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RESERVE OF OOCYTES OF PROTOPLASMATIC GROWTH IN THE OVARIES OF BREAM, *ABRAMIS BRAMA* (L.) FEMALES FROM LAKE KORTOWSKIE AND LAKE BLANKI

ZAPAS OOCYTÓW PROTOPLAZMATYCZNEGO WZROSTU W JAJNIKACH SAMIC POPULACJI LESZCZA, *ABRAMIS BRAMA* (L.), JEZIORA KORTOWSKIEGO I JEZIORA BLANKI

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1.5 to 14.5% of the oocytes develop in the annual cycle in the ovaries of bream females in Lake Kortowskie and Lake Blanki. This corresponds to 20.7–321.3 thousand eggs. An increase of absolute fecundity of the females takes place through utilization of the reserve of oocytes of protoplasmatic growth which are found in the ovaries during vitellogenesis from 1.5 to 14.5% as well as through an increase of the number of eggs per one per cent of oocytes in the ovaries.

INTRODUCTION

Oocytes of protoplasmatic growth in the ovaries of mature fish females represent a group of reproductive cells which give raise to eggs that are to be spawned in the given year. In the species which spawn in spring and early summer, and in which there is a rapid succession of stages II and III of ovary development according to Sakun and Buckaja (1968) just after spawning, the oocytes of trophoplasmatic growth fill with yolk in autumn (stage IV according to Sakun and Buckaja 1968) and remain in this stage throughout winter.

Studies were carried out on the reserve of the oocytes of protoplasmatic growth in the period when the portion of oocytes filled with yolk had already been esta-

blished in the ovaries of two populations of bream females. Bream spawns in Poland in spring and early summer, and vitellogenesis tajes place in the oocytes at the turn of summer and autumn (Brylińska and Długosz 1970, Kopiejewska 1989). The aim of the studies was to determine what fraction of the oocytes of protoplasmatic growth developed in course of one cycle, and what remained in the ovaries till next year. An attempt was also made to determine whether these fractions were characteristic for the development of ovaries in bream females in the annual cycle.

MATERIAL, METHODS, ENVIRONMENT

Materials were collected in Lake Kortowskie on 17–18 Dec. 1986 and between 5 May and 17 June 1987, and in Lake Blanki on 22–24 Nov. 1990. In November–December 47 bream females were collected, and in May–June – 24 females. The materials and the characteristics of the females are presented in Tables 1–3. Bream females collected in December from Lake Kortowskie were 26.6–31.5 cm long, and their body weight was 420–680 g. They were aged 4–7 years. Bream females collected in November from Lake Blanki were 25.6–40.9 cm in length, of body weight 360–1650 g, aged 4–10 years. Bream females collected from Lake Kortowskie in May–June were 21.1–36.2 (43.5) cm in length, of body weight 190–1200 (1900) g, aged 4–9 years.

Table 1

Percentage of the oocytes of proto- and trophoplasmatic growth in the ovaries and individual data for bream females in Kortowskie Lake in December 1986

Age	n	Body length cm	Body weight g	Gonad weight g	Oocytes of protoplasmatic growth %	Oocytes of trophoplasmatic growth %
4+	1	26.8	440	39	92.2	7.8
5+	12	26.6	420	20	92.7	7.3
		27.2	470	43	95.4	4.6
		27.4	450	36	95.3	4.7
		27.9	500	39	92.8	7.2
		28.0	440	30	92.3	7.7
		28.0	490	27	89.1	10.9
		28.2	450	31	95.0	5.0
		28.7	450	40	94.3	5.7
		28.7	600	36	92.8	7.2
		29.3	550	34	91.3	8.7
		29.4	680	70	91.7	8.3
		30.2	620	49	91.4	8.6
6+	2	30.3	610	40	85.5	14.5
		31.2	680	49	90.4	9.6
7+	2	30.4	580	24	91.7	8.3
		31.5	640	42	95.3	4.7
Total	17					

Table 2

Percentage and number of the oocytes of proto- and trophoplasmatic growth in the ovaries and individual data for bream females in Kortowskie Lake in May–June 1987

