bream. The dependence is significant when presented in either linear or power equation.
10. The relationship between the absolute fecundity and length or weight in the blue bream from Międzyodrze is very similar to the respective relationships for the blue bream from Szczecin Lagoon and Lake Dąbie.

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ROZRÓD I PŁODNOŚĆ ROZPIÓRA *ABRAMIS BALLERUS* L., 1758 Z WÓD MIEDZYODRZA

STRESZCZENIE

Stado tarłowe rozpiórów złowionych w latach 1992–1996 składało się z dużych, starych osobników; dominowały ryby o długości 29–34 cm *SL* należące do VII–XII grup wieku (Tab. 2). Wśród osobników młodocianych w latach 1993–1996 przeważały ryby silnego pokolenia urodzonego w 1991 r.

Zależność masa–długość wyrazić można w postaci równań potęgowych: $W_1 = 0.0113\, l^{3.0812}$; $r = 0{,}9940$ oraz $W_2 = 0.0141\, l^{2.9802}$; $r = 0{,}9901$, gdzie: W_1 = masa całkowita; W_2 = masa bez wnętrzności, l = długość ciała *SL* (Fig. 1). Najwyższe wartości współczynników kondycji obserwowano jesienią, najniższe – wiosną po tarle, przy czym w tych samych okresach samce na ogół charakteryzowały się lepszą kondycją niż samice (Tab. 3).

Dojrzałość płciową rozpióry z Międzyodrza osiągają przeciętnie przy długości 20,5 cm – co odpowiada wiekowi 3–4 lat (Fig. 2).

W okresie bezpośrednio poprzedzającym tarło jajniki stanowiły 17.0–30.8% masy ciała samic (bez wnętrzności), masa jąder nigdy nie przekroczyła 2,75% masy ciała samców (bez wnętrzności) (Tab. 5).

Płodność absolutna badanych rozpiórów zawarta była w granicach 7743–112936 jaj, średnio 52912 ± 22331, u samic o długości *(SL)* 25,0–34,5 cm. Zwiększanie się płodności absolutnej wraz z długością i masą samic można przedstawić w postaci równania potęgowego oraz w postaci równania prostej. W obu przypadkach zależność jest istotna statystycznie (Fig. 3–5). Płodność względna badanych rozpiórów zmieniała się w granicach 36,9–162,2 jaj przypadających na 1 g masy całkowitej ciała samicy i jest skorelowana dodatnio z długością i masą bada-

nych samic. Zależność płodności absolutnej od długości i od masy ciała jest u rozpiórów z Międzyodrza bardzo zbliżona do odpowiednich zależności u rozpiórów z Zalewu Szczecińskiego i jeziora Dąbie.

Received: 6 May 1997

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