Age	n	Body length cm	Body weight g	Gonad weight g	Oocytes of proto-plasmatic growth %	Oocytes of tropho-plasmatic growth %	Absolute fecundity thous.	Reserve of the oocytes protoplasmatic growth thous.
4+	4	21.1	210	15	96.5	3.5	36.6	1009.1
		21.2	190	11	96.3	3.7	53.8	1400.2
		26.0	360	33	91.4	8.6	68.0	722.7
		26.6	360	20	98.1	1.9	23.7	1223.7
5+	4	23.6	250	14	96.4	3.6	58.8	1574.5
		24.5	290	14	95.9	4.1	20.8	486.5
		27.2	420	53	91.7	8.3	61.3	677.2
		29.0	490	41	91.7	8.3	65.1	719.2
6+	7	27.3	490	64	90.7	9.3	84.6	825.1
		28.5	500	49	93.4	6.6	80.9	1144.8
		28.7	520	54	86.5	13.5	96.7	619.6
		29.3	640	89	88.8	11.2	110.6	876.9
		30.3	640	87	92.2	7.8	93.6	1106.4
		31.9	730	45	98.5	1.5	35.3	2318.0
		32.2	850	94	93.2	6.8	120.5	1651.5
7+	5	32.0	750	76	95.1	4.9	92.6	1797.2
		32.2	760	50	92.9	7.1	63.1	825.6
		32.6	850	96	93.4	6.6	133.5	1889.2
		34.3	890	112	92.3	7.7	115.1	1379.7
		35.0	1040	110	93.4	6.6	153.7	2175.1
8+	2	35.2	1060	161	90.4	9.6	209.0	1968.1
		36.2	1200	187	91.1	8.9	192.4	1696.4
9+	2	35.7	1140	179	91.8	8.2	168.6	1887.5
		43.5	1900	303	89.3	10.7	309.6	2583.8
Total	24							

Percentage of the oocytes of proto- and trophoplasmatic growth in the ovaries was determined in all collected bream females. To achieve this histological samples were made from ovary scraps. Ovary scraps 10–15 μ thick were stained with Delafield hematoxylin and eosine. All sections of proto- and trophoplasmatic oocytes were counted on three ovary scraps. Real number of the oocytes was calculated using the formula of Marrable (1962):

Table 3

Percentage and number of the oocytes of proto- and trophoplasmatic grwoth in the ovaries and individual data for bream females in Blanki Lake in November 1990

Age	n	Body length cm	Body weight g	Gonad weight g	Oocytes of proto-plasmatic growth %	Oocytes of tropho-plasmatic growth %	Absolute fecundity thous.	Reserve of the oocytes protoplasmatic growth thous.
4+	2	25.6	360	18	95.3	4.7	68.2	1382.9
		28.2	440	21	97.5	2.5	57.2	2230.1
5+	9	25.6	410	27	93.1	6.9	104.4	1408.6
		29.5	550	25	97.4	2.6	55.9	2094.1
		30.5	540	28	96.2	3.8	46.4	1174.6
		30.8	670	59	94.5	5.5	154.5	2654.6
		30.9	650	44	89.9	10.1	164.0	1459.8
		31.2	640	39	94.3	5.7	130.2	2154.0
		32.0	720	36	97.3	2.7	84.2	3034.3
		32.2	730	47	94.3	5.7	140.6	2326.1
		33.5	810	71	89.4	10.6	139.6	1177.4
6+	6	33.7	820	66	93.5	6.5	157.8	2269.9
		34.0	840	73	92.0	8.0	182.6	2099.9
		34.2	910	66	93.2	6.8	183.9	2520.5
		35.1	920	77	96.8	3.2	185.8	5620.4
		35.4	1000	98	95.3	4.7	179.9	3647.7
		36.9	1050	94	91.3	8.7	227.7	2389.5
7+	6	34.8	950	63	92.4	7.6	143.8	1748.3
		35.5	1100	130	93.2	6.8	249.4	3418.2
		36.3	1070	106	93.8	6.2	238.3	3605.2
		36.6	1090	117	91.3	8.7	227.9	2391.6
		37.0	1070	115	89.8	10.2	246.3	2168.4
		38.3	1250	122	93.0	7.0	273.9	3638.9
8+	5	36.2	1090	109	94.4	5.6	246.4	4153.6
		37.3	1150	122	92.0	8.0	321.3	3694.9
		38.5	1200	116	97.3	2.7	242.9	8753.4
		38.9	1450	160	91.5	8.5	249.6	2686.9
		39.6	1350	122	92.1	7.9	233.9	2726.8
9+	1	38.8	1230	119	93.9	6.1	220.6	3395.8
10+	1	40.9	1650	191	93.3	6.7	309.6	4311.3
Total	30							

$$N = \frac{T}{T+D} \times n; \text{ where}$$

N – real number of oocytes,
n – number of all counted oocyte sections,
T – scrap thickness,
D – average diameter of 20 oocytes in the given stage.

Reliability of the data was checked calculating real number of oocytes and oocyte percentage for each scrap separately. When the differences in the percentage of oocytes in the given stage did not exceed 1%, all counted oocyte sections in the three scraps were summed up and the formula was used to calculate the oocyte numbers. When the difference exceeded 1% oocyte sections were counted on more sections. Absolute fecundity was determined with weight method (Brylińska and Bryliński 1972) for females collected in May–June from Lake Kortowskie, and in November from Lake Blanki. Reserve of oocytes of protoplasmatic growth in female ovaries was estimated on the basis of proportion:

$$O_t : F_a = O_p : x; \text{ where}$$

O_t – percentage of the oocytes of trophoplasmatic growth in the ovaries,
F_a – absolute fecundity (number of oocytes of trophoplasmatic growth-eggs in thousand),
O_p – percentage of oocytes of protoplasmatic growth in the ovaries,
x – reserve of oocytes of protoplasmatic growth in thousand.

Lakes: Kortowskie and Blanki are located in Mazurian Lakeland. Lake Kortowskie is a flow-through lake of 89.7 ha, maximal depth 17.2 m and average depth 5.9 m (Synowiec 1965). It is polluted with domestic sewage (Mientki 1986). Since 1956 the lake is recultivates with the method of removing the hypolimnion water to the outflow. This procedure slowed down rapid lake eutrophication, but it did not liquidate periodic oxygen deficits in the bottom water layer (Mientki 1986). The lake is not fished commercially.

Lake Blanki is also a flow-through lake of 435.7 ha, maximal depth 12.0 m, average depth 9.0 m (data of the Inland Fishereis Institute). The lake is totally mixed. Oxygen is always present in the bottom water layer, and temperature may reach 16°C. Transparency of water is up to 2.7 m. It is a pike-perch type of lake. Commercial fish landings in 1986–1990 were 19.3–24 kg/ha annually, in this bream represented: large bream (D) 0.1–4.1 kg/ha, mediumsized bream (S) 1.7–7.3 kg/ha.

RESULTS

Reserve of the oocytes of protoplasmatic growth in the ovaries of bream females from Lake Kortowskie.

Percentage of oocytes of protoplasmatic growth in the ovaries of females collected in December ranged from 85.5 to 95.4% (Tab. 4). Range of average diameter of protoplasmatic oocytes was 0.069–0.111 μ, and of trophoplasmatic ones 0.478–0.780 μ. Percentage of oocytes of protoplasmatic growth in the ovaries of bream females collected in May–June was 86.5–98.5% (Tab. 4). Average diameter of these oocytes ranged from 0.072 to 0.156 μ. and of the oocytes of trophoplasmatic growth from 0.497 to 1.086 μ. Arithmetic mean of the percentage of protoplasmatic oocytes in the ovaries of bream females collected in December was 92.3%, and in the ovaries of the fish collected in May–June 92.9%. Comparison of the arithmetic means (Tab. 4) showed that the differences were not significant statistically. Since the moment when trophoplasmatic oocytes filled with yolk there were no vacuolized oocytes in bream ovaries. (Brylińska and Długosz 1970, Kopiejewska 1989), similarly as in the oocytes of other fish species of similar sexual cycle. The latter oocytes may change oocyte proportion in the ovaries during spring accumulation of nutritive substances. Insignificant differences in the mean percentage of protoplasmatic oocytes in the ovaries in December and May–June suggest that the same proportion is maintained till spawning.

Fractions of proto- and trophoplasmatic oocytes changed with changing absolute fecundity (Tab. 2, Fig. 1). The two parameters were significantly inter–related, as shown by the correlation coefficients. Absolute value of the correlation coefficient ($r = -0.5748$) was higher than $r_{tab.} = 0.4227$ at significance level $\alpha = 0.05$. Percentage of the oocytes of protoplasmatic growth in female ovaries decreased with increasing absolute fecundity. This dependence is presented in Fig. 1 in form of linear regression. It shows that when percentage of protoplasmatic oocytes was 96–98%, absolute fecundity of the females amounted to about 60–40 thousand eggs. When this percentage was 89–91%, absolute fecundity was 150–130 thousand eggs. Change of the proportion toward increased percentage of trophoplasmatic oocytes with increasing absolute fecundity suggests utilization of the pool of protoplasmatic oocytes in the ovaries when the oocytes are filled with yolk.

Estimation of the reserve of oocytes of protoplasmatic growth in female ovaries (Tab. 2, 5) showed that number of protoplasmatic oocytes in the ovaries ranged from 486.5 to 2583 thousand, the mean value being 1367.9 thousand. Individual variations in the number of oocytes of protoplasmatic growth ($V = 44.0$) was lower than the variations in egg numbers ($V = 65.8$). Females characterized by greater fecundity had bigger reserve of the oocytes of protoplasmatic growth, but there were also females of low fecundity, low percentage of trophoplasmatic oocytes in the ovaries, and high reserve of protoplasmatic oocytes.

Table 4

Percentage of the oocytes of protoplasmatic growth in the ovaries of bream females

Reservoir	Author	Date	n	Oocytes of protoplasmatic growth					
				Range	$\bar{x}$	S	V	t	$t_{P_{0.05}}$
Kortowskie Lake	author's data	5.V–17.VI.1987	24	86.5–98.5	92.9	2.964	3.2	0.697	2.02
Kortowskie Lake	author's	17–18.XII.1986	17	85.5–95.4	92.3	2.528	2.7	1.752	2.02
Blanki Lake	author's	22–24.XI.1990	30	89.4–97.5	93.6	2.297	2.4	3.704*	1.99
Śniardwy Lake	Kopiejewska (1989)	1978–1980	47	78.9–96.6	90.5	4.969	5.5	2.542*	1.99
Kortowskie Lake	author's	5.V–17.VI.1987	24	86.5–98.5	92.9				

*Difference significant

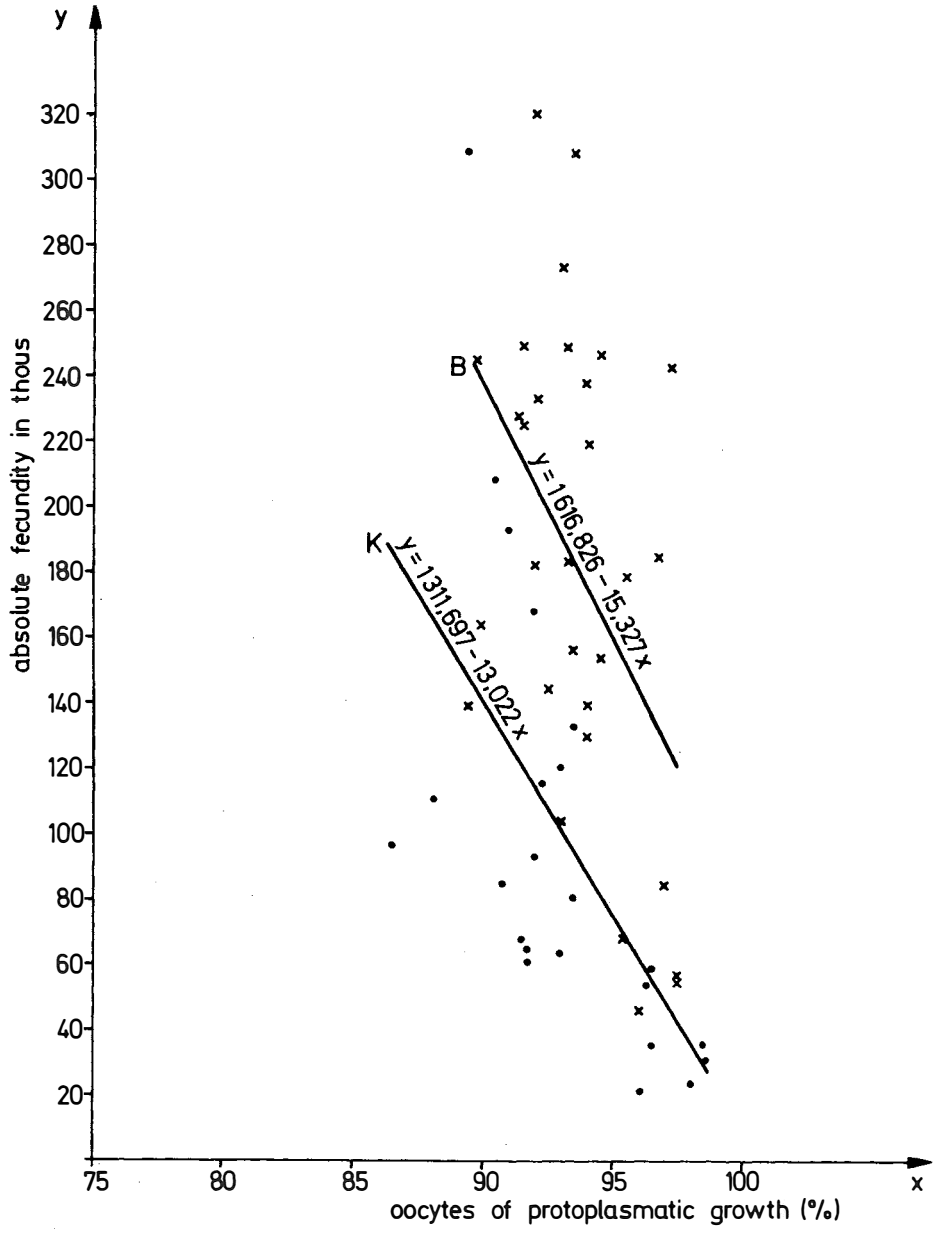

Fig. 1. Dependence between absolute fecundity and percentage of protoplasmatic oocytes for bream females from Kortowskie Lake (K) and Blanki Lake (B)

Table 5

Absolute fecundity and reserve of the oocytes of protoplasmatic growth in the ovaries of bream females in Kortowskie Lake and Blanki Lake

Reservoir		n	Range	$\bar{x}$	S	V	t	$t_{P_{0.05}}$
Kortowskie Lake	Absolute fecundity	24	20.8—309.6	102.0	67.1	65.8	4.131 *	2.01
Blanki Lake		30	46.4—321.3	182.2	75.3	41.3		
Kortowskie Lake	Reserve of oocytes	24	486.5—2583.8	1367.9	602.6	44.0	5.0 *	2.01
Blanki Lake		30	1174.6—5620.4 (8753.4)	2877.9	1510.9	52.5		

* Difference significant

Reserve of the oocytes of protoplasmatic growth in the ovaries of bream females from Lake Blanki.

In bream females from Lake Blanki range of the precentage of protoplasmatic oocytes in the ovaries was 89.4–97.5% (Tab. 4). Average diameter of the oocytes of protoplasmatic growth ranged from 0.077 to 0.109 μ, and of the oocytes of trophoplasmatic growth from 0.498 to 0.785 μ. Arithmetic mean of the percentage of protoplasmatic oocytes was 93.6%. This value did not differ significantly from the arithmetic mean obtained for bream females from Lake Kortowskie (Tab. 4). This suggests that there was no population variability of oocyte percentage in the ovaries of bream females in the two lakes.

Similarly as in the case of bream females from Lake Kortowskie, also in Lake Blanki the percentage of protoplasmatic oocytes correlated with the absolute fecundity of females. Absolute value of the correlation coefficient was $r = -0.4673$ against a tabelaric value $r_{tab.} = 0.3494$ at significance level $\alpha = 0.05$. Also in this case decreasing percentage of protoplasmatic oocytes corresponded to increasing absolute fecundity (Fig. 1). When percentage of the oocytes of protoplasmatic growth was 96–97%, absolute fecundity of the females amounted to 140–130 thousand eggs, while at 89–91% of protoplasmatic oocytes absolute fecundity was 250–220 thousand eggs. Differences in absolute fecundity of bream females from Lake Kortowskie and Lake Blanki at the same proportion of maturing oocytes showed that this proportion did not change at the same levels of population fecundity. Average fecundity of female population in Lake Blanki was significantly higher than average fecundity of female population in Lake Kortowskie (Tab. 5). Estimated average reserve of protoplasmatic oocytes in the ovaries of bream females in Lake Blanki was also significantly higher than in Lake Kortowskie (Tab. 5). On the other hand, proportions of maturing oocytes in the ovaries did not differ significantly in the two bream populations. The regression equations (Fig. 1) reveal that 1% decrease of protoplasmatic oocytes in female ovaries will increase the number of mature oocytes in both populations, but this increase will not be the same. Hence, 1% of maturing oocytes in the ovaries of bream population in Lake Kortowskie and Lake Blanki corresponded to different number of mature eggs, higher in the population characterized by higher fecundity.

Bream females from Lake Blanki (Tab. 5) were characterized by higher individual variability as regards the number of oocytes of protoplasmatic growth ($V = 52.5$) than with respect to the number of mature eggs ($V = 41.3$). Similarly as in the case of bream females from Lake Kortowskie, the following trend was observed: females with higher fecundity had higher reserve of oocytes of protoplasmatic growth in the ovaries.

DISCUSSION

Proportions of oocytes in fish ovaries were studied most of all in species with batch spawning. Their aim was to determine the period of egg development, or to define ovary functioning and strategy of reproduction (Monich 1953, Messtorff 1959, Gotting 1961, Yamamoto and Yamazaki 1961, Yamamoto and Yoshioka 1964, Dunn and Tyler 1969, Tong and Vooren 1972, Oven 1976, Crossland 1977, Htun-Han 1978, Fox 1978, Hoffman and Grau 1989, Pimpicka 1990). It was shown that in some species with batch spawning the oocytes of protoplasmatic growth were able to develop during the spawning season and could be spawned during the same season, theroby increasing female fecundity (Egami 1959, Oven 1961 a, b, Peters 1968 cit. after Lisovenko and Andrianov 1991, Bowers and Holliday 1961 cit. after Hoffman and Grau 1989). Transfer of the protoplasmatic oocytes into trophoplasmatic ones during spawning season and their ability to develop into mature eggs in the same season is related to continuous maturation of oocytes in the ovaries of fish species which spawn in batches. Reserve of protoplasmatic oocytes in the ovaries of these fishes differs for particular species. A reserve of oocytes in sea fishes was estimated at 80–90% (Messtorff 1959, Gotting 1961, Oven 1976), Yamamoto and Yoshioka (1964) estimated proportion of oocytes in the annual cycle in Oryzias latipes and found that oocytes of protoplasmatic growth represented 75–95%. Crossland (1977) found that they represented 47–97% in Chrysophrys auratus, Pimpicka (1990) stated that in tench, a freshwater fish, they amounted to 68–95% while Hoffman and Grau (1989) found 25–45% un Thalassoma duperrey in autumn, and 60–95% in summer. Different percentages of protoplasmatic oocytes in fish ovaries may be due to different methods of counting, different sampling periods in the annual cycle of ovary development, or species-specific functioning of the ovaries.

In polycyclic species of single portion spawning, oocytes development is periodic. It is sometimes defined as interrupted (Gotting 1961, Oven 1976 cit. after Lisovenko and Andrianov 1991). In ovaries of interrupted development all vacuolized oocytes are filled with yolk at the same time (endogenic vitellogenesis). In bream from natural Polish waters the process of filling with yolk (exogenous vitellogenesis) lasts for two months, it begins in August and ends in September–October (Brylińska and Długosz 1970, Kopiejewska 1989). In the period between spawning (May–June) and oocyte filling with yolk (September–October) number of the oocytes to be spawned during next spawning is established in the ovaries. Oocytes reserve retained in the ovaries of bream females spawning in one egg-batch was determined for the fish form Lake Śniardwy (Kopiejewska 1989). Studies were made on three bream populations: in Lake Śniardwy (Kopiejewska 1989) percentage of oocytes of protoplasmatic growth in the ovaries ranged from (78.9) 80.4 to 96.6%, the arithmetic mean being 90.5%; in Lake Kortowskie and Lake Blanki these oocytes represented 85.5–98.5% and 89.4–97.5%, the aritmetic means being 92.7 and 93.6 respectively. Arithmetic mean of the percentage of protoplasmatic oocytes in bream ovaries was lower in

Lake Śniardwy. The difference between this lake and lakes Kortowskie and Blanki was statistically significant (Tab. 4). Population of bream females in Lake Śniardwy was characterized by nigher percentage of trophoplasmatic oocytes in the ovaries. Basing on the results obtained for the three populations it may be stated that percentages of protoplasmatic oocytes in bream ovaries in lakes Śniardwy, Kortowskie and Blanki were within the limits (78.9) 80.4–98.5%. Range of these values exceeds (3.7) 4.1–65.7 times the percentage of trophoplasmatic oocytes in the ovaries. Aritmetic means of the percentage of protoplasmatic oocytes in the ovaries of bream females from Lake Kortowskie and Lake Blanki did not differ significantly (Tab. 4). Since average fecundity and average reserve of protoplasmatic oocytes in the ovaries differed significantly in the two lakes (Tab. 5) it may be concluded that there might be some regularity in the functioning of bream ovaries. In the populations in lakes Kortowskie and Blanki 1.5–14.5% oocytes developed in the ovaries in the annual cycle. This corresponds to 20.7–321.5 thousand eggs. Hence, different number of mature eggs corresponded to 1% of maturing oocytes. On the average it is higher in the population of higher fecundity. Hence an increase of female fecundity is achieved in two ways: through utilization of protoplasmatic oocytes which are present in the ovaries during oocyte filling with yolk (an increase in the percentage of trophoplasmatic oocytes from 1.5 to 14.5%, and through an increase of the number of eggs per 1% of oocytes present in the ovaries.

CONCLUSIONS

1. From 1.5 to 14.5% oocytes develop in the annual cycle of ovary development in bream females from Lake Kortowskie and Lake Blanki. This corresponds to 20.7–321.3 thousand eggs.

2. An increase of absolute fecundity of bream females takes place through utilization of the reserve of protoplasmatic oocytes which are present in the ovaries during vitellogenesis, within the limit of 1.5–14.5%, and through an increase in the number of eggs corresponding to 1% of oocytes in the ovaries. In case of females characterized by higher fecundity (bream females from Lake Blanki) number of eggs corresponding to 1% of oocytes was higher.

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ZAPAS OOCYTÓW PROTOPLAZMATYCZNEGO WZROSTU W JAJNIKACH SAMIC LESZCZA *ABRAMIS BRAMA* (L.) JEZIORA KORTOWSKIEGO I JEZIORA BLANKI

STRESZCZENIE

Określono proporcje oocytów w jajnikach 41 samic leszcza o długości ciała 21.1–36.2 (43.5) cm, masie ciała 190–1200 (1900) g i wieku 4–9 lat w Jeziorze Kortowskim i 30 samic leszcza o długości ciała 25.6–40.9 cm, masie ciała 360–1650 g i wieku 4–10 lat w jeziorze Blanki. W cyklu rocznym rozwoju jajników samic leszcza w tych jeziorach dojrzewa od 1.5 do 14.5% oocytów, jest to od 20.7 tys. do 321.3 tys. jaj. Wzrost płodności absolutnej samic odbywa się poprzez wyczerpywanie zapasu oocytów protoplazmatycznego wzrostu jaki znajduje się w jajnikach w czasie witellogenezy w granicach od 1.5 do 14.5% oocytów, oraz poprzez zwielokrotnienie ilości jaj przypadających na jeden procent oocytów w jajnikach.

